CONTENTS

巻頭言／ Preface

寄稿／ Contribution

特集　環境対応～ eco ～に向けた新たな技術の創出

Special Feature : JATCO's Environmental Efforts

- Creating New Eco-technologies for Environmental Performance -

－ ジヤトコの環境対応　概要 －

－ 環境を支える技術 －

− オペレーションの改革 −

商品紹介／ Introduction of Products

トピックス／ Topics

拠点紹介／ Introduction of Business Operation Office

特許紹介／ Patents

外部発表・表彰リスト／ List of Released Reports for Public

CO_2削減のための視点

Perspectives for Reducing CO_2 Emissions

副社長 Exective Vice President 薄葉 洋 Yo USUBA

ジヤトコ･テクニカル･レビュー第 9 号の特集は，「環境対応～ eco ～に向けた新たな技術の創出」です.

2004 年のデータですが，世界のエネルギー消費による CO_2 排出量の内，18%が産業部門，20%が運輸部門から排出されたというデータがあります．さらに運輸部門から排出の内，自動車（乗用車，トラック，バスなど）が 8 割，つまり世界の CO_2 排出の 16%を占めていました（出典：International Energy Agency：World Energy Outlook 2006）．それほどの寄与があるからこそ，自動車の燃費改善が叫ばれているのです．したがって，燃費改善の技術を世界中の自動車に広く拡大することが，より効果的な CO_2 削減へとつなげられます.

ジヤトコの製品･技術の特徴となっている CVT は，自動車の燃費性能向上に大変有効な技術です．2008 年に世界中で生産された CVT は 391 万台にのぼり，そのうち約 43%にあたる 167 万台をジヤトコが生産しました（出典：CSM）．ジヤトコが，CVT 技術を広く展開してきている背景は，まさに自動車燃費改善に CVT の量的拡大で貢献しようと考えているからに他なりません.

どんなに燃費性能のよい自動車であっても，それを操るドライバーの運転の仕方で燃費性能も大きく変化します．一方，ドライバーにとって，クルマを意のままに走らせる楽しさも自動車に求める重要な要素です．ドライバーの「意のままに走りたい」という要求と「燃費運転」とを両立させることができるか，その問いに CVT 技術が挑戦しています.

CVT による燃費改善のメカニズムは，自由に変速比を設定できる利点を使って，いろいろな運転シーンに対し，常にエンジンが最適燃費領域で運転できるようコントロールすることです．アクセルペダルでクルマを操作しているドライバーからすると，トランスミッションの存在はクルマを動かしている黒子の一人にす

The special feature of JATCO Technical Review No. 9 focuses on the challenge of "creating new eco-technologies for environmental performance."

According to data for 2004, the industrial sector and the transport sector respectively accounted for 18% and 20% of the world's total carbon dioxide (CO_2) emissions resulting from energy consumption. Of the CO_2 emissions attributed to the transport sector, motor vehicles (passenger vehicles, trucks, buses, etc.) emitted 80%, which means they accounted for 16% of the world's total CO_2 emissions. (Source: International Energy Agency, World Energy Outlook 2006) There are strong calls for improving the fuel efficiency of vehicles precisely because their contribution to CO_2 emissions is so large. Accordingly, expanding the application of technologies for improving fuel efficiency to a greater number of vehicles worldwide would lead to a more effective reduction of CO_2 emissions.

Continuously variable transmissions (CVTs), one of the strong suits of JATCO's products and technologies, are markedly effective in improving the fuel efficiency of vehicles. In 2008, some 3.91 million CVTs were manufactured worldwide, of which JATCO produced 1.67 million, or approximately 43%. (Source: CSM Worldwide) The motivation for the broad deployment of our CVT technologies is simply a desire to contribute to improving vehicle fuel efficiency through the quantitative expansion of CVT use.

No matter how excellent a vehicle's fuel efficiency is, it will vary greatly depending on the driving style of the person operating the vehicle. On the other hand, the pleasure of having driving a vehicle respond faithfully to one's wishes is an important attribute that people want in vehicles. The challenge for CVT technology is to be able to reconcile this desire for driving pleasure with fuel-efficient vehicle operation.

The mechanism by which a CVT improves fuel efficiency is through control of the engine so that it always operates in the range of optimum fuel economy in all sorts of driving situations. This is accomplished by using the advantage of a CVT that it allows flexible setting of the gear ratio. From the viewpoint of the driver who is controlling the vehicle's speed by means

ぎません．その立場を生かし，CVT がドライバーの意図（どのように加減速したいか）を理解し，最適な加減速を行う変速比とエンジンの最適燃費領域での運転を組み合わせるようにコントロールできれば，わがままなドライバーの要求と燃費改善の両立も可能になるわけです．

自動車の CO_2 排出削減のための切り口には，①車やパワートレイン自体の燃費性能の向上（ジヤトコがまさに取り組んでいる領域です），②ドライバーの運転の仕方の改善での CO_2 削減，③自動車の走る道路環境（渋滞の頻度，平均車速など）改善での削減の 3 つの領域での取り組みが考えられます．（出典：2006 年日産先進技術説明会－トリプルレイヤードアプローチ）

CVT の制御技術は「CVT がドライバーの意図を最適なエンジンの運転に翻訳すること」が出来る技術ですから，上述の①の領域だけでなく，②のドライバーの加減速に対する期待を満たしながら，実質的にエコ運転をさせたりすることが可能となります．また，将来は道路交通情報などの交通インフラと自動車のナビとの連携で CVT を動かすことが出来れば③の領域でも CVT 技術が生かせるかもしれません．

このように，CO_2 削減のための技術開発は，ジヤトコの製品や技術の市場への提供だけでなく，CVT 搭載の車を使っていただくお客さまとの関わり，さらに社会環境の情報と CVT とをどうリンクさせるかというように，更なる広がりと可能性を持っている技術でも有ります．将来を考えるとき，ひとつの技術を磨き，極めるだけでなく，周囲との連携の中で新たな価値を作り出すという，より広い視野での取り組みも必要だと思います．

ジヤトコは単にハードウエアとしての AT／CVT での CO_2 削減にとどまらず，お客さまである人間と社会との連携を意識した環境活動を進めていきます．

of accelerator inputs, the transmission is merely like a phantom stagehand that is making the vehicle go. By taking advantage of that position, a CVT can discern how the driver wants to accelerate or decelerate. If gear ratio control for achieving optimum acceleration or deceleration is combined with engine management in the region of optimum fuel efficiency, a CVT can satisfy the driver's wish for driving pleasure while improving fuel efficiency at the same time.

As initiatives for reducing CO_2 emissions from vehicles, efforts can be considered in the following three areas: (1) improving fuel efficiency through improvements to vehicles and powertrain systems themselves (this is precisely the area of JATCO's activities); (2) reducing CO_2 emissions by improving the driving styles of drivers; (3) emission reductions through improvements to the road environment where vehicles are driven, including reducing the frequency of traffic congestion and optimizing the average driving speed, among other aspects. (Source: Triple-layered Approach concept presented at the 2006 Nissan Advanced Technology Forum)

CVT control technology enables the transmission to translate the driver's intentions into the optimum engine operating range. That capability not only improves fuel efficiency with respect to area (1) above, it also facilitates real eco-driving while simultaneously satisfying the driver's expectation for acceleration or deceleration. In the future, if it becomes possible to control a CVT according to road and traffic information obtained through cooperative operation of the roadside infrastructure and in-vehicle navigation system, it may be possible to utilize CVT technology in the third area as well.

As described here, further technological development for reducing CO_2 emissions involves not only the provision of JATCO's products and technologies to the market, but also relations with customers who drive CVT-equipped vehicles and the question of how to link CVTs to driving environment information. Thus, CVT technology entails various possibilities and potential for further extension. In thinking about the future, it is necessary to promote efforts from a broader perspective of creating new value amid cooperation with the surrounding environment, rather than just refining and enhancing individual technologies.

At JATCO, our efforts to reduce CO_2 emissions do not stop with just the development and provision of hardware in the form of automatic transmissions and CVTs. We are proceeding with a full spectrum of activities that take into account the relationship with drivers as the end users of our products and with society as a whole.

宇宙から温室効果ガスを測る ー「いぶき」のミッションー

Measuring Greenhouse Gases from Space –Ibuki's Mission

浜崎　敬*
Takashi HAMAZAKI

1. 地球温暖化の現状

地球温暖化の現状は，世界中の科学者の研究成果をレビューして集大成した，気候変動に関する政府間パネル（IPCC）の第 4 次評価報告書に詳述されている[1]．過去 100 年間で平均気温は 0.74 度上昇したこと，平均海面が約 17 センチ上昇したこと，北極海の雪氷面積が大きく減少していること，多くの地域で降水量が増加する一方で干ばつの影響を受ける地域が増加していること，陸域生態系への影響が出はじめていることなどである．また，コンピュータシミュレーションの結果から，20 世紀半ば以降に観測された世界平均気温の上昇のほとんどは，人間が放出した温室効果ガス濃度の増加によってもたらされた可能性が非常に高いと述べている．

2. 温室効果ガス

地球温暖化をもたらす温室効果ガスにはいろいろな種類がある．温室効果の 60% は二酸化炭素，20% はメタンガス，残りの 20% は一酸化二窒素とハロカーボン類（フロンなど）が原因である．温室効果ガスが地球温暖化をもたらすのはなぜだろうか．気温は，太陽から地球に到達するエネルギと，地球から宇宙空間に放出されるエネルギのバランスで決まる．太陽から地球に到達するエネルギの大半は波長 0.4 ～ 0.8 ミクロンの可視光に含まれている．大気は可視光に対しほぼ透明であるため，太陽エネルギは直接地表を暖め，気温が上昇する．これに対して，暖まった地表や大気から宇宙に放出されるエネルギの大半は赤外線で，波長 10 ミクロン付近の強度が

1. Present state of global warming

The present state of global warming is described in detail in the Fourth Assessment Report issued by the Intergovernmental Panel on Climate Change (IPCC), based on a comprehensive review of the research results reported by scientists around the world.[1] Some of the findings summarized in the report include: the average atmospheric temperature has risen 0.74°C in the last 100 years; the average sea level has risen approximately 17 cm; the area of the Arctic Ocean ice cap has shrunk drastically; the amount of rainfall has increased in many regions while an increasing number of areas suffer from the effects of drought; continental ecosystems are beginning to be affected. The report also notes that the results of computer simulations suggest that most of the rise in the global average temperature observed since the middle of the 20th century can very likely be attributed to the increased concentration of greenhouse gases released by human activity.

2. Greenhouse gases

There are various types of greenhouse gases that cause global warming. Carbon dioxide accounts for 60% of the greenhouse effect, methane for 20% and dinitrogen oxide and halocarbons (Freon and other chlorofluorocarbons) for the remaining 20%. Why is it that greenhouse gases cause global warming? The temperature of the atmosphere is determined by the balance between the energy that reaches the earth from the sun and the energy that the earth releases into space. Most of the solar energy that reaches the earth is contained in visible light in a wavelength range of 0.4-

* 宇宙航空研究開発機構　宇宙利用ミッション本部　事業推進部長
Director, Space Utilization Mission Directorate, Japan Aerospace Exploration Agency

最大である．大気はこの波長の赤外線に対してもほぼ透明であるため，エネルギは宇宙空間に放出され，両者が釣り合ったところで気温が決まる．ところが，温室効果ガスがあるとこのバランスが変わってくる．温室効果ガスは可視光に対しては透明でエネルギを吸収しないが，赤外線に対しては不透明で，赤外線を吸収する性質を持っている．そのため地球から宇宙に放出されるエネルギを吸収し，気温が上昇する訳である．これを温室効果と呼ぶ．温室効果ガスが全く存在しない場合，気温は現在の世界平均 14 度から 33 度も下がってマイナス 19 度になり，全球が凍結してしまうと推定されている．温室効果ガスの存在は生物の存在に不可欠であるが，ある一定の範囲にコントロールする必要がある．

3. 炭素循環

大気中の二酸化炭素は植物の光合成により葉や幹，根などに取り込まれる一方で，呼吸や，腐敗，燃焼などにより植物から大気中に放出される．また，大気中の二酸化炭素は，海洋とも交換がある．深海からの上昇海流があるペルー沖などでは海洋から大気中に放出され，ハワイ沖などでは大気から海洋に吸収されていることが観測されている．このように二酸化炭素は直接または炭素化合物の形で地球上の大気・植物・海洋などの間で相互に交換されている．これを炭素循環と呼んでいる．地球の大気中に含まれる二酸化炭素の中の炭素は約 7600 億トン，植物や土壌の中の炭素は約 2 兆トン，海洋中の炭素は 38 兆トンと莫大な量であるが，大気と植物の間の交換量，大気と海洋の間の交換量ともほぼ釣り合っている．一方で，ガソリンによる車の走行，石油や石炭による発電などにより，人間活動により大気中に排出される二酸化炭素は年間に 64 億トンと小さいが，これだけがアンバランスであり，温暖化の要因となっているわけである．極論をすると温暖化を防止するためには二酸化炭素排出量をゼロにすることが必要となる．これができないまでも，省エネを進め排出量を大幅に削減して，温暖化を最小限に食い止めなければならない．

0.8 μm. Since the atmosphere is virtually transparent to visible light, solar energy warms the earth directly, causing the atmospheric temperature to rise. In contrast, the greater part of the energy released into space from the warmed earth's surface and from the atmosphere is infrared radiation with a maximum intensity near a wavelength of 10 μm. Since the atmosphere is virtually transparent to infrared radiation at this wavelength, energy is released into space and the atmospheric temperature is determined at the point where the two types of energy are balanced.

However, this balance changes when greenhouse gases are present. By their nature, greenhouse gases are transparent to visible light and do not absorb any energy, whereas they are opaque to and absorb infrared radiation. Accordingly, greenhouse gases absorb energy released into space from the earth and that is why the atmospheric temperature rises. This is known as the greenhouse effect. It is estimated that if there were no greenhouse gases present at all, the atmospheric temperature would fall from the current global average of 14°C to -19°C, a drop of as much as 33°C, and our entire planet would freeze. The presence of greenhouse gases is essential for the existence of living things on the earth, but it is necessary to control their concentrations within certain limits.

3. Carbon cycle

Carbon dioxide in the atmosphere is taken into the leaves, stems and roots of plants in the process of photosynthesis and is released into the atmosphere from plants through respiration, decomposition, combustion and other processes. There are also exchanges of carbon dioxide between the atmosphere and the oceans. It has been observed that carbon dioxide is released into the atmosphere from the oceans, such as in the waters off Peru where there is an upward ocean current from the depths of the ocean, and that carbon dioxide is absorbed from the atmosphere by the oceans, which occurs, for example, in the waters off Hawaii. There are mutual exchanges of carbon dioxide between the earth's atmosphere, plants, oceans and other carbon reservoirs, which take place directly or in the form of carbon compounds. This circulation of carbon is referred to as the carbon cycle.

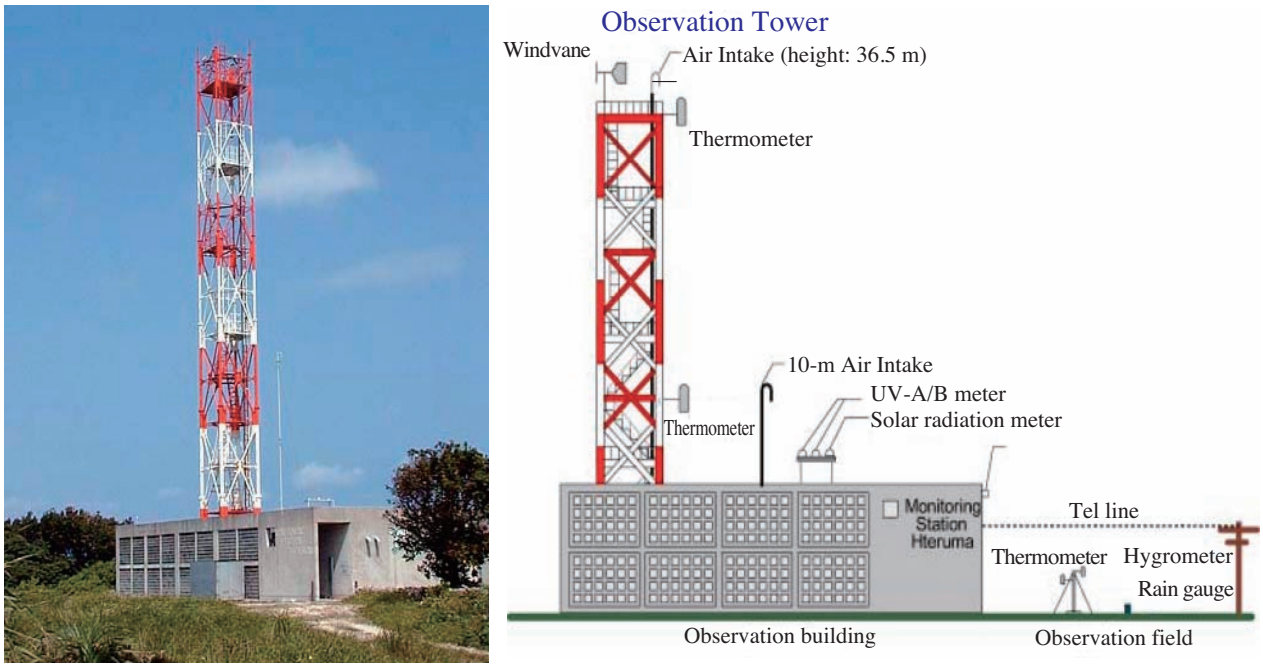


Fig. 1 NIES Hateruma monitoring station (from the NIES web site)[5)]

4. 温室効果ガスの地上観測の現状

地球温暖化を正確に予測するためには，温室効果ガスの濃度を正確に知ることが必要である．このために地上観測が続けられている．温室効果ガスの観測ステーションの一例として，国立環境研究所の波照間ステーションの概要を図 1 に示す．地上 36.5m のタワーの上部から採取された大気は観測室に送られ，測定器で分析されて濃度が観測される．通常の観測は無人で自動的に実施されるが，1 ヶ月に 1 回程度の定期的な保守が行われている．同様な観測点は各国の気象機関や研究機関が所有し運用している．図 2 に世界気象機関の温室効果ガス世界資料センターの観測点を示す．世界 61 カ国の 303 の観測地点（2009 年 10 月現在）のデータが温室効果ガス世界資料センターに送られ，インターネットで公開されている [2)]．この温室効果ガス世界資料センターは日本の気象庁が運営しており，世界の温室効果ガスのデータは一旦日本に集められ，日本から世界に発信される状況となっている．日本はいわば温室効果ガス観測データの「メッカ」となっている．図 2 から分かるとおり観測点はヨーロッパ，日本，アメリカには比較的数多く分布しているが，アフリカ，シベリア，オーストラリア，南米，海洋上には観測点が極めて少なく，偏在して

The amount of carbon contained in carbon dioxide in the earth's atmosphere is estimated at some 760 billion tons, that in plants and soil at some 2 trillion tons and that in the oceans at 38 trillion tons. While these are massive amounts, the quantity of carbon exchanged between the atmosphere and plants is nearly balanced, as is the amount exchanged between the atmosphere and the oceans. On the other hand, the amount of carbon dioxide released into the atmosphere by human activity, such as by burning gasoline to propel auto mobiles or by burning petroleum or coal to generate electricity, is small at 6.4 billion tons. However, this amount alone is unbalanced and becomes a cause of global warming. In an extreme argument, the prevention of global warming would require the reduction of carbon dioxide emissions to zero. Even if it is not possible to go that far, it is necessary to keep global warming to a minimum by substantially reducing atmospheric emissions of carbon dioxide through the adoption of energy-saving measures.

4. Present state of terrestrial observation of greenhouse gases

In order to predict global warming accurately, it is necessary to know the exact concentrations of greenhouse gases in the atmosphere. Terrestrial

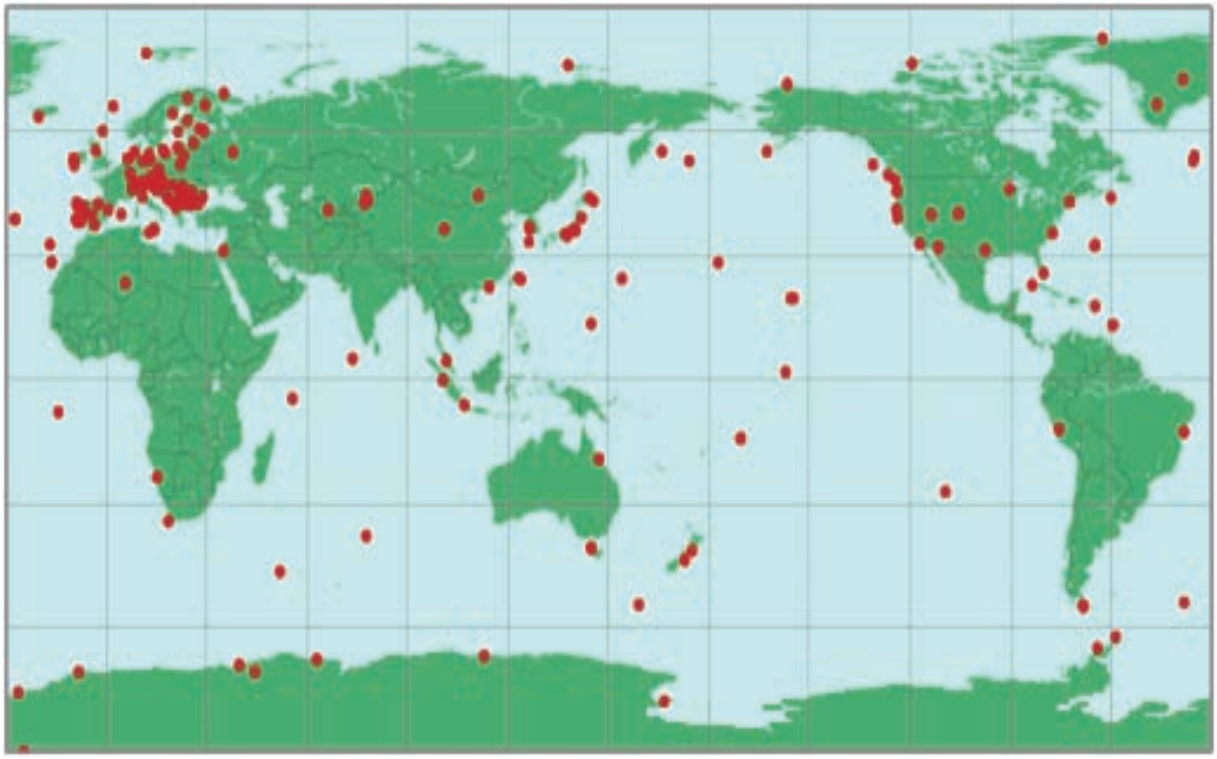


Fig. 2 WDCGG observation points (303 observation points in 61 countries)

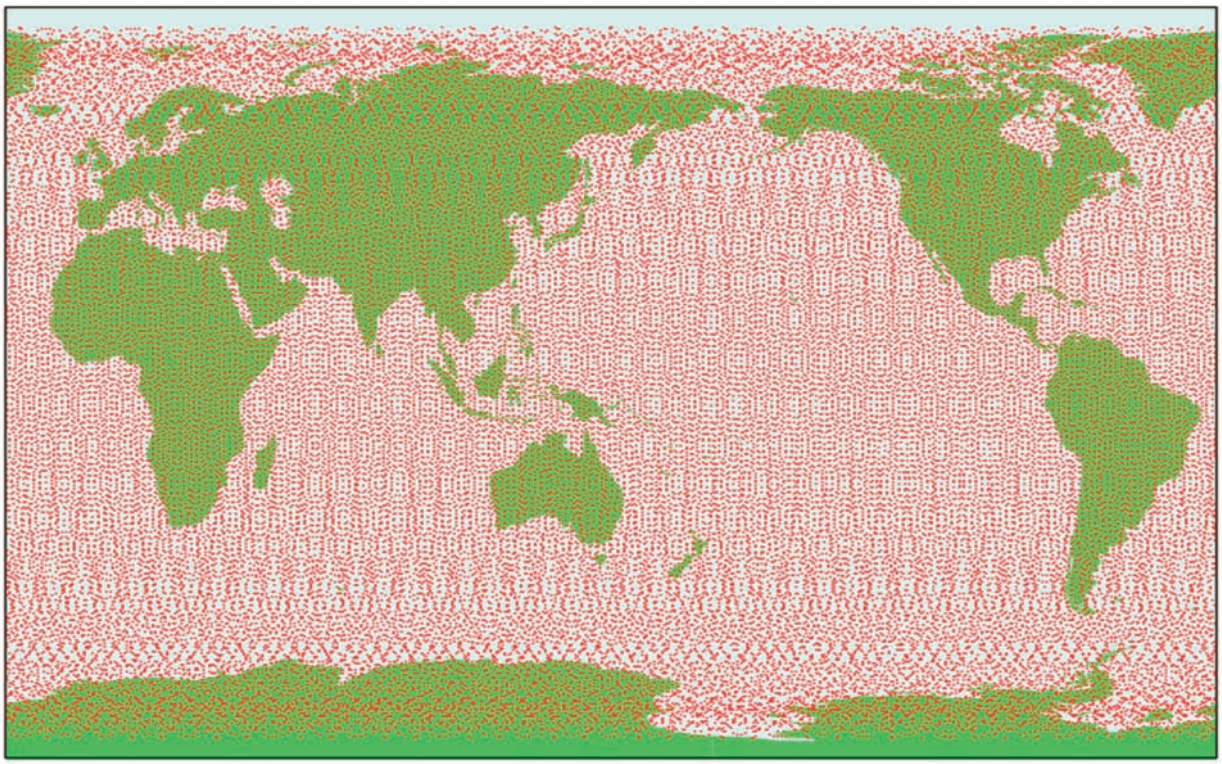


Fig. 3 Ibuki's observation points (56,000 locations)

おり，多くの観測欠落域が残っているのが現状である．地球温暖化の研究者は地球気候モデルをスーパーコンピュータで走らせてシミュレーションし，温

observations of greenhouse gas concentrations are continually being made to obtain such information. As one example of a greenhouse gas observation station, Fig. 1 shows the appearance of the Hateruma

暖化予測を行っているが，その結果をこれらの観測データと比較して，地球気候モデルの検証とチューニングを行っている．観測欠落域があるとその地域の特有の事象が取り込まれないため，精度を上げることができない．そのため，より組織的な観測が重要となってきた．これに応えるべく提案されたのが宇宙からの温室効果ガス観測である．

5.「いぶき」計画

「いぶき」は宇宙航空研究開発機構（JAXA），環境省，国立環境研究所（NIES）が共同で進めているプロジェクトで，温室効果の 60%を占める二酸化炭素と 20%を占めるメタンガスの濃度分布を宇宙から計測する世界初，世界唯一の温室効果ガス観測専用衛星である [3)4)]．JAXA は主にセンサ・衛星・ロケットの開発・打上げ・運用とデータの一次処理を，国立環境研究所はデータの高次処理と検証を，環境省はデータの行政利用を担当している．「いぶき」は高度 666km の軌道を秒速 7.4km，時速 26,600km で飛行し，地球を 100 分で 1 周する．3 日間で全球の観測を行い，再び同一地点の観測を繰り返す．図 3 に「いぶき」の観測点を示す．観測点の総数は 56,000 地点で現在の地上観測点の約 200 倍の観測を行うとともに，観測欠落域を解消することができる．

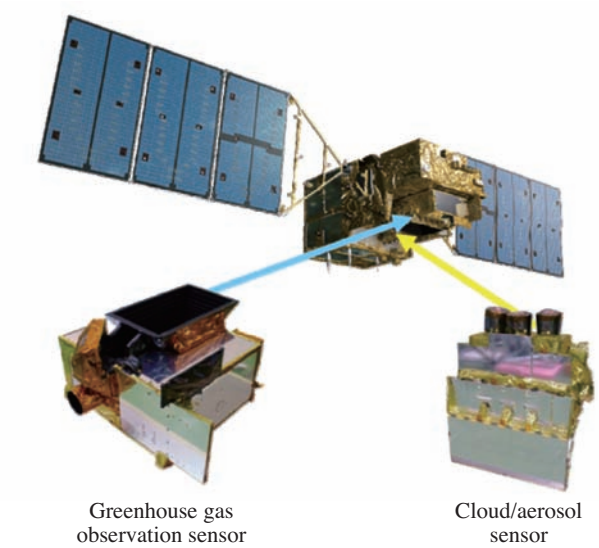


Fig. 4 Ibuki's appearance and onboard sensors

「いぶき」の外観と搭載センサを図 4 に示す．「いぶき」は本体が 1.8m × 2.0m × 3.7m の箱形で，3.8kW

monitoring station operated by the National Institute for Environmental Studies. Atmospheric samples collected at the top of the 36.5-meter-high tower are sent to an observation room for analysis and greenhouse gas concentrations are measured with measuring instruments. Normally, monitoring is done automatically without any human intervention, though the equipment is regularly maintained about once a month.

Similar observation stations are being operated by meteorological agencies and research institutes in many countries around the world. Fig. 2 shows the locations of the fixed stations of the World Data Center for Greenhouse Gases (WDCGG) under the World Meteorological Organization. As of October 2009, there are 303 observation stations in 61 countries throughout the world. The measurement data these stations collect are sent to the WDCGG and are made public at the latter's website.[(2)] The WDCGG is operated by the Japan Meteorological Agency. Global greenhouse gas data are first collected in Japan and then distributed from Japan throughout the world. In a sense, Japan is a “Mecca” for greenhouse gas observation data. As is clear from Fig. 2, the distribution of observation stations is not uniform, as there are relatively many observation stations in Europe, Japan and the United States, but very few in Africa, Siberia, Australia, South America and at oceanic locations. Many regions remain unobserved.

Researchers make predictions of global warming based on simulations conducted by running global climate models on supercomputers. The results obtained are then compared with the observation data in order to validate and fine-tune their global climate models. Since the specific environmental characteristics of the regions without observation stations cannot be incorporated into the models, it is impossible to improve prediction accuracy. Consequently, that has made systematic monitoring all the more important. Greenhouse gas monitoring from space was proposed as a way of dealing with this situation.

5. Ibuki project

Ibuki is the world's first and only satellite

の電力を発生する太陽電池パネルの翼端間は 13.7m，全体質量は 1,750kg である．「いぶき」の設計寿命は 5 年間である．

dedicated to monitoring greenhouse gases.[3)4)] It was launched in January 2009 in a joint project being promoted by the Japan Aerospace Exploration

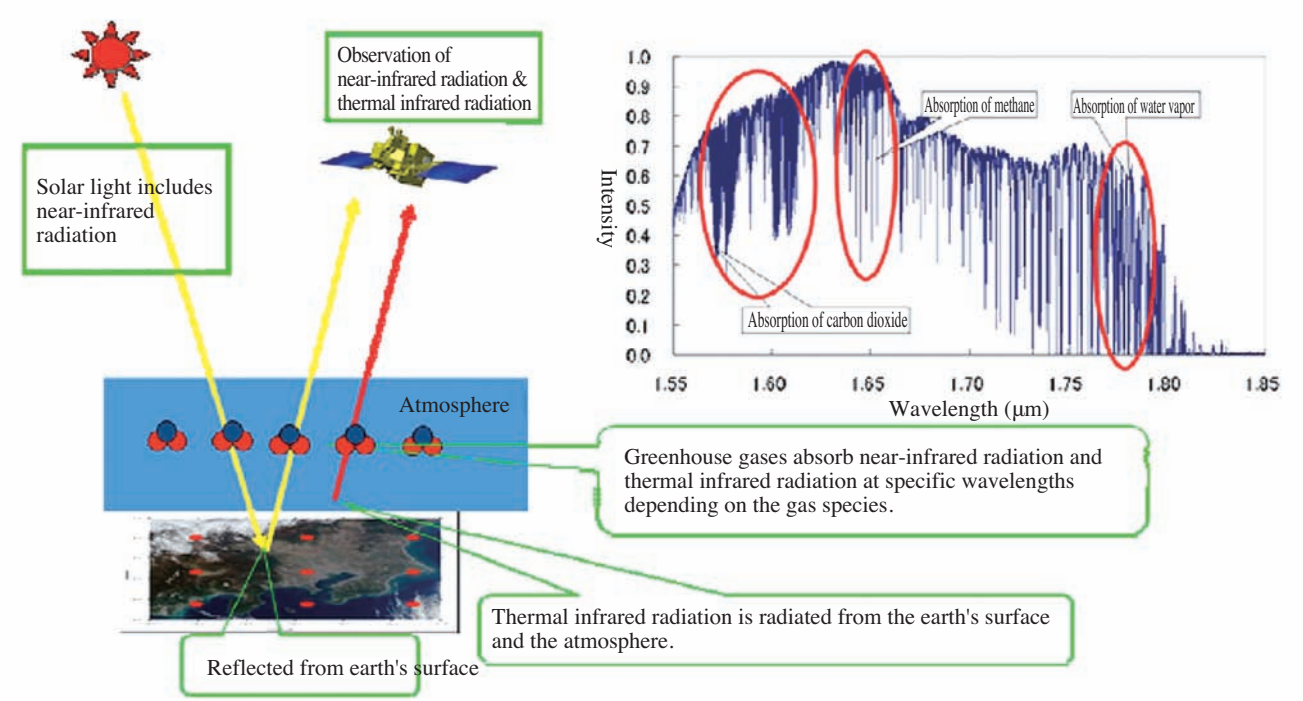


Fig. 5 Observation principle of Ibuki's greenhouse gas sensor

図 5 に「いぶき」の温室効果ガスセンサの観測原理を示す．「いぶき」の温室効果ガスセンサは太陽から放射され，地上で反射した近赤外線（波長 1.6 ミクロンから 2.0 ミクロン）と，大気や地表から直接放射される熱赤外線(波長 15 ミクロン)を精密に観測する．温室効果ガスはその種類毎に特定の波長の赤外線を吸収し，その吸収量は濃度に比例する．また，吸収線は多数有り，多くの吸収線の観測データを用いることにより，高精度の観測が可能となる．二酸化炭素の平均濃度は 380ppm（100 万分の 380，すなわち 0.038%）と極めて微量であるが，「いぶき」の温室効果ガスセンサはその濃度の 100 分の 1 の変化，すなわち 4ppm（100 万分の 4，すなわち 0.0004%）以下の精度での観測が可能である．

Agency (JAXA), the Ministry of the Environment (MOE) and the National Institute for Environmental Studies (NIES). Ibuki measures from space the concentrations and distributions of carbon dioxide that accounts for 60% of the greenhouse effect and methane that accounts for 20%. JAXA has mainly been responsible for the development of the sensors, satellite and launch vehicle, the launching and operation of Ibuki and the primary data processing. NIES is responsible for the higher order processing and validation of the observation data and MOE for the governmental use of the resultant data.

Ibuki obits the Earth once every 100 minutes at an altitude of 666 km, flying at a speed of 7.4 km/s or about 26,600 km/h. It observes the entire globe in three days and then repeats its observation of the same locations again. Fig. 3 shows the 56,000 observation points observed by Ibuki. It observes approximately 200 times more locations than the current number of terrestrial observation stations and overcomes unobserved regions.

The appearance of Ibuki and its onboard sensors are shown in Fig. 4. The main body of the satellite

Fig. 6 Ibuki undergoing a vibration test at the JAXA Tsukuba Space Center

6. 人工衛星の開発

人工衛星はロケット打上げ時の振動，音響，衝撃に耐えなければならない．そのために実際よりも 1.5 倍程度厳しい環境で振動試験，音響試験，衝撃試験などを行い構造設計の妥当性を確認する．図 6 に筑波宇宙センターで実施した「いぶき」の振動試験の様子を示す．また，宇宙空間では太陽光が直接当たる面の温度は 100 度を超える一方で，太陽光が当たらず宇宙空間に曝される面はマイナス 100 度にもなり温度差は 200 度にも達する．衛星に搭載されるセンサは高感度で，温度の変化に敏感なため 23 度プラスマイナス 3 度の狭い範囲にコントロールしなければならない．そこで熱設計が重要となる．衛星全体を, 宇宙空間の超高真空と太陽光を模擬するスペースチャンバに入れ，熱真空試験を実施して熱設計の妥当性を検証する．また，人工衛星の設計では信頼性設計も大きな課題である．人工衛星は打ち上げると修理ができないため，故障率が低く放射線耐性などを確認済みの宇宙用高信頼性部品を用いるとともに

has a box shape measuring 1.8 m x 2.0 m x 3.7 m. The wing span of the solar array panels, capable of generating 3.8 kW of electricity, measures 13.7 m, and the satellite's overall mass is 1,750 kg. Ibuki has a design life of five years.

The observation principle of the greenhouse gas sensor aboard Ibuki is outlined in Fig. 5. The sensor can accurately monitor near-infrared radiation (wavelength range of 1.6-2.0 μm) that is radiated from the sun and reflected from the surface of the earth and thermal infrared radiation (wavelength of 15 μm) radiated directly from the atmosphere and the earth's surface. Greenhouse gases absorb infrared radiation at specific wavelengths depending on the gas species, and the quantity absorbed is proportional to the gas concentration. Additionally, there are numerous absorption lines, so by using observation data on many absorption lines, it is possible to obtain highly accurate observations.

The average atmospheric concentration of carbon dioxide is 380 ppm (parts per million, or 0.038%), which is an extremely small amount. However, Ibuki's greenhouse gas sensor can accurately measure a 1% (i.e., 4 ppm or 0.0004%) change in this concentration.

6. Satellite development

Satellites must endure the vibration, acoustic effects and shock that occur during the launch. For that reason, the validity of the satellite structural design is verified by conducting vibration tests, acoustic tests and shock tests in an environment that is about 1.5 times harsher than the actual conditions. Fig. 6 shows the setup of a vibration test conducted on Ibuki at the Tsukuba Space Center. Satellites are also subjected to extreme temperature differences as great as 200°C in space, as surfaces exposed to direct sunlight reach temperatures higher than 100°C, while the temperature of surfaces not exposed to sunlight may be as low as -100°C. The sensors used on board satellites have high sensitivity and are very sensitive to temperature changes, so their temperature must be controlled within a narrow range of 23°C ±3°C. That makes the thermal design of a satellite vitally important.

The validity of the thermal design is verified by conducting a thermal vacuum test on an entire

に，すべての電子機器や配線を完全に二重化し，どこの部分に故障が起きても冗長系に切り替えて運用の継続ができるように設計している．寿命が問題となる機器については 10 年分以上の寿命試験を実施して確認した．開発途中で様々な技術課題に遭遇し，その解決に多くの努力を要したが，プロジェクトチーム発足から 5 年 9 ヶ月後の 2009 年 1 月 23 日に「いぶき」を種子島宇宙センターから H-IIA ロケット 15 号機で打上げることができた．図 7 に「いぶき」打上げの様子を示す．これまでの衛星に比べると開発期間の大幅短縮を達成することができた（陸域観測技術衛星「だいち」の場合，プロジェクトチーム発足から打上まで 11 年 9 ヶ月）．

Fig. 7 Launching of Ibuki at the Tanegashima Space Center on January 23, 2009

7.「いぶき」の初期成果

「いぶき」は 1 月 23 日の打上げ後，3 ヶ月間をかけてチェックアウトを行い，すべての機能が正常であることを確認した．図 8 に「いぶき」搭載カメラで撮影した太陽電池パネル展開状況を示す．4 月末から 7 月末にかけて，地上での赤外線強度や二酸化炭素の濃度との比較を行う初期校正・検証作業を実施し，感度の補正などを行った．4 月末からは国立環境研究所や，公募した世界の研究者にデータの配布が開始され評価が行われている．

satellite in a space chamber that simulates the ultra-high vacuum and intense solar radiation of space. The reliability design of satellites is also a critical design issue. Because satellites cannot be repaired after they have been launched, they are built of highly reliable components engineered for space use and whose low failure rates, radiation resistance and other characteristics have been thoroughly confirmed. Satellites are also designed with complete redundancy of all electronic components and wiring, so that if a failure should occur somewhere in one system, a switch can be made to the redundant system immediately to ensure continued operation.

The service life of Ibuki equipment that might be problematic was confirmed by conducting life tests equivalent to more than ten years of use. Various technical issues were encountered during the development of Ibuki and enormous efforts were needed to resolve them. Nonetheless, five years and nine months after the formation of the project team, Ibuki was launched on January 23, 2009 from the Tanegashima Space Center using H-IIA launch vehicle No. 15. Fig. 7 is a photograph showing the launching of Ibuki. The development period for Ibuki was substantially shortened compared with that of previous satellites such as the "Daichi" Advanced Land Observing Satellite, which took eleven years and nine months to complete following the formation of the project team.

7. Initial results obtained with Ibuki

Ibuki's onboard equipment was thoroughly checked out during the first three months after the launch on January 23, and all functions were confirmed to be operating normally. Fig. 8 is a photograph taken with an onboard camera showing the deployed state of one of the solar array panels. Initial calibration of the sensors and validation of the data were performed from the end of April to the end of July by making comparisons with the infrared radiation intensities and carbon dioxide concentrations measured at earth-based stations. Sensor sensitivity and other adjustments were made on that basis. Observation data have been distributed to NIES and other publicly recruited researchers worldwide for evaluation since the end of April.

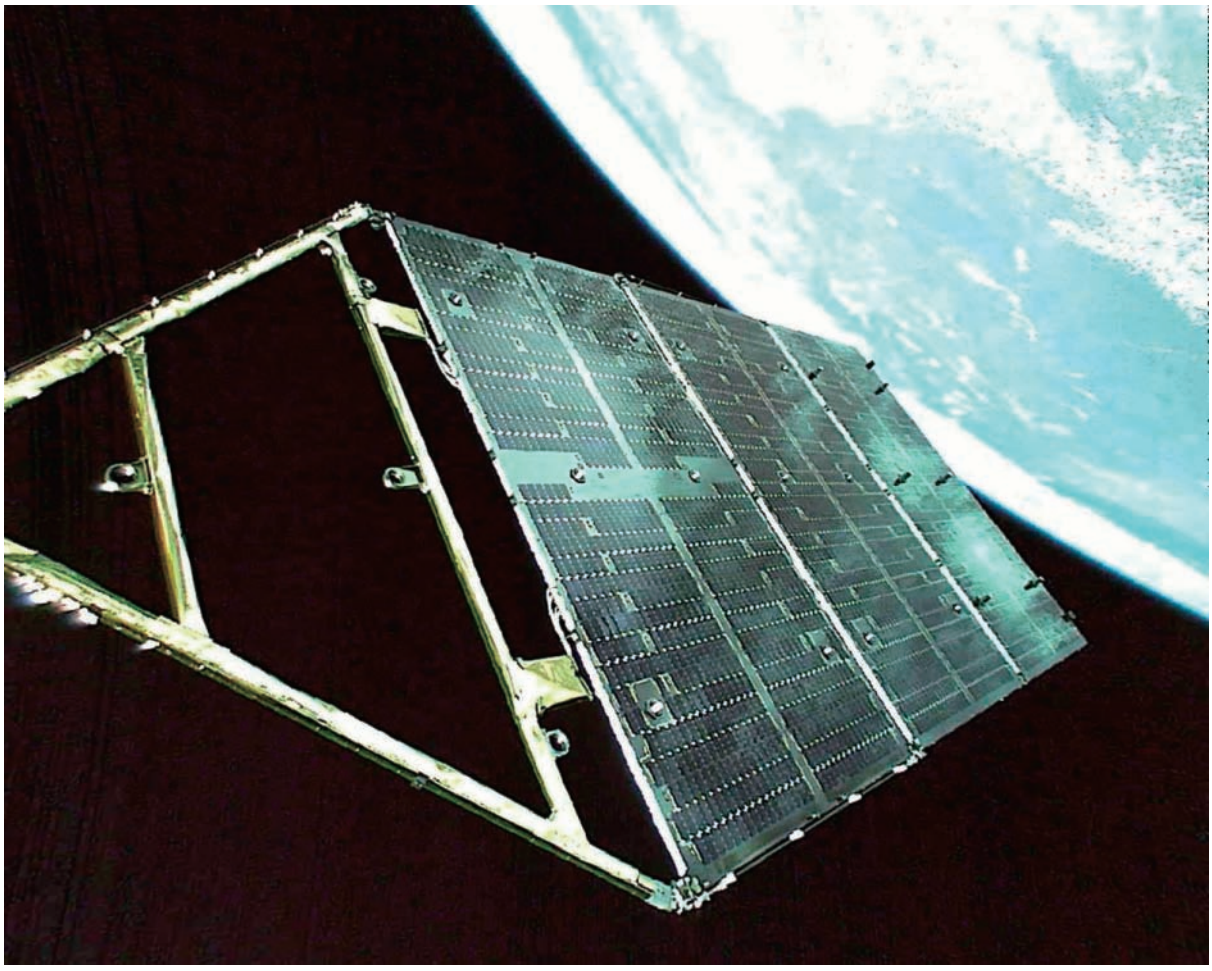


Fig. 8 Deployed state of an Ibuki solar array panel (photo taken with an onboard camera)

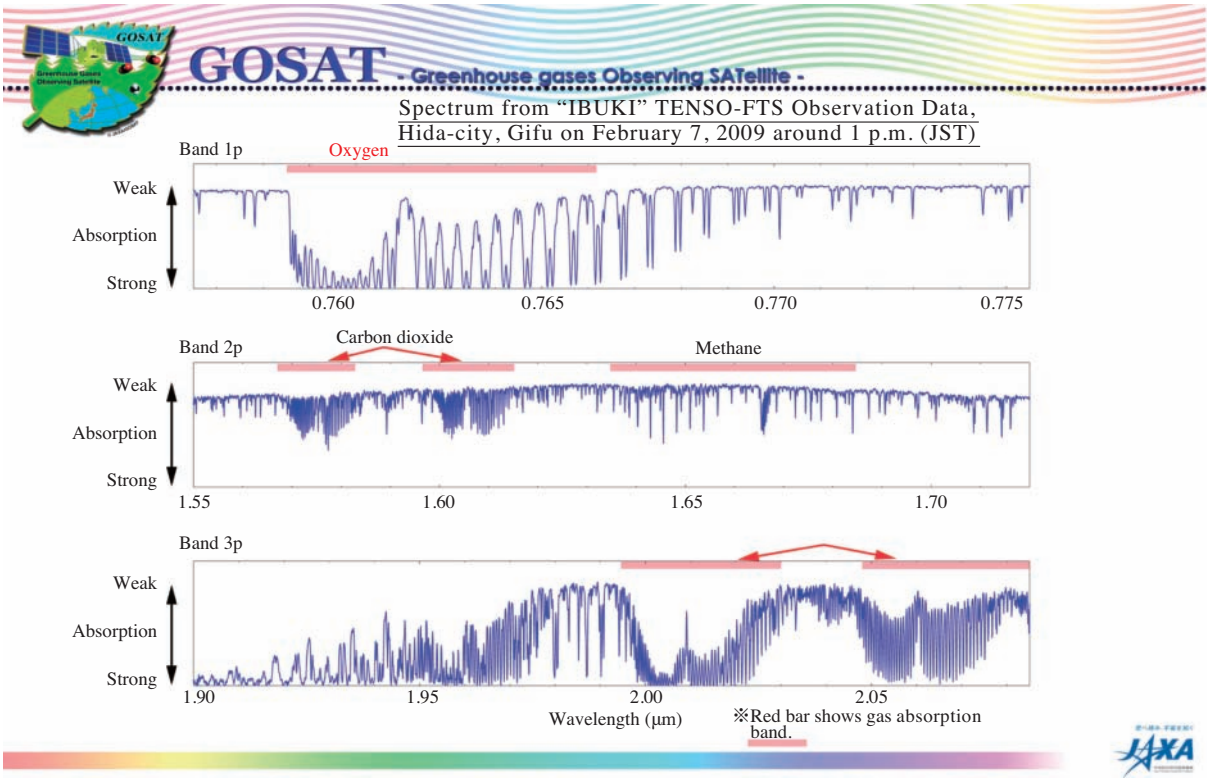


Fig. 9 Analysis results for initial Ibuki data

図 9 は「いぶき」のデータの初期解析結果である．二酸化炭素とメタンガスの吸収線が事前の予測通りに観測された．図 10 は国立環境研究所による短波長赤外線データを用いた二酸化炭素濃度の算出結果である．まだ十分な検証が行われていないため，誤差が含まれている．白い部分は雲と判定された地域または誤差が大きいと判定された地域などである．今後，検証作業の進展とともに精度の向上と，全球の観測データがそろうことを期待している．

Fig. 9 shows typical results of an initial analysis of the data obtained with Ibuki. The absorption lines for carbon dioxide and methane were observed as were predicted previously. Fig. 10 shows the carbon dioxide concentrations that were calculated at NIES using the data for short wave infrared radiation. These calculated results still contain error because the sensor data have not yet been sufficiently validated. The white portions indicate regions judged to be clouds or regions having large error. It is expected that accuracy will be improved as the validation work proceeds and that observation data for the entire globe will be obtained in the near future.

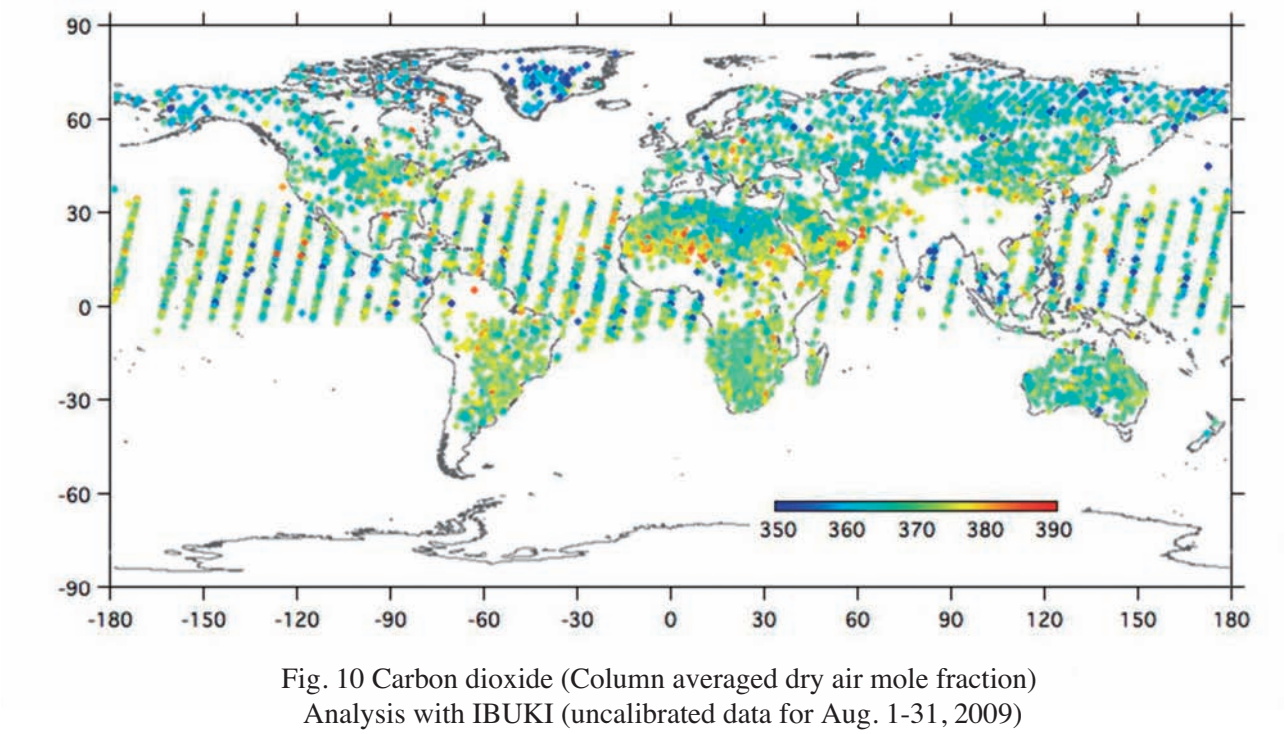


Fig. 10 Carbon dioxide (Column averaged dry air mole fraction)
Analysis with IBUKI (uncalibrated data for Aug. 1-31, 2009)

8.「いぶき」のデータ活用

「いぶき」のデータは 2010 年 2 月には内外の研究者に対するデータの提供を開始する予定である．我が国の国際貢献として，データは科学目的の場合無料で提供されることから，多くの研究者から利用要望が寄せられている．「いぶき」のデータは温室効果ガスを測る世界初の，世界唯一の，そして世界共通の「ものさし」であり，データの活用により，地球温暖化の予測精度が向上し，温暖化対策の立案に活用されると想定している．「いぶき」のデータを用いた各国研究者の研究成果は IPCC の第 5 次評価報告書に大きく寄与することになろう．また，「いぶき」はメタンガスの検出が可能であることから，世界の天然ガスパイプラインからのガス漏れ検知と早期修

8. Uses of Ibuki data

Ibuki data will begin to be provided to researchers both in Japan and overseas from around the end of February 2010. Many researchers have expressed a desire to use the data, which will be provided free of charge for scientific purposes as part of Japan's contributions to the international community. Ibuki data will serve as the world's first, only, and common scale for measuring greenhouse gases in the atmosphere. It is presumed that effective uses of the

理に貢献することが検討されている．これができれば「いぶき」は温室効果ガスを観測するのみならず，温室効果ガスの排出削減に寄与することも可能になる．

これらのデータ利用に加えてわれわれが最も期待しているのは，「いぶき」のデータを用いた「二酸化炭素の濃度の可視化」である．濃度の高いところを赤，低いところを青で表現し動画化すれば，都市，森林や海洋が大気中に二酸化炭素を吐いたり吸ったりする様子，すなわち「地球の息づかい」＝「いぶき」を誰もが見て，感じることができるようになる．二酸化炭素濃度の 3 日ごとの変化，月単位の変化，季節変化，年変化を感じ，二酸化炭素の排出量の多い国の周辺は赤くなって行き，排出量削減に努力した国の周辺が青くなって行く動画を見るときに，二酸化炭素の排出削減が人類共通の課題であることを誰もが自然と受け入れられるようになるのではないかと想像している．「地球の息づかい」を早く見てみたい，早く皆さんにお届けしたいと，「どきどき」，「わくわく」しながら「いぶき」のデータ利用を進めていきたいと考えている．また，自動車用変速機の効率向上などにより，二酸化炭素の排出量が減り，それを「いぶき」やその後継機で観測できる日が早く来ることを期待している．

参考文献

1) 気候変動に関する政府間パネル第 4 次評価報告書統合報告書政策決定者向け要約，2007，http://www.env.go.jp/earth/ipcc/4th/syr_spm.pdf
2) 温室効果ガス世界資料センターホームページ，http://gaw.kishou.go.jp/wdcgg/jp/wdcgg_j.html
3) JAXA「いぶき」ホームページ，http://www.jaxa.jp/projects/sat/gosat/index_j.html，2009
4) 山根一眞，「メタルカラー列伝　温暖化クライシス」，2006，小学館
5) 国立環境研究所ホームページ，http://ab.cger.nies.go.jp/gem/warm/Ground/hs.html

data will improve the accuracy of global warming predictions and will be helpful in proposing countermeasures against global warming. The research results obtained by researchers worldwide who make use of Ibuki data should contribute significantly to the IPCC's Fifth Assessment Report. Moreover, since Ibuki is capable of detecting methane, the satellite's potential contribution to the early detection and repair of leaks in natural gas pipelines worldwide is now being examined. If that proves possible, Ibuki will contribute not only to the observation of greenhouse gases but also to the reduction of their emissions.

In addition to this effective utilization of the data, what we are expecting the most from the use of Ibuki data is to be able to visualize atmospheric concentrations of carbon dioxide. Video clips could be created, for example, with high concentrations indicated in red and low concentrations in blue, making it possible to show how cities, forests and oceans emit and absorb carbon dioxide emissions to and from the atmosphere. That would enable everyone to see and feel the earth's breathing (i.e., the meaning of "ibuki"). It would be possible to indicate changes in carbon dioxide concentrations every three days, monthly, seasonally and yearly. The videos would show the areas around countries that are large emitters of carbon dioxide becoming redder and the areas around countries striving to reduce emissions becoming bluer. It is imagined that anyone seeing the videos would naturally understand that reducing carbon dioxide emissions is a shared task for all of humankind. We feel thrilled and excited as we work to promote uses of Ibuki data, as we want to see the earth's breathing as soon as possible and also to show it to everyone else as quickly as we can.

Improving the efficiency of automotive transmissions will reduce atmospheric emissions of carbon dioxide. It is hoped that the day will soon come when such reductions can be observed by Ibuki and its successor satellites.

References

(1) "Climate Change 2007: Synthesis Report, Summary for Policymakers ", IPCC, 2007http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr_spm.pdf.

(2) World Data Center for Greenhouse Gases (WDCGG) Web Site, http://gaw.kishou.go.jp/wdcgg/wdcgg.html.
(3) JAXA's Ibuki website, http://www.jaxa.jp/projects/sat/gosat/index_e.html, 2009 .
(4) Kazuma Yamane, Metal Collar Biographies: The Global Warming Crisis, Shogakukan, Tokyo, 2006 (in Japanese).
(5) NIES Web Site, http://ab.cger.nies.go.jp/gem/moni-e/warm/Ground/st02_hsinfo.html

実用燃費向上の主役は自動変速機

Key Role of Automatic Transmissions in Improving Real-world Fuel Efficiency

内田　正明*
Masaaki UCHIDA

抄　録　エンジントルクとエンジン回転数の組み合わせを決定するのは自動変速機であり，実用燃費向上のために自動変速機が果たす役割は大きい．今回，燃費の良い運転の運転操作の解析に基づいて，エンジンと自動変速機を協調制御して運転者のエコ運転を自動的に支援する技術を開発した．複数の運転者で実用燃費改善効果を検証し，コンパクトカーの例で略 10% の実用燃費改善効果を確認した．

Summary　Automatic transmissions can play a key roll in improving the real-world fuel efficiency of vehicles because the combination of engine torque and engine speed is determined by the transmission. This article describes newly developed control technologies, based on analyses of fuel-efficient driving operations, for cooperatively managing the engine and AT so as to automatically support eco-driving. Tests were conducted with multiple drivers to validate the effect of these technologies on improving real-world fuel efficiency. Results obtained with a compact car indicated that they increased real-world fuel efficiency by approximately 10%.

1. はじめに

地球環境問題への対応と石油価格高騰に象徴されるエネルギー資源問題への対応のために，自動車からの CO_2 排出量の削減が急務である．自動車からの CO_2 排出量を効果的に削減するためには，ハイブリッド車や電気自動車などの電動車の開発および普及と，グローバル市場で当面多数を占める現行パワートレイン車の更なる燃費向上の双方が重要である．

本稿では，現行パワートレイン車の実用燃費向上技術について概説する．

2. トリプルレイヤーアプローチ

実用燃費向上技術開発は，トリプルレイヤーアプローチ（図 1）で推進されている．

2.1. Vehicle

一般的なガソリンエンジン車のパワートレインのエネルギー収支の例を図 2 に示す．ガソリンのエネル

1. Introduction

The task of addressing global environmental concerns and energy resource issues, symbolized by the sharp rise in oil prices, requires an urgent reduction of carbon dioxide (CO_2) emissions from vehicles. One effective approach to reducing CO_2 emissions from vehicles is to develop and popularize electrically powered vehicles such as hybrid vehicles and electric vehicles. An equally important approach is to further improve conventional powertrain vehicles that will continue to represent the vast majority of vehicles on the road in global markets in the foreseeable future.

This article outlines several newly developed control technologies for improving the real-world fuel efficiency of vehicles fitted with conventional powertrains.

2. Triple-layered Approach

Technologies for improving real-world fuel

* 日産自動車株式会社 パワートレイン開発本部（出向中）
Powertrain Engineering Division, Nissan Motor Co., Ltd.

ギーは，冷却損失，排気エネルギー，ポンピング損失，フリクション損失などで失われてしまう．これらの損失は，フリクションの低減とエンジン運転条件（所定の駆動出力を実現するエンジントルクとエンジン回転数の組み合わせ）の最適化によって低減できる．

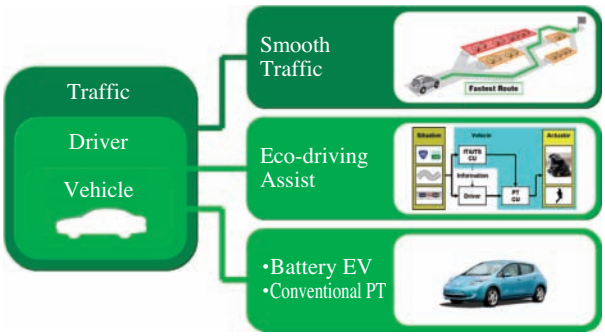


Fig. 1 Triple-Layered Approach for CO_2 reduction

自動変速機はアクセル操作量と車速に応じてエンジン回転数を決定する。したがって，運転者に要求された駆動力を実現するためのエンジントルクとエンジン回転数の組み合わせを決定するのは自動変速機であり，実用燃費向上のために自動変速機が果たす役割は大きい．

2.2. Driver

運転の仕方で燃費が大きく変動することは，よく知られている．日産自動車（株）は，エコ運転を啓蒙するためのサービスであるエコ運転アドバイスをナビゲーションシステムを介して提供している．図 3[1] にエコ運転アドバイスの燃費改善効果を示す．エコ運転によって燃費は大幅に改善している．このことから，燃費の良い運転の運転操作を再現するようにエンジンと自動変速機を制御することによって運転者のエコ運転を自動的に支援する技術を開発すれば，実用燃費向上のために極めて有効となることが分かる．

2.3. Traffic

国土交通省道路局によれば，日本全体で年間 10 兆円規模の経済損失が発生していると推定される．スムーズな交通の流れは実用燃費向上のためにも重要であり，図 4[1] に示すように平均移動速度を適度に保つことで燃費は大きく向上する．IT／ITS 技術を駆使してスムーズな交通の流れを実現するシステムの開発が重要である．

efficiency are being developed under a Triple-Layered Approach as outlined in Fig. 1.

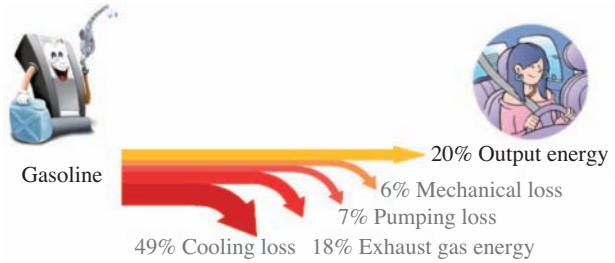


Fig. 2 Energy balance of a typical gasoline vehicle

2.1. Vehicle

An example of the powertrain energy balance of a typical gasoline engine vehicle is shown in Fig. 2. Much of the energy contained in gasoline is lost in the form of cooling loss, exhaust gas energy, pumping loss and mechanical friction loss. These losses can be reduced by reducing friction and by optimizing the engine operating conditions through a suitable combination of engine torque and engine speed for producing the desired driving force.

An automatic transmission (AT) determines the engine speed according to the amount of accelerator pedal depression and the vehicle speed. Accordingly, it is the AT that determines the combination of engine torque and engine speed for producing the driving force demanded by the driver. This means that ATs can play a major role in improving real-world fuel efficiency.

2.2. Driver

It is commonly known that fuel efficiency varies greatly depending on the driving style. As a service for educating drivers about eco-driving, Nissan Motor Co., Ltd. provides eco-driving tips through the in-vehicle navigation system. The effect of this eco-driving advice on improving fuel efficiency is shown in Fig. 3.[(1)] It is seen that eco-driving greatly improves gas mileage. These results indicate that the development of technologies for automatically supporting eco-driving could be very effective in improving real-world fuel efficiency. Such technologies would be designed to control the engine and the AT so as to reproduce fuel-efficient driving operations.

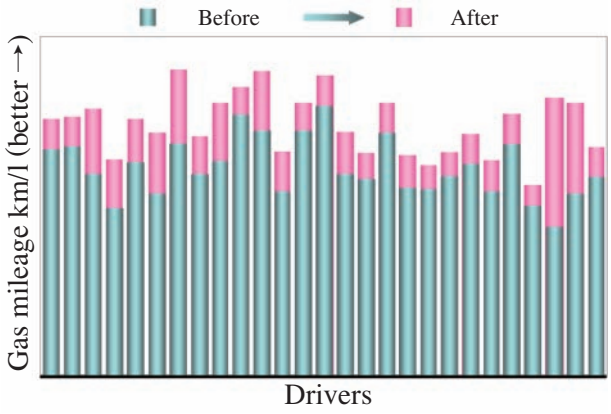


Fig. 3 Example of mileage improvement by eco-driving

3. 実用燃費向上技術の例

トリプルレイヤーの“人”に関わる実用燃費向上技術について述べる．以下に述べる実用燃費向上技術などを搭載した実験車両（コンパクトカー：1.5L ガソリンエンジン+CVT）を用いて，複数の運転者の実用燃費を検証した結果を図 5[2] に示す．多くの運転者が良好な実用燃費を実現することができ，平均で略 10% の実用燃費の向上が期待できる．

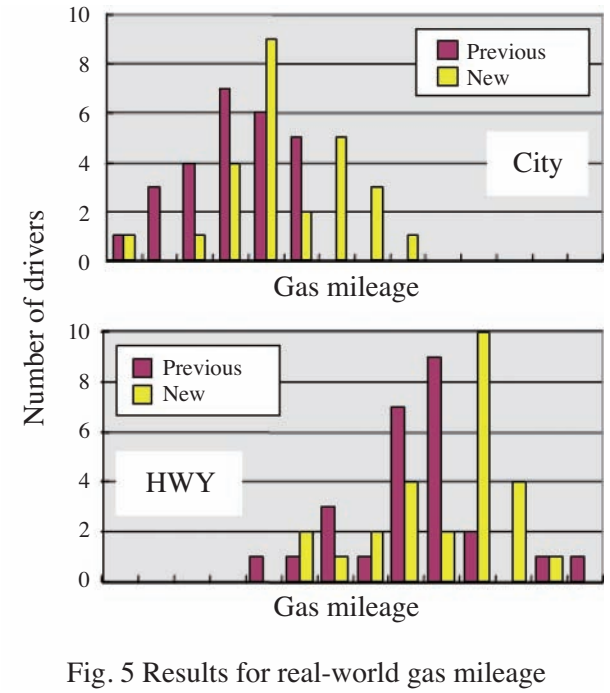


Fig. 5 Results for real-world gas mileage

3.1. スムーズ発進アシスト

発進時にエンジン回転数がオーバーシュートするような不要に強い加速をしなければ，燃費を向上することができる．そこで，アクセル操作に応じた必要十

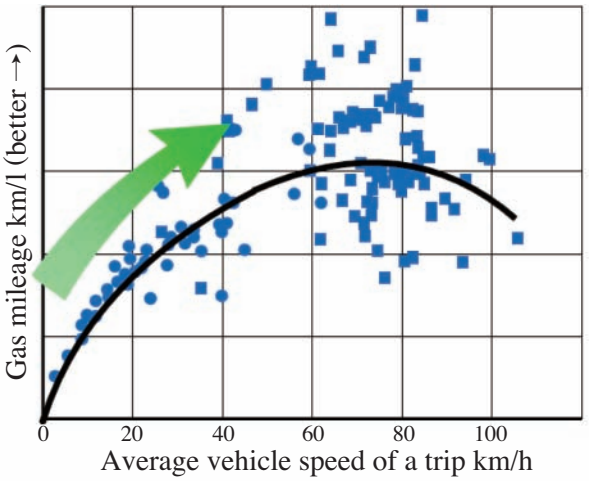


Fig. 4 An example of the relation between gas mileage and average vehicle speed of a trip

2.3. Traffic

According to the Road Bureau of the Ministry of Land, Infrastructure, Transport and Tourism, it is estimated that traffic congestion causes economic losses of around 10 trillion yen annually throughout Japan. Smooth traffic flows are an important factor in improving real-world fuel efficiency. The data in Fig. 4[(1)] show that fuel efficiency is markedly improved by maintaining a suitable average driving speed. It is important to develop systems that use IT and ITS technologies effectively to achieve smooth traffic flows.

3. Examples of Control Technologies for Improving Real-world Fuel Efficiency

This section describes control technologies for improving real-world fuel efficiency that pertain to the driver in the Triple-layered Approach. Figure 5[(2)] presents the results of driving tests conducted with a plurality of drivers to validate the real-world fuel efficiency obtained with the technologies described below. These technologies were incorporated in an experimental compact car fitted with a 1.5-liter gasoline engine and a CVT. Many of the drivers achieved excellent real-world fuel efficiency in the tests. It is estimated from the results that an improvement in real-world fuel efficiency of approximately 10% could be expected on average.

3.1. Smooth take-off assist

Fuel efficiency can be improved so long as drivers

分な発進加速を確保しつつ，自動的にスムーズな発進を実現できるようにエンジンの電制スロットルとCVTの変速比を協調制御して，実用燃費を向上させている（図6）．更に，走行時も不要なエンジン回転数の変動を抑制している．

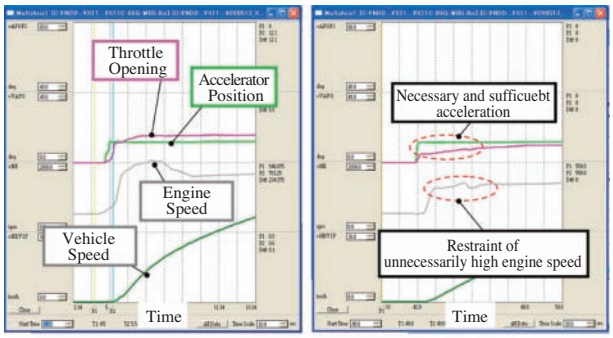


Fig. 6 Control for smooth take-off

3.2. 地図情報による変速比制御

燃費の良い運転者は，下り坂やカーブ手前や料金所手前などで上手にエンジンブレーキを使って速度をコントロールしている．この運転は，エンジンのフューエルカット時間を長くできるので燃費に良い．そこで，ナビゲーションシステムからの地図情報に基づいてCVTの変速比を制御して，自動的に適切なエンジンブレーキを実現させている（図7）．

4. まとめ

1） 自動車からの CO_2 排出量の削減のために，電動車の開発および普及だけでなく，現行パワートレイン車の更なる燃費向上が重要である．
2） 現行パワートレインの燃費向上のために，効率向上技術の開発だけでなく，エンジントルクとエンジン回転数の組み合わせを最適化する技術の開発が重要であり，自動変速機の果たすべき役割は大きい．
3） エンジンと自動変速機の協調制御によって運転者のエコ運転を自動的に支援できる技術を開発し，コンパクトカーの例で実用燃費を略10%向上した．

5. 参考文献

1） 二見　徹：SKYプロジェクトによるクルマと交通

do not accelerate unnecessarily fast when taking off, thereby causing an engine speed overshoot. A control system has been developed for cooperatively managing the engine's electronically controlled throttle and the CVT gear ratio to improve real-world fuel economy (Fig. 6). This control system automatically achieves a smooth vehicle launch while securing necessary and sufficient take-off acceleration matching the driver's accelerator input. Moreover, it also works to restrain unnecessarily high engine speeds during driving.

3.2. Gear ratio control using map information

Fuel-efficient drivers use engine braking skillfully to control their driving speed when traveling downhill, approaching a curve or coming to a tollgate, among other situations. This driving style is good for improving fuel efficiency because it extends the duration of fuel cut-off to the engine. A system has been developed for controlling the CVT gear ratio using map information obtained through the navigation system, thereby achieving suitable engine braking automatically (Fig. 7).

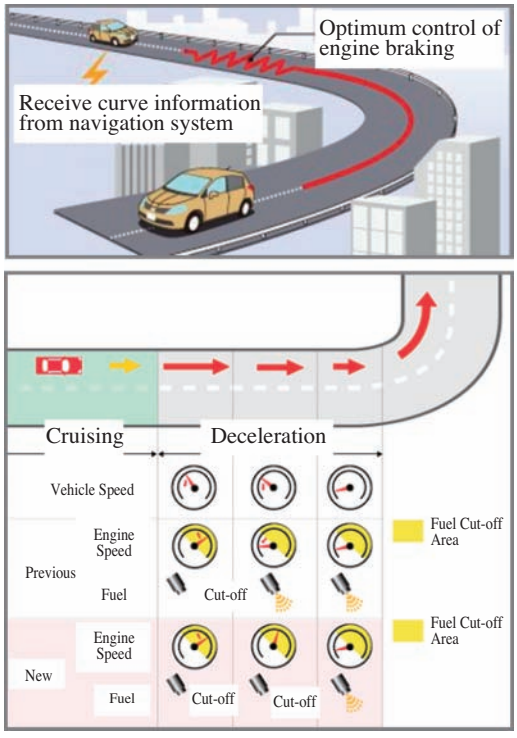


Fig. 7 CVT control with use of the information from a navigation system

社会の革新，日立μVALUEコンベンション2008
2) M.Uchida, Fuel Economy Improvement Technology in Nissan Automatic Transmissions, 2009 International Symposium on Transmission Innovation and China Market Development.

4. Conclusion

(1) Further improving the fuel efficiency of conventional powertrain vehicles is also an important approach to reducing CO_2 emissions from vehicles, in addition to developing and popularizing electrically powered vehicles.
(2) Besides developing technologies for improving powertrain efficiency, it is also important to develop control techniques for optimally combining the engine torque and engine speed so as enhance the fuel efficiency of conventional powertrains. Automatic transmissions can play a key role in improving real-world fuel efficiency.
(3) A system for cooperatively controlling the engine and AT has been developed as a technology for automatically supporting eco-driving. In tests conducted with a compact car, real-world fuel efficiency was improved by approximately 10%.

5. References

(1) T. Futami, Innovations in Vehicles and Mobility through SKY Project, uVALUE CONVENTION 2008 (in Japanese).

■ Authors ■

Masaaki UCHIDA

ジヤトコの環境への取組み

JATCO's Measures to Address Environmental Issues

常務
Senior Vice President
奥村　俊彦
Toshihiko OKUMURA

抄　録　近年，地球規模での環境変化である地球温暖化問題に対しては，従来以上の環境対応が重要となってきている．ジヤトコは企業活動を通じた環境対応を従来の活動を踏まえつつ，将来に向けた環境マネジメントシステムに基づいた取り組みを積極的に進めている．
本報では，取り組みの概要と今後の展望について報告する．

Summary　The issue of global warming, representing a worldwide environmental change, has made environmental measures more important than ever before in recent years. In line with our previous programs, JATCO is proceeding with vigorous efforts to address environmental concerns in all of our corporate activities based on a future-oriented environmental management system. This article outlines these efforts and describes the prospects for the future.

1. はじめに

ジヤトコは「お客様・クルマ文化・社会への価値の提供」を使命として掲げ，その企業活動を通じて，持続可能な社会の実現に貢献することを目指している．

ジヤトコはこれまで商品である自動変速機（ステップAT・CVT）の提供を通して，クルマ社会の発展に大きな役割を果たしてきた．しかし，クルマが地球環境に与える影響は決して小さくない．我々は事業活動全体において，環境に対する様々な影響に配慮し，その負荷を低減する責務を負っている．

今後も続く世界経済の発展と環境保護の両立は人類が挑戦すべき共通のテーマであり，ジヤトコはこの難題に挑戦し続けている．

2. ジヤトコの環境対応

弊社が提供する自動変速機は，エンジンと並ぶ基幹部品として，クルマ社会の発展に大きな役割を果たしてきた．近年では環境意識の高まりとともに，持続可能な社会実現に向け，その役割はさらに大きくなっている．

1. Introduction

JATCO's corporate philosophy defines the company's mission as "to provide value to our customers, to automotive culture and to society." Through our corporate activities we aim to contribute to the formation of a sustainable society.

To date, JATCO has contributed significantly to the development of the motorized society through the provision of our stepped AT and CVT products. However, the impact of vehicle use on the environment is definitely not insignificant. In all of our corporate activities, we consider the resultant environmental impact and bear the responsibility for reducing it.

The challenge of reconciling future global economic development with environmental protection is a common theme for all of humankind. At JATCO, we are continuing our vigorous efforts to meet this challenge.

2. JATCO's Environmental Measures

The ATs that JATCO provides have greatly helped to advance the motorized society in their role as a core vehicle component that ranks alongside the

地球環境に対し，燃費性能改善に貢献できる変速機を継続的に開発し，提供していくことが重要である．これにより，燃費が向上し，クルマから排出される CO_2 排出量は削減され地球温暖化防止に大きく貢献できることになる．中でも，その燃費性能の良さから注目を集めている CVT の分野において，ジヤトコはトップランナーとして業界をリードしてきている．

3.5L クラスに対応する唯一のベルト式 CVT や世界最大の変速比（7.3）を誇る副変速機つき CVT など世界初への挑戦を続けている．

ジヤトコは，軽乗用車から大型乗用車までをカバーする世界で唯一の CVT フルラインナップメーカーとして，CVT の世界生産台数に占めるシェアでは 40％以上の業界トップを維持している．

今後もその専門領域を更に強化するために，性能向上のための研究開発やエンジンとの協調制御の最適化，ユニットの小型軽量化，ハイブリッド車用ユニットの開発など，燃費向上と快適な走りの提供に貢献するあらゆる技術開発を継続していく．

また，環境対応は商品のライフサイクル全体での環境影響を最小にするために，それぞれのサイクルやプロセスでの影響度を正しく把握し，全体最適の視点で取組んでいくことが重要である．

生産面では，2006 年からはジヤトコ メキシコ社で，今年は中国の生産拠点ジヤトコ（広州）自動変速機有限公司でも CVT の生産を開始し，環境に優しいクルマ社会の実現のために，世界の CVT の需要に応える供給体制も整備している．「環境に優しい商品は環境に優しい工場から」の信念から，これまでも積極的に取り組んでいる．

グリーン調達の実施や物流のモーダルシフト，省資源・省エネルギー工法の導入など，事業活動におけるさまざまな環境保全への取り組みについても，事業のグローバル化に伴い，海外拠点と一体となった活動を推進していく．

engine. The role of ATs has become even greater in recent years in connection with the building of a sustainable society accompanying heightened environmental awareness. It is essential for us to continue to develop and provide transmissions capable of contributing to global environmental protection by improving vehicle fuel economy. As a result of enhancing fuel economy, CO_2 emissions from vehicles will be reduced, which will contribute significantly to curbing global warming. In this regard, CVTs have attracted much attention for their excellent fuel efficiency. JATCO has been an industry leader in the CVT field as a top supplier of CVTs.

JATCO supplies the only steel-belt CVT capable of being used on 3.5-liter class vehicles, as well as a recently developed CVT that features an auxiliary transmission and boasts the world's highest gear ratio (7.3:1). We are continuing the challenge of developing world-first technologies.

JATCO is the world's only CVT manufacturer that offers a full lineup of CVTs covering the entire spectrum of vehicle models from minicars to large-size vehicles. We continue to rank as the industry's top CVT manufacturer, accounting for a 40% share of the global CVT production volume.

We are steadily moving ahead with the development of technologies that can contribute to providing both improved fuel economy and driving pleasure in order to further strengthen our position in this specialized field in the future. This includes R&D efforts for enhancing performance, optimizing cooperative engine-transmission control, downsizing and lightening CVTs and developing transmissions specifically for hybrid vehicles, among other activities.

Our environmental measures are intended to minimize the environmental impact throughout the entire product life cycle. That makes it important to grasp accurately the degree of impact occurring in each cycle and process and to undertake efforts from the standpoint of achieving overall optimization.

In the area of manufacturing, we launched CVT production at JATCO Mexico, S.A. de C.V. in 2006 and also at JATCO (Guangzhou) Automatic Transmission Ltd., our local production center in China, in 2009. JATCO has been building a CVT supply system to meet the global demand for CVTs in

3. ジヤトコの環境マネジメントシステム

環境マネジメントシステム（EMS）の推進体制としては，Fig. 1 の通り，環境管理責任者 12 名，実務運営責任者 12 名を設け，環境管理責任者の責任と権限のもと，EMS の推進を行っている．また，当社全体の EMS 推進は，環境統括責任者 1 名，生産部門担当執行役員及び総務部担当執行役員，環境管理責任者による環境統括委員会で，総合的に審議と評価，そしてフォローをする体制をとっている．この様に複数の事業所と開発機能をはじめ各機能を共通の EMS を運用することで企業としての環境への取組みのベクトルを一元化し，強力に推進していることが大きな特徴である．

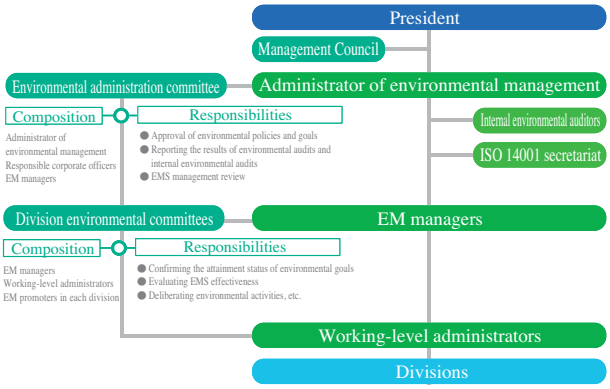


Fig. 1 Organization for promoting EMS

ジヤトコの環境活動は，環境委員会を各地区に設置し，その地域に合った環境活動を実施している．

また，Fig. 2 の様に各地区での活動の PDCA（サブ EMS スパイラル）と全体的活動の PDCA（メイン EMS スパイラル）の 2 つの PDCA サイクルを相互に連動させて，各取り組みの方向性を統一し，より効果的で有効な活動となるように継続的な改善を行っている．

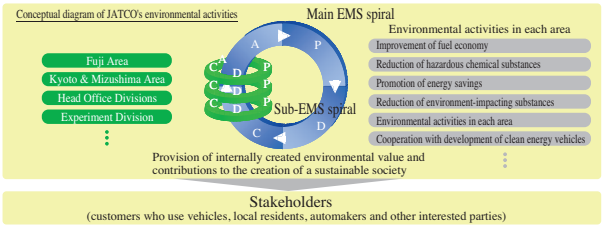


Fig. 2 Interaction of two PDCA cycles

order to contribute to the creation of a motorized society friendly to the environment. We are consistently promoting these vigorous activities in line with our principle of "providing eco-friendly products from eco-friendly plants."

Various efforts are under way to protect the environment in our business operations, including green purchasing, a modal shift in logistics and the implementation of methods for saving resources and energy. As our business continues to expand globally, we will strive to promote these same efforts through close teamwork with our overseas operations.

3. JATCO's Environmental Management System

JATCO's internal structure for promoting our environmental management system (EMS) is outlined in Fig. 1. Twelve managers are responsible for environmental management and twelve administrators are in charge of the working-level administration of the EMS program. EMS activities are promoted under the clearly defined responsibilities and authority of these employees charged with environmental management. There is also an environmental administration committee that comprehensively deliberates and evaluates the company-wide promotion of the EMS program and follow-up activities. The committee consists of one overall administrator of environmental management, the corporate officers overseeing the production division and the general administration department, and the managers responsible for environmental management. This provides a framework for operating a common EMS in all corporate functions, including multiple manufacturing departments and research and development areas. A major feature of our EMS is that we can set a unified vector for our environmental activities as a company and promote them vigorously.

An environmental committee has been established in each area where JATCO has facilities and each committee undertakes environmental activities matching its own area. Figure 2 illustrates the interaction between two PDCA (plan, do, check, act) cycles. One is a sub-EMS spiral of activities in each area, and the other is a main EMS spiral of overall activities. This enables us to unify the direction of

この様な一貫した環境マネジメントを行うことで，ステークホルダーへ環境価値を創造し，提供することを目指している．これらの活動により持続可能な社会の実現に向け，ジヤトコが果たすべき役割だと考えている．

そして，2008 年度に新たに中長期の環境戦略を検討する組織として，環境企画分科会を設置した．EMS 推進体制が，サイト・機能毎の短期的な環境マネジメントを行うのに対し，環境企画分科会は，大きく変化する社会情勢や上位方針等を受け，ジヤトコが取るべき環境の中長期戦略を企画・推進していくことを目指している．

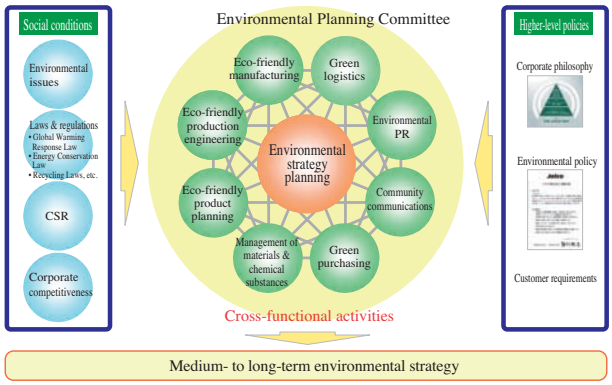


Fig. 3 Role of the Environmental Planning Committee

商品開発や生産，調達等の事業活動ごとに 8 つの機能に対し，少分科会を設け，全体マネジメントすることにより，従来の単独での活動になりがちな各機能軸が相互に連携しながら，全体最適の視点で企画・マネジメントをすることが可能となった．

特に，環境企画分科会では，我々が環境最重要課題としている「地球温暖化防止」,「環境保護」,「資源の有効活用」の 3 つの分野での取り組みを強化している．

また，海外拠点での環境活動の企画・マネジメント等も支援を積極的におこなっていく．

これらの環境マネジメントを通して，グローバルジヤトコとして，総力を挙げて，その商品や事業活動を通じて創り出す価値のすべてを『お客様・クルマ文化・社会』に提供していく．

each activity and make continuous improvements so as to achieve more efficient and effective activities.

By carrying out this type of integrated environmental management, we aim to create and provide environmental value to our stakeholders. These environmental activities are regarded as the role that we should discharge in working toward the formation of a sustainable society.

In fiscal 2008, an environmental planning committee was newly formed as an organization for examining the company's medium- to long-term environmental strategy. The structure for promoting the EMS program undertakes short-term environmental management at each site or in each function. In contrast, the aim of the environmental planning committee is to plan and promote the medium- to long-term environmental strategy that JATCO should pursue, taking into account significant changes in social conditions, higher-level policies and other factors (Fig. 3).

A sub-committee has been formed in each of the company's eight functions, including product development, manufacturing and purchasing. This structure for executing overall management ensures mutual collaboration between each function, whereas previously there was a tendency for each one to promote activities independently. It is now possible to undertake environmental planning and management from the perspective of overall optimization for the entire company.

It is especially noteworthy that the environmental planning committee has strengthened our efforts in the three areas that we regard as our top environmental priorities, namely, the prevention of global warming, environmental protection and effective utilization of resources.

Vigorous support is also provided for the planning and management of environmental activities at JATCO's overseas operations.

This environmental management system enables us to mount concerted efforts to address environmental issues throughout JATCO's global organization. All the value that we create through our products and corporate activities is provided to our customers, automotive culture and society.

4. おわりに

以上，当社の環境への取り組みのアプローチの方向性について紹介したが，これからもジヤトコは地球環境に配慮ある技術をさらに進化させ，「よいモノづくり」を通じて，さまざまなステークホルダーへの価値を提供することにより，クルマと環境が共生できる社会の実現に挑戦していくことを約束する．

4. Conclusion

This article has described the objectives and approaches we are pursuing in our environmental activities at JATCO. We will continue to further advance our technologies friendly to the global environment in the future and strive to provide value to our various stakeholders through JATCO's fine monozukuri operations. In this way, we are committed to the challenge of building a society where vehicle use is in harmony with the environment.

究極の変速機を目指した技術開発

Technological Development aimed at Ultimate Transmissions

平工　良三*
Ryozo HIRAKU

抄　録　近年特に, 自動変速機の技術は, 環境性能向上に対して非常に重要な役割を担っている. 本稿では, 我々の, 環境対性能向上に対する究極の変速機を目指す方向性と, その次のステップに向けた考え方を概説する.

Summary　Automatic transmission technology has played a key role in improving vehicle environmental performance, especially in recent years. This article outlines the direction of our efforts aimed at achieving ultimate transmissions for improving environmental performance and some ideas toward the next step in this process.

1. 究極の変速機へのロードマップ

近年自動変速機は, 多段化や無段化などに伴い, 飛躍的な進化を遂げ, クルマの環境性能向上において, 非常に重要な役割を担っている. しかし, 自動変速機の技術は未だ更なる進化の途中であり, 環境対応の観点でもパワーソースと同様に, 将来に渡って極めて重要な技術と言える.

クルマにおける変速機の機能は, エンジンやモーターなどのパワーソースが発生した運動エネルギーを無駄なく要求される回転とトルクに変換して車軸まで伝えることである. この機能の優劣は, 大きく括ると2つの軸で表現できる. [1] 1つめの軸は, 動力を如何に効率良く伝達するか, という Efficiency (効率) の軸. そしてもう一つは, 如何に自由に回転とトルクを変化させる (変速) ことができるか, という Flexibility (自由度) の軸である. 変速機の Flexibility が低いと, エンジンを最適な効率で運転することが難しくなり, クルマとしての効率 (＝燃費) が悪くなる.

変速機は多段化すると Flexibility は増加するが, 要素数が増え機構が複雑になるため何の工夫も無ければ Efficiency は低下する. この事からも分かるように, 両軸は一般的にはトレードオフの関係にあると考えられる.

より良い性能を実現するためには, どちらの軸も磨

1. Roadmap to Ultimate Transmissions

Automatic transmissions have made dramatic progress in recent years by reason of the addition of more steps or the attainment of continuously variable gear ratios. They now play a crucial role in improving the environmental performance of vehicles. However, automatic transmission technology is still evolving and, will continue to be a key element in meeting environmental performance requirements like power source systems, in the years ahead.

The function of an automotive transmission is to efficiently convert the kinetic energy produced by the engine, motor or other power source to the required rotational speed and torque and transmit it to the drive axle. The relative performance of a transmission can be broadly represented by two axes. [(1)] One axis is for efficiency in terms of how efficiently it transfers motive power. The other axis is for flexibility in terms of how flexibly it can change the rotational speed and torque, i.e., shift-change. Low transmission flexibility makes it difficult to operate the engine at optimum efficiency, which worsens the vehicle's fuel economy.

Adding more steps increases the flexibility of a transmission, but it also results in a more complicated mechanism because of the larger number of elements

* 先行技術開発室
Advanced Technology Development Department

き上げることが重要であるが, それぞれの重要度合いは組み合わせる車両や市場の走行パターンによって異なる. 概ね, コンパクトカーを日本市場のように低速の加減速が多い条件で走らせるなら Flexibility, 駆動力に余裕を持って中高速をクルージングするなら Efficiency が比較的より重要となる傾向にある.

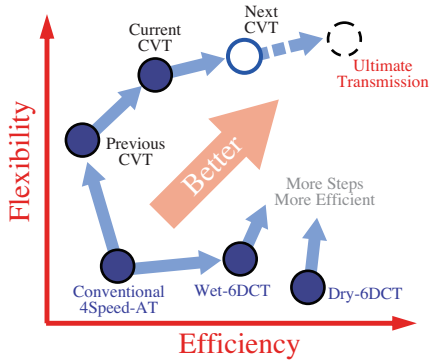


Fig. 1 Road map to the Ultimate Transmission[1)]

世界中には, 多くの種類の自動変速機が存在するが, Flexibility と Efficiency の両面で他を圧倒する自動変速機は今のところ存在しない. CVT (Continuously Variable Transmission) は両軸のうち, Flexibility を究極に追求した技術, 一方, DCT (Dual Clutch Transmission) をはじめとする MT (Manual Transmission) ベースの自動変速機は, Efficiency を優先して磨き上げた技術と解釈できる. もし, 両軸を同時に高いレベルに到達させる事ができれば, 求められる機能を完全に果たす究極の変速機となる.

我々の技術開発のロードマップは, CVT の Efficiency を極限まで磨き上げ, 究極の変速機を目指している. CVT は遊星ギア式の自動変速機や MT に比較すると, まだ歴史の浅い技術であり, これから技術開発によって, 格段に Efficiency が向上するポテンシャルをもっている。一方, MT ベースの変速機は Efficiency には優れているが, どうしても Flexibility の向上には限界があることを考えると, 我々の CVT 技術は, 最も究極の変速機へ近い技術と認識している.

2. 究極はゴールではない

さらなる環境性能向上に貢献するため, 究極の変速機を実現することは我々の大きな目標である. それでは, この究極を達成すれば我々の技術開発は完了

used. Therefore, unless some innovative measure is taken, efficiency will decline. As this example makes clear, the two axes of transmission performance generally involve a trade-off.

It is essential to refine both axes in order to achieve higher performance. The degree of importance of each axis, though, differs depending on the mating vehicle and the driving patterns found in the targeted market. Generally speaking, flexibility tends to be relatively more important for compact car use under driving conditions that involve frequent acceleration/deceleration at low speed, which is the case in Japan. On the other hand, efficiency tends to be relatively more important in vehicle applications involving cruising at medium to high speeds with ample power in reserve.

While there are many types of automatic transmissions in use around the world, there has yet to be one that is overwhelmingly superior to others in terms of both flexibility and efficiency. The continuously variable transmission (CVT) is a system that pursues ultimate flexibility. In contrast, the dual clutch transmission (DCT) and the automated manual transmission are built with technologies that give priority to improved efficiency. If high levels could be achieved for both axes simultaneously, it would result in the ultimate transmission capable of discharging both required functions perfectly.

Our roadmap for technological development has been aiming at achieving ultimate transmissions by enhancing the efficiency of CVTs to the utmost level. CVT technology has a much shorter history compared with planetary-type automatic transmissions and manual transmissions. CVTs have the potential for a marked improvement in efficiency through further technological development. While automated manual transmissions have excellent efficiency, improvement of their flexibility is invariably limited. Considering these characteristics, we see our CVT technology as being the shortest technical path to ultimate transmissions.

2. The Ultimateness is not the Final Goal

Achieving ultimate transmissions that can contribute to the further improvement of environmental performance is our major target. If the

するのだろうか?答えは当然 NO である. 技術の進化に終わりは無い.

技術進化の S 時カーブ※ (Fig. 2[2] 参照) を考えると, 究極とはある技術の限界とも言える. 即ち, 究極が見えたなら, その次のステップを考えなくては, さらなる性能向上は期待出来ないと言うことを意味している.

その次のステップとは, どのように見出されるのだろうか.

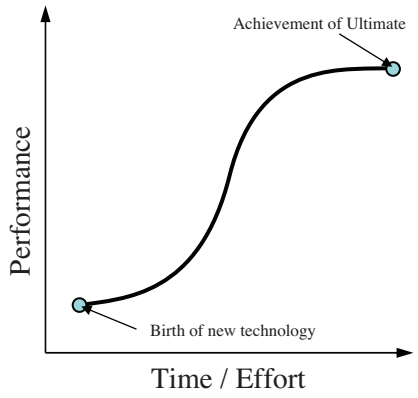


Fig. 2 S-curve of technological evolution[2]

The S-curve of technological evolution is a theory that posits a new technology in the initial stage shows a slow rate of progress in improving performance. Once the technology is better understood and widely diffused, the rate of performance improvement accelerates. However, in its mature stage, the technology gradually approaches its physical limit and the rate of improvement in performance slows down.

究極を目指す技術開発の目標や方向性は, 他社調査やベンチマークなどの分析から決めていくケースが多かったが, その手法は突然通用しなくなる可能性がある. すなわち, 次のステップの技術は多くの場合, 前のステップを極めたレベルより, 低い性能で誕生してくる事が多いと言う事である. (Fig. 3 参照)

しかしそれは, 全く関係のないところから何かが誕生する, ということではない. 多くの場合,「革新技術は決してゼロから起きない. これまでの技術の蓄積があって初めて実現する.」[4] と考えられる. すなわち, 究極を目指す技術開発を通して, 多少効率が悪くても, その次のステップに繋がる可能性のある技術を注意深く新たな視点で見出す必要がある.

先ずは, 新しい機能と評価軸の登場を見極める必要があろう.

ある種の回生機能は変速機に求められるかもしれない. Hybidization を考慮したモーターとの親和性は重要な要素になるであろうし, 可能性は他にもある.

ultimate transmission is achieved in terms of efficiency and flexibility, does that mean the completion of our technological development efforts? The obvious answer to this question is No, because the evolution of technology never ends.

In line with the S-curve of technological evolution in Fig. 2,[(2)] ultimateness can be regarded as the physical limit of a certain technology. This means that if the ultimate limit is visible, then one must think about the next step, otherwise no further improvement in performance can be expected. The question is how to discover what the next step is.

The targets and direction of technological development programs aimed at achieving the ultimate level of something have often been determined on the basis of surveys of other companies, benchmarking and various types of analyses. However, that approach entails the possibility of suddenly becoming invalid. The reason is that the technology of the next step often has a lower level of performance initially than the height of the performance attained in the previous step (Fig. 3).

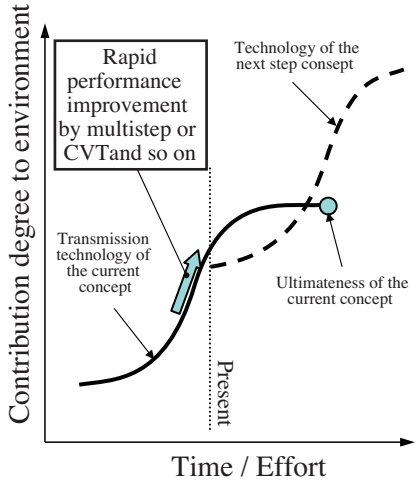


Fig. 3 Ultimatenessand the next step

However, it does not mean that something new will appear from somewhere that is totally unrelated. In many cases, it is considered that "technological innovation does not occur from zero; it is achieved only because technologies have been accumulated up to that point."[(4)] In short, in any effort to develop the ultimate technology, it is necessary to examine a certain candidate closely from a new perspective that considers the possibility that it might lead to the next

究極の変速機という目標を掲げながら, 現在の“変速機”という概念に捕らわれることなく, 技術開発を通して, 新たな視点を加えながら, 次のステップの新たな可能性を提案していきたい.

そして, 明日もその先も, 環境対応を含めた社会に必要とされる技術で貢献し続けることが, 我々の使命と認識している.

3. 参考文献

1) Ryozo Hiraku, Strategic development target for transmissions, 7th International CTI-Symposium Innovative Automotive Transmissions, (2008).
2) Clayton M.Christensen,伊豆原弓 訳:イノベーションのジレンマ The Innovator's Dilemma, p.72, 翔泳社 (2001)
3) 亀岡秋男:「技術経営 (MOT) のパラダイムシフト」, 研究技術計画学会誌 Vol.12 1／2, p.8-25, (1997)
4) 馬渕浩一:「技術革新はどう行われてきたか」, 日外選書 (2008)

step, even though its efficiency may be somewhat poor at present.

As the first step, it is necessary to discern a new function and the criteria for evaluating it. For example, some type of energy recovery function may be needed for a transmission. The affinity with the motor, taking into account hybridization, may be a critical element here, or there may be still other possibilities that should be examined as well.

In the course of aiming to achieve ultimate transmissions, it is essential not to be bound by existing concepts of automotive transmissions. Rather, it is desirable to add new perspectives to technological development activities and propose various new possibilities for the next step.

It is our recognized mission to continue contributing the technologies required by society tomorrow as well as in the future, including the necessary environmental performance.

3. References

(2) Clayton M. Christensen, The Innovator's Dilemma, Japanese translation by Yumi Izuhara, Shoeisha, Tokyo, p. 72, (2001).
(3) Akio Kameoka, "Paradigm Shift in Management of Technology (MOT)," Journal of The Japan Society for Science Policy and Research Management, Vol. 12, 1/2, pp. 8-25, (1997) (in Japanese).
(4) Koichi Mabuchi, How is Technological Innovation Achieved?, Nichigai Sensho, Tokyo, 2008 (in Japanese).

■ Authors ■

Ryozo HIRAKU

モノづくりを通じた環境対応

JATCO's Production Measures to Address Environmental Issues

常務　黒沢　実
Senior Vice President　Minoru KUROSAWA

抄　録　現在，クルマの環境性能に新たな期待と注目される中，加速性・快適性・安全性のみならず，燃費にも貢献する基幹部品としてトランスミッションの役割はこれまで以上に大きなものとなっている．ジヤトコは，環境性能の高いトランスミッションの開発と供給を通じて，クルマと環境が共生できる社会の実現を目指している．
本報では，環境に優しいクルマ社会の実現に向け，「環境に優しい商品は環境に優しい工場から」の信念のもとでのモノづくりにおける環境への取組みの概要と今後の展望について報告する．

Summary　The environmental performance of vehicles is currently the focus of new expectations and attention. In this context, the automotive transmission has a larger role to play than ever before as a core vehicle component, contributing not only to acceleration performance, comfort and safety but also to fuel economy. By developing and providing transmissions with excellent environmental performance, JATCO aims to contribute to the formation of a society where vehicle use is in harmony with the environment.
Our philosophy regarding the promotion of a motorized society friendly to the environment is that "eco-friendly products come from eco-friendly plants." This article outlines our efforts to address environmental issues in JATCO's monozukuri (i.e., manufacturing) operations in line with this principle and the prospects for the future.

1. はじめに

ジヤトコは「お客様・クルマ文化・社会への価値の提供」を使命として掲げ，その企業活動を通じて，持続可能な社会の実現に貢献することを目指している．

ジヤトコの提供する自動変速機（AT・CVT）はエンジンと並ぶクルマの基幹部品として，クルマ社会の発展に大きな役割を果たしてきた．しかし，クルマが地球環境に与える影響は決して小さくなく，我々は事業活動全体において，環境に対する様々な影響に配慮し，その負荷を低減する責務を負っている．今後も続く世界経済の発展と環境保護の両立は人類共通のテーマであり，ジヤトコはこの難題に挑戦し続けている．

1. Introduction

At JATCO, our stated mission is "to provide value to our customers, to automotive culture and to society." Through our corporate activities, we aim to contribute to the creation of a sustainable society.

The automatic transmissions (ATs & CVTs) that we provide as our products have helped substantially to advance the motorized society in their role as a core vehicle part, ranking alongside the engine. However, the environmental impact of vehicle use is by no means inconsequential. In all of our corporate activities, we consider the resultant effects on the environment and assume the responsibility for lessening their impact. Reconciling global economic development with environmental protection will continue to be a shared task for humankind in the years ahead. At JATCO, we are continuing the challenge of addressing this difficult issue.

2. モノづくりの考え方

当社は高品質（Quality），低コスト（Cost），短納期（Delivery）における世界 No. 1 のモノづくりを目指している．ジヤトコの生産方式 JEPS（Jatco Excellent Production System）は，『素材仕上～加工～組立～出荷』までの各工程が一本のラインと同じ様に同じスピード，同じ順序でタイムリーに生産，運搬する，一切無駄のないモノづくりのシステムである．

■ JEPS の狙い

JEPS での狙いは，サプライヤーチェーン全体での「2つの限りない」を特徴としている．

1）限りないお客様への同期

お客様が求める価値を重視した品質の同期・ムダの徹底排除によるコストの同期・お客様にお届けする時間を同期すること．

2）限りのない課題の顕在化と改革

モノづくりのありたい姿と現状のギャップを認識し，表に出しにくかった悪さを見える化し，積極的に改善していくこと．この 2 つを追求し，製造や支援プロセスの有効性と効率を高めると同時に，資源の枯渇を予防し，CO_2 排出量の削減を目指している．

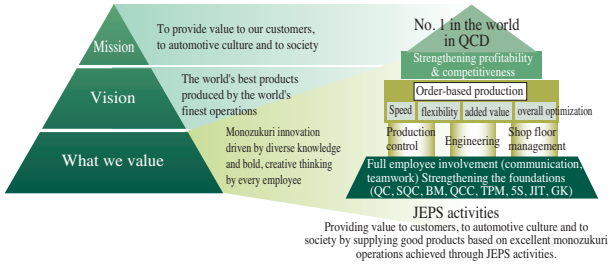


Fig. 1 Conceptual overview of JEPS activities

3. モノづくり現場における省エネルギー・省資源活動

1）全員参加による省エネルギー活動

各製造事業所では CO_2 削減の為，省エネルギーに向けた様々な取組みを進めている．特に省エネルギー活動は Fig. 2 に示す様な 6 つのステップにより進めている．

2. Concept of Monozukuri

JATCO aims to have the world's finest monozukuri operations in terms of providing high quality, low cost and short delivery times. Our Jatco Excellent Production System (JEPS) is a completely waste-free monozukuri system in which every process from casting and forging to machining, assembly and shipment proceeds at the same speed and in the same sequence just like one integrated line. This enables production and transport operations to be carried out in a timely manner.

■ Objectives of JEPS

The objectives of JEPS are characterized by two endless pursuits throughout the entire supplier chain.

1) Endless synchronization with the customer

This includes synchronization of quality that emphasizes the value sought by the customer, synchronization of cost through thoroughgoing elimination of waste, and synchronization of the time of product delivery to the customer.

2) Endless efforts to uncover issues and implement reforms

This involves recognizing the gap between the desired monozukuri condition and the present situation, visualizing unsatisfactory aspects not conducive to representation in charts, and vigorously undertaking improvements.

The efforts made in these pursuits enhance the effectiveness and efficiency of our manufacturing operations and support processes. Simultaneously, they are also aimed at preventing the depletion of resources and the reduction of CO_2 emissions.

3. Activities to Save Energy and Resources in Monozukuri Workplaces

1) Energy-saving activities based on full employee involvement

Each manufacturing department is proceeding with various activities to save energy in order to reduce CO_2 emissions. Specifically, energy-saving activities are promoted in a series of six steps, as outlined in Fig. 2.

The first step is to ascertain accurately the energy

(1) Ascertaining the energy balance	Ascertaining from the energy flow of the facilities the amount of energy effectively used to produce the final product
(2) Improving facilities	Implementing measures to improve the facilities so as to reduce ineffective energy consumption
(3) Manufacturing with minimal energy input	Manufacturing with minimal energy input by reducing ineffective energy consumption
(4) Process design	Designing processes that eliminate ineffective energy consumption
(5) Developing new methods	Developing new methods that reduce both ineffective and effective energy consumption
(6) Designing and developing new products	Designing and developing new products that do not require the use of energy during production

<< Areas for which priority activities are needed in the future >>

Fig. 2 Steps involved in energy-saving activities

まず，第一に設備のエネルギー収支を正しく把握し，最終的に製品に対して有効に使われた量を管理すること．第二に無駄に使用された部分を徹底して改善していく．第三のステップが最も大きな効果を挙げることができる最少のエネルギーで生産をする活動である．

これには従来，省エネルギー活動とは別な活動と考えられている品質対策，生産性向上や生産体制といった活動を省エネルギー活動と関連づけて活動を行っている．(Fig. 3)

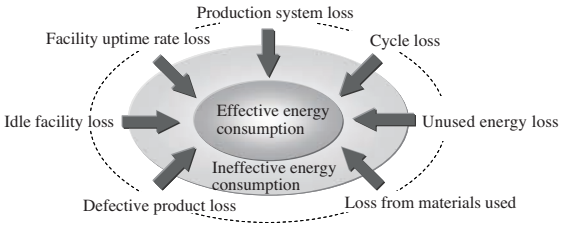


Fig. 3 Energy savings achieved through optimum monozukuri operations

つまり，従来のケチケチ活動を中心とした省エネルギー活動から，モノづくり活動の徹底した最適化を進めていくことが重要である．この様な JEPS 活動を中心とした徹底したモノづくりの有効性と効率化の向上によって，売上高当りの CO_2 排出量原単位の継続的な減少に繋がっている．(Fig. 4)

2) 再資源化率の向上

生産活動に伴い，産業廃棄物はもとより，解体鉄屑や切り粉，残材など色々な種類の不要物が発生する．これらのすべてを，焼却・埋立て処理するのをやめ，サーマルリサイクル（燃料化）やマテリアルリサイクル（再生利用）出来るよ

balance of the facilities and to manage the amount used effectively to produce the final product. The second step is to make improvements to thoroughly eliminate any portion used ineffectively. The third step is to manufacture with minimal energy input, which is the activity that yields the greatest benefits.

Previously, it was thought that activities involving quality measures, productivity improvements and the production system were separate from energy-saving efforts. Carrying out these activities in tandem with efforts to save energy can result in optimum energy conservation in monozukuri operations, as shown in Fig. 3.

In other words, it is essential to shift from conventional energy-saving activities centered on ways of using energy sparingly to the promotion of thoroughgoing optimization of monozukuri operations. Exhaustive efforts to improve the effectiveness and efficiency of our monozukuri operations through these JEPS activities are leading to a continuous reduction of the basic unit of CO_2 emissions relative to the company's net sales (Fig. 4).

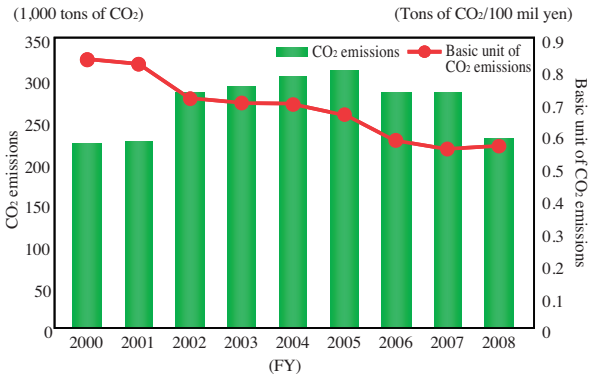


Fig. 4 Change in basic unit of CO_2 emissions relative to net sales

2) Improvement of recycling rate

In the course of carrying out production activities, various kinds of unneeded things are generated, such as scrap iron, chips from machining processes and leftover materials, in addition to industrial waste. We have stopped incinerating and sending such things to landfills altogether; instead, we are working closely with many waste recyclers to facilitate thermal recycling into fuel

うに，多くの廃棄物処理企業と連携しながら，再資源化を進めている．また，さらに廃棄物をより有効な資源として回収できるよう，分別を徹底して進めたことで 2009 年度 5 月に再資源化率 100% のゼロエミッションを達成した．

4. 環境対応技術力の強化

当社では，開発・設計から素材成形，加工，熱処理，組立，検査，ユニット完成まで一貫生産を行っている．　そこで，このメリットを生かし，新しいユニットの開発段階では，全ての工程でエネルギー及び資源のインプットとアウトプットを最小化するための取り組みを行っている．

具体的には，①バーチャルツールを用いた V-3P* 活動による開発リードタイムの短縮，試作の極小化，②製造段階で必要なエネルギー及び資源を最小化するための設計，工法開発及び工程計画，③排出されるエネルギー・資源を回生・回収し，再利用できるエコプラント計画などがそれである．

①ではバーチャルツールを用いることにより，コンピュータ上で組立時の部品の干渉，工場計画などが可能となり，従来は試作を実施しなければ分からなかった範囲でも検証が出来るようになっている．

*V-3P：Value up Innovation of Product Process Program

②ではチップレス，加工レス，熱処理レスを最終到達点とした工法開発を実施しているほか，現行工程を如何に短縮・削減するかという視点で設計，工程計画を実施している．

③では熱処理での廃熱の利用，自然エネルギーの利用など新たな試みを初めており，今後，さらに加速する商品のエコ化に合わせて，工場・工程もエコにすることで日本でしか出来ないモノづくりを目指していく．

以下に最近の適用事例を紹介する．

1）小型・軽量箱物部品採用による CO_2 削減

2008 年度新たに発表した次世代 CVT では，小型・軽量の箱物部品を採用した．同機種の開発には，開発当初より製品開発部門と生産技術部門が共同で『生産設及び生産限界で決まる一般肉厚部を薄肉化することで，従来の同クラスの CVT に比

and material recycling into reusable resources. Moreover, we are promoting complete sorting of waste so as to recover reusable resources more effectively. As a result, we achieved a 100% recycling rate with zero emissions in May 2009.

4. Strengthening of Eco-friendly Technological Capabilities

JATCO carries out integrated manufacturing from design and development to casting/forging, machining, heat treatment, assembly, inspection and completion of fully assembled units. In order to capitalize on the advantages of this system, we make concerted efforts at the development stage of a new transmission to minimize inputs and outputs of energy and resources in all processes.

Specific examples of these efforts include: (1) Reducing development lead time and minimizing trial production work through V-3P* activities using virtual tools; (2) Development of design/manufacturing methods and process planning so as to minimize the quantities of energy and resources needed at the manufacturing stage; (3) eco-friendly plant planning that allows emitted waste energy and resources to be recovered, recycled and reused.

The use of virtual tools in (1) above makes it possible to perform various jobs on the computer screen, such as plant planning and checks for part interference in assembly operations. This facilitates validation even of aspects that could not be known previously without conducting production trials using physical models.

*V-3P : Value-up Innovation of Product, Processd and Program

With regard to (2) above, we are developing manufacturing methods with the ultimate goal of eliminating chips, machining processes and heat treatment procedures. In addition, we are also designing and planning processes from the perspective of how to shorten or eliminate existing processes.

As for (3) above, we have launched new initiatives such as using the waste heat from heat treatment processes and the use of natural energy sources. Moreover, along with further accelerating the eco-friendliness of our products in the future, we intend to make our plants and processes eco-friendly as well.

べ 22% の軽量化を実現した．これにより，車両燃費の向上はもとより，当該部品生産時の CO_2 排出量も大幅に低減され，年間約 300t を削減することが可能となった．

2）バッチ式ガス浸炭炉移行による CO_2 削減
少量で特殊熱処理（浸炭窒化）をしている部品を，高効率で省エネルギー性の高い熱処理炉への移行を行っている．従来は大型の連続式ガス浸炭炉で行っていた 4 速 AT のアウトプットギアの処理を小型のバッチ式ガス浸炭炉への移行を行った．移行の際にバッチ式浸炭炉を改造し，浸炭・浸炭窒化・ガス軟窒化等の複数の熱処理を可能にした．この様に，少量生産品はバッチ式浸炭炉を使うことで，従来の連続式浸炭炉と比べ，約 68% の CO_2 排出量削減を実現できた．

3）ファイナルテスター削減による CO_2 削減
前述の『生産設計』による製品性能と生産性の向上を両立させる活動を進めることで，製品性能を部品単体精度まで落し込むことが可能となった．また，組立精度確認のフロントローディング（工程内化）により，組立工程における製品性能試験項目が削減され，ファイナルテスターのサイクルタイムを短縮することができた．これによりファイナルテスターが半減され，CO_2 排出量を年間約 170t 削減することができた．

4）鍛造工程の残熱利用による CO_2 削減
従来，熱間鍛造後にワークを一旦冷却し，再度過熱して粗材熱処理をする工程を採用していた．しかし現在は熱間鍛造後の残熱を利用する熱処理方式（自熱焼鈍化）への変更を進めている．これにより，別ラインで熱処理していた工程を一貫ライン化することが可能となり，物流の省略と合せて，年間で約 1,115t の CO_2 削減を図ることができた．

The aim here is to achieve monozukuri operations that are only possible in Japan.

The following are some examples of initiatives we have adopted recently.

1) Reducing CO_2 emissions by using smaller and lighter transmission case parts
The new next-generation CVT that JATCO announced in fiscal 2008 adopts smaller and lighter case parts. From the outset of the development of this CVT, the product development department and the production engineering department worked together to reduce the plate thicknesses of case parts, which are generally determined by design for production and the producible limits. As a result, the weight of the case was reduced by 22% compared with that of previous CVTs of the same class. This weight saving will naturally improve vehicle fuel economy and also substantially reduce CO_2 emissions in the production processes of the case parts. On an annual basis, it will reduce CO_2 emissions by approximately 300 tons.

2) Reducing CO_2 emissions by changing to a batch-type gas carburizing furnace
We have changed to a high-efficiency, high-energy-saving heat treatment furnace for small-volume parts subjected to a special carbonitriding heat treatment process. Previously, the output gears of 4-speed ATs were heat-treated in a large continuous gas carburizing furnace. That heat treatment process is now performed in a small batch-type gas carburizing furnace. In making this change, we modified the batch-type carburizing furnace so that it is capable of performing multiple heat treatment processes, including carburizing, carbonitriding and gas soft nitriding, among others. The use of this batch-type carburizing furnace for small volumes of parts has reduced CO_2 emissions by approximately 68% compared with the previous continuous carburizing furnace.

3) Reducing CO_2 emissions by shortening the final tester cycle time
We have been promoting design for production activities for improving both product performance

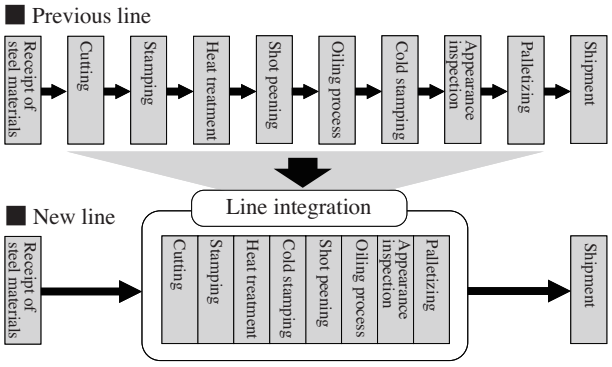


Fig. 5 Formation of an integrated forging line

これら以外にもダイキャスト時の溶湯購入，歯車部品のシェービング工程廃止，熱処理工程の廃止，材料変更による軽量化など様々な活動に取組んでおり，今後もあらゆる可能性を追求しさらなる技術のブレークスルーにチャレンジする．

5. 物流の取組み

1）モーダルシフト

物流に伴う CO_2 の排出量削減の為，輸送方法の改善を図り，1994 年よりモーダルシフトを実施している．

具体例として，九州のお客様への商品輸送を自動車からフェリーに切替え，CO_2 削減率で 75% の効果を挙げた．また，広島方面（780km）・岡山方面（680km）の離れた場所から静岡の生産拠点へトラック輸送していた調達部品を鉄道での輸送に切替え，2005 年度より順次モーダルシフトの拡大を進めている．これにより，年間 83.3% の CO_2 削減につながっている．

2）パレット・梱包資材の環境負荷低減

■荷姿の軽量化・梱包資材の簡素化

お客様への製品納入には，鉄製リターナブルパレットを主として使用していたが，輸送車両の燃費改善の観点から 1997 年より軽量化を推進している．樹脂性ダネッジの採用により，21% の軽量化を実現するとともに，製品保護として使用しているビニール袋・仕切り等のダネッジ類に関して，仕様の簡素化・リターナブル化や再利用可能な材料の採用などにより廃棄物削減も推進し

and productivity. As a result, it is now possible to break down product performance to the level of individual part accuracy. In addition, the front-loading of assembly accuracy checks has reduced the need for product performance tests in assembly processes, thereby shortening the final tester cycle time. As a result, the final tester cycle time has been halved, reducing annual CO_2 emissions by approximately 170 tons.

4) Reducing CO_2 emissions by using the residual heat of the forging process

Conventionally, workpieces were initially cooled following hot forging and then heated again when they underwent heat treatment. However, we are now changing to a self-heating annealing process that utilizes the residual heat following hot forging. This allows the heat treatment process that was previously performed on a separate line to be combined into an integrated line (Fig. 5). Together with the resulting simplified logistics, it enables us to reduce CO_2 emissions by approximately 1,115 tons a year.

Various other activities have also been undertaken, including the purchasing of molten metal for die casting, discontinuation of the shaving process and heat treatment process for gears, and material changes for obtaining weight savings. We will continue to pursue manifold possibilities in our challenge to achieve further technological breakthroughs in the future.

5. Logistics Activities

1) Modal shift

We began implementing a modal shift in 1994 to improve our transport methods in order to reduce CO_2 emissions that occur in logistics operations. Specifically, we switched from trucks to ferries for transporting our products to customers in Kyushu, which had the effect of reducing CO_2 emissions by 75%. In addition, we have been switching from truck to rail transport for parts procured from distant locations, such as Hiroshima (780 km away) and Okayama (680 km away), and brought to our production centers in Shizuoka. This modal shift has been steadily expanded since fiscal 2005

ている.

■樹脂製容器類の再利用・リサイクル
製品の移動・保管に使用している樹脂製容器や製品の保護の為に使っている樹脂系緩衝材類は劣化や製品の変更などにより使用できず廃棄物となっていたものを 2004 年度より製品への再利用の他に，樹脂製品製造会社と連携し，原料としてのリサイクル化を進めている.

6. 今後の取組み

企業にとっての環境対応の重要性は，今後さらに高まっていくことは明らかである. 特に取組みのスコープとしてグローバル活動と CO_2 削減にフォーカスし，地球環境へのネガティブインパクトを最小化していく活動は継続して，これまで以上に新技術のブレークスルーと全員参加による究極のモノづくりを進めていくことで環境に優しいモノづくりの実現を達成していきたい.

また，一方でモノづくり拠点の周辺環境に対しては，当社も含めて多くの企業が過去に公害問題等，ネガティブインパクトを最少化にする活動を進めてきた過去がある．しかし今後は，地域に対し様々なポジティブインパクトを与えていく活動ができるかがキーポイントになってくる．その地域に企業があることで，周辺環境，地域意識や人材育成など様々な面でより良くなっていき，その企業が地域の学校の様な存在（Factory as School）となり，地域と共生を目指した CSR 活動の一環として重点的に進めていくことが重要となるであろう.

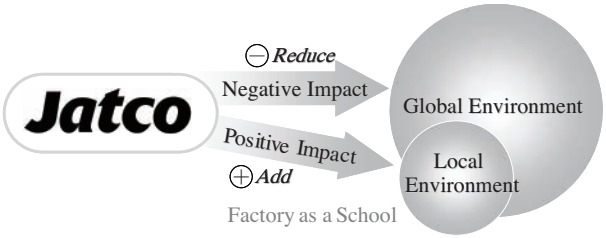


Fig. 6 Production Measures to Address Environment Issues

and has resulted in a annual reduction of CO_2 emissions of 83.3%.

2) Reduction of environmental impact of pallets and packing materials

■ Reduction of load weight and simplification of packing materials
Previously, our products were delivered to customers mainly on returnable steel pallets, but since 1997 we have been lightening the load weight to improve the fuel economy of the transport trucks. The use of molded plastic trays has reduced the load weight by 21% and the adoption this material for the partitions and polyvinyl bags used to protect products has also promoted a reduction of waste. This is because it allows the packing material specifications to be simplified and is returnable and reusable.

■ Reuse and recycling of plastic containers
The plastic containers used in transporting and storing products and the plastic buffer material used to protect products previously ended up as waste when it became unusable due to degradation or product changes. Since fiscal 2004, we have been reusing these plastic items for products and have also been working with plastic product manufacturers to promote the recycling of such plastics into reusable materials.

6. Future Activities

It is clear that the importance of a company's environmental efforts will increase further in the coming years. We will be continuing our activities to minimize the negative impact on the global environment, focusing our efforts in particular on global activities and the reduction of CO_2 emissions as the scope of our activities. We will strive even harder than ever before to achieve the ultimate monozukuri operations through new technical breakthroughs and the full involvement of all employees. In this way, we aim to achieve more eco-friendly monozukuri operations.

JATCO has been among the many companies that have heretofore promoted activities to minimize the negative impact on the environment surrounding

7. おわりに

以上，当社のモノづくりにおける環境への取り組みについて紹介したが，これからも，ジヤトコのモノづくりは，さまざまな新技術のブレークスルーにチャレンジしていく．また，モノづくりの効率と有効性を究めていくとともに，地域社会との調和を実現していくことで，地球環境に貢献していきたいと考えている．

monozukuri centers, including efforts to address pollution problems and other issues in the past. In the years ahead, however, a key point will be whether a company is able to undertake activities that have various positive effects on the community. The presence of a company in a community can have a variety of positive benefits with respect to the surrounding environment, community awareness, the development of human resources and other aspects. The company can be a "factory as a school" for the community (Fig. 6). It will be important for companies to put priority on promoting such activities as one part of their CSR efforts aimed at fostering harmonious relations with local communities.

7. Conclusion

This article has described JATCO's efforts to address environmental issues in monozukuri operations. In our monozukuri activities, we will continue to tackle the challenge of achieving various new technical breakthroughs. We intend to continue to contribute to the global environment by maximizing the efficiency and effectiveness of our monozukuri operations and also by fostering harmony with the local communities where we do business.

ECOを目指した次世代新小型CVT

New Next-generation Small CVT Designed for Eco-friendliness

大原　俊樹 **
Toshiki OHARA
立石　純一郎 ***
Junichiro TATEISHI
大西　静治 ***
Seiji OHNISHI
蒔田　健一 ***
Kenichi MAKITA
嶋田　哲 ***
Akira SHIMADA
寺田　悟史 *
Satoshi TERADA
福井　雅巳 ****
Masami FUKUI
遠藤　雅亜 ****
Masatsugu ENDO
橘　祐介 ***
Yuusuke TACHIBANA
白水　友朗 *
Tomoaki SHIRAMIZU

抄　録　ジヤトコ（株）は，2009 年 7 月に新小型 CVT（JF015E）の生産を開始した．この CVT は従来の軽用 CVT と小型車用 CVT を統合した幅広い適用領域をカバーすると同時に，副変速機構を有することにより大幅な低燃費を実現した次世代 CVT である．
本論文では JF015E の商品コンセプトと新構造・新技術およびそれらを実現するためのモノづくり関連部門の取り組み内容について紹介する．

Summary　JATCO launched production of a new small CVT (JF015E) in July 2009. This next-generation CVT has a wide range of applicability that combines the coverage of existing CVTs for mini-vehicles and small cars. Moreover, it incorporates an auxiliary transmission for a substantial improvement in fuel economy. This article describes the product concept, structure and new technologies incorporated in the JF015E as well as the efforts of JATCO's monozukuri-related departments that made this new CVT possible.

1. はじめに

近年，法規制を含めて地球環境問題への関心がますます高まる中で，自動車業界では燃費向上の競争が激しさを増している．いろいろな燃費向上技術が実施されているが，CVT はその中でも有力な技術の一つであり，この数年の間に各メーカーでそのシェアを広げてきた．ジヤトコは早くから CVT に着目し，他社に先駆けてフルラインナップ化の取り組みをおこなってきた．1997 年に当時としては世界初となる 2.0L クラス FF ベルト CVT を発表して以来，軽自動車用から 3.5L クラス大型車用まで幅広いトルク容量に対応した CVT を実用化し，好評を得ている．

今回，新規に開発した新小型 CVT（Fig. 1）を 2009 年 9 月に発売されたスズキ　パレットに搭載した．以降軽自動車から小型自動車へ幅広く搭載していく予定である．本稿ではこの次世代新小型 CVT の商品概要と構造技術内容について紹介する．

1. Introduction

Competition to improve vehicle fuel economy has been intensifying in the automotive industry in recent years, amid the heightened concern about global environmental issues, including legal and regulatory aspects. Among the various technologies implemented to improve fuel economy, CVTs are one of the most effective approaches. These past few years all of the automakers have been increasing the percentage of their vehicles fitted with a CVT.

JATCO was among the first to focus on CVTs and has led other companies in developing a full lineup of CVTs that have been highly acclaimed. In 1997, we announced the world's first steel-belt CVT for use on 2.0-liter class front-wheel-drive (FWD) cars. Since then, we have developed CVT models with a wide spectrum of input torque capacities, ranging from units for mini-vehicles to a CVT for application to large vehicles fitted with a 3.5-liter class engine.

The newly developed small CVT (JF015E) described here was adopted on the Suzuki Palette

* 商品開発室
Product Development Department
** プロジェクト推進室
Project Promotion Office
*** 部品システム開発部
Hardware System Development Department
**** 調達プロジェクトセンター
Purchasing Project Center

Fig. 1 JF015E

2. 商品・新技術

2.1. 商品コンセプト

JF015E は以下のコンセプトで開発をおこなった.

1) 環境への貢献 (燃費向上のためのフリクション低減)
2) 世界最小 (軽量化, 衝突安全性への配慮)
3) 最先端技術の導入
4) コスト低減

世界的な原油価格の高騰により, 小型の良燃費車への要求が従来より増してきている.

法規的な面で言えば, 日本国内のグリーン税制 (優遇税制含む), 北米, 欧州, 中国という自動車メインマーケットでの燃費規制の強化等も年を追うごとに厳しくなっている.

その対応について, 台数影響を考慮すると最量販であるレシプロエンジンとの組合せで使われるトランスミッション (TM) の燃費向上が非常に重要になる.

また, 軽自動車用としても共用するためには, 小型化と低フリクションを実現させなければならない. (Fig. 2)

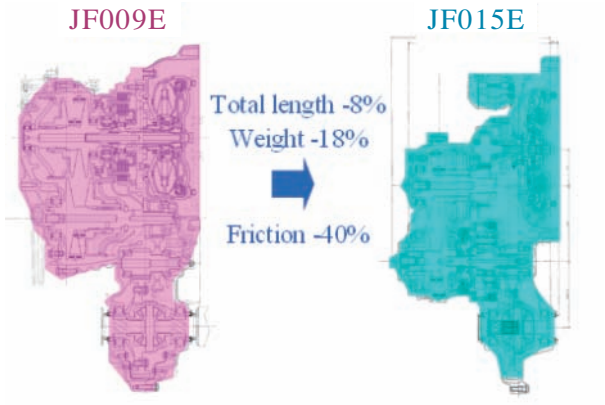


Fig. 2 Overview comparison

released in September 2009. This CVT is scheduled to be used on a wide variety of vehicles in the coming years, ranging from mini-vehicles to small cars. This article outlines the product concept and the details of the structural technologies incorporated in this new next-generation small CVT.

2. Product Concept and New Technologies

2.1. Product concept

The JF015E was developed around the following product concept.

1) Contribution to the environment (reduction of friction to improve fuel economy)
2) World's smallest package (lighter weight and crash safety compatibility)
3) Introduction of cutting-edge technologies
4) Cost reductions

Demand for small, fuel-efficient cars is greater today than ever before owing to the sharp increase in oil prices worldwide. With regard to legal and regulatory aspects, fuel economy regulations are becoming tighter every year in the main vehicle markets of North America, Europe and China. This trend is also seen in Japan's Green Tax system, including the preferential tax breaks for eco-friendly vehicles.

In order to meet these stricter requirements, it is imperative to improve the fuel economy of transmissions intended for use with reciprocal engines on mass-market vehicles, taking into consideration the resultant volume effect. Furthermore, to facilitate common use on mini-vehicles as well, transmissions need to be smaller in size and achieve lower friction (Fig. 2).

Reducing the size further while still accommodating 180 Nm of input torque would pose an extremely high hurdle. We concluded that it would be virtually impossible to meet both conditions if the JF015E were designed simply as an extension of the conventional CVT structure. For that reason, the JF015E was engineered as the world's first CVT with an auxiliary transmission.

2.2. Specifications and structure

2.2.1. Applicable torque

JATCO has a full lineup of CVTs, ranging from

180Nm までの適用としながら，更なる小型化は非常にハードルが高く，従来の CVT 構造の延長では，両立させることが困難であると考え，世界初となる副変速機付き CVT の構造とした.

2.2. 諸元と構造

2.2.1. 適用トルク

ジヤトコは軽自動車用から排気量 3.5 リットルクラスまでの CVT フルラインナップを実現している.

機種構成は軽自動車用・小型車用・中型車用・大型車用の 4 機種構成を採ってきた.

JF015E では副変速機の追加により，レシオカバレッジの拡大と軽量・コンパクト化に成功しており，軽自動車にも搭載可能な CVT に仕上げることができた.

これにより，軽自動車用と小型車用を 1 機種でカバーし機種削減に貢献している.

JF015E の適用トルクを Fig. 3 に示す.

適用トルクは 60 ～ 180Nm で JF012E，JF009E，F1C1 の適用トルク領域を1ユニットでの適用を実現している.

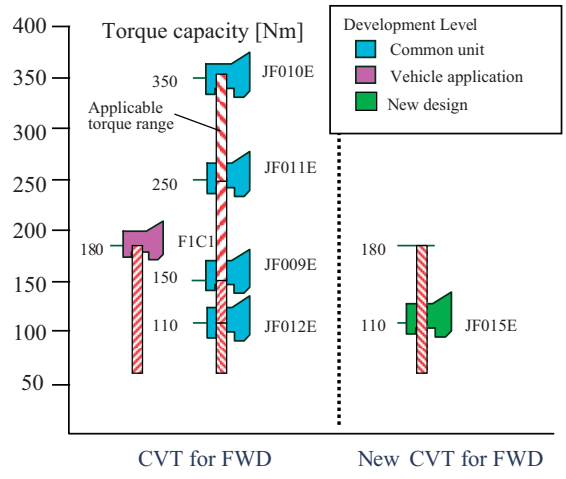


Fig. 3 Torque range

2.2.2. レシオカバレッジ

他に類を見ないプーリと副変速機を組み合わせることで，量産 CVT，STEP-AT の中で最も広いレシオカバレッジを実現し，燃費・動力性能向上へ貢献している.(Fig. 4)

2.2.3. 構造

従来の CVT と同様，発進要素にトルクコンバータ

units for mini-vehicles to a CVT for use with large engines of the 3.5-liter class. The model mix consists of four types designed for application to mini-vehicles, small cars, midsized cars and large cars, respectively.

The addition of an auxiliary transmission to the JF015E successfully expanded the ratio coverage and reduced the size and weight of the unit. This resulted in a CVT that is also applicable to mini-vehicles. Because the JF015E can cover both mini-vehicle and small car applications, it has helped to reduce the number of models in our CVT lineup.

The applicable torque range of the JF015E is shown in Fig. 3. It can handle input torque ranging from 60 to 180 N-m. As a result, this single CVT can accommodate the applicable torque range of the existing JF012E, JF009E and F1C1 models.

2.2.2. Ratio coverage

The combination of unique pulleys and an auxiliary transmission enables the JF015E to achieve the widest ratio coverage among current mass-produced CVTs and stepped ATs. This wide ratio range contributes to improved fuel economy and power performance (Fig. 4).

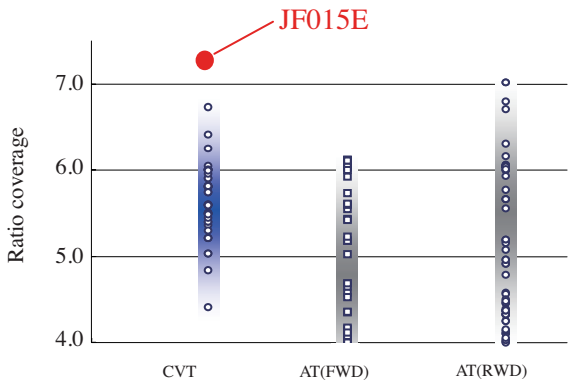


Fig. 4 Ratio coverage

2.2.3. Structure

Like conventional CVTs, the JF015E adopts a torque converter as the start-off element. Torque input from the engine is transferred via the torque converter and a counter gear to the belt and pulley assembly that forms the shift mechanism. Drive torque is then transferred via the auxiliary transmission and the forward-reverse changeover mechanism through the final reduction gear to the

を採用し，エンジンからの入力トルクは，このトルクコンバータとカウンタギヤを介し，変速機構であるベルト&プーリへ伝達される．

そして副変速機構と前後進切替え機構部を介し，リダクションギヤ列を介して，デフギヤにより左右の駆動輪を駆動する．(Fig. 5)

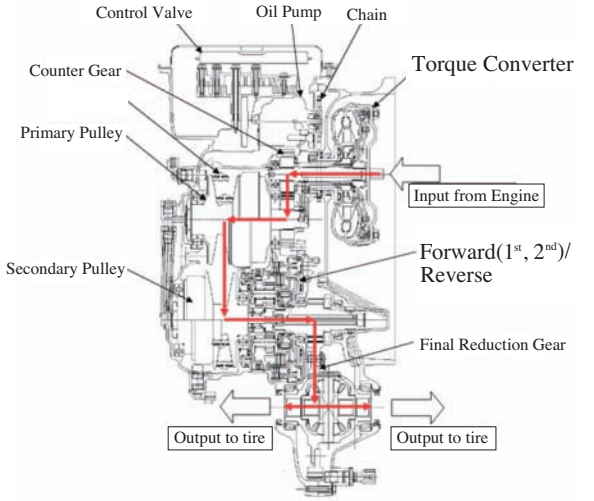


Fig. 5 Layout

トルク伝達や変速のための油圧を発生させるオイルポンプは 1 軸の下方に配置され，エンジンと直結された入力軸から，チェーンシステムを介して駆動される．

制御系の油圧回路は従来同様，ケース下方のオイルパン内に配置した．

2.3. 7 つの主要技術

2.3.1. 世界初，副変速機付き CVT

JF015E では今回，世界初となる副変速機構を開発した．前進時は直結で Rev 走行のトルク伝達機能しか持たない従来 CVT の遊星歯車とは異なり，本副変速機 (Fig. 6) は前進 2 段，後進 1 段の変速が可能である．その構造は Fig. 7 に示すとおりラビニヨ遊星を採用し，副変速という機能を追加しながらもコンパクトに収めている．

JF015E に採用した遊星歯車機構は，1st：1.821，2nd：1.0，Rev：1.714 というギヤ比を有するラビニヨタイプの遊星である．また従来 CVT に対して Low ブレーキ，サンギヤ各 1 つの要素を追加した．従ってサイズは従来に対して不利な構造となる．この問題を解決するために，2nd 走行時に遊星歯車を直結するスケルトンを選択し，遊星歯車の動力伝達を 1st，Rev 走行時のみとした．同時に歯面フラッシュ温度と

differential gear from which it is output to the right and left drive wheels (Fig. 5).

The oil pump that generates the hydraulic pressure for torque transfer and shifting is positioned under the first shaft and is driven via a chain system from the input shaft connected directly to the engine. Like existing CVTs, the hydraulic circuit for the control system is located in the oil pan below the case.

2.3. Seven principal technologies

2.3.1. World's first CVT with an auxiliary transmission

The JF015E is the world's first CVT to feature a newly developed auxiliary transmission. The planetary gear set of a conventional CVT is directly coupled for forward motion and provides only a torque transfer function during travel in reverse. In contrast to that arrangement, the auxiliary transmission (Fig. 6) provides two forward speeds and one reverse speed. It is constructed with a Ravigneaux planetary gear set as shown in Fig. 7 and achieves a compact design while still adding an auxiliary shifting function.

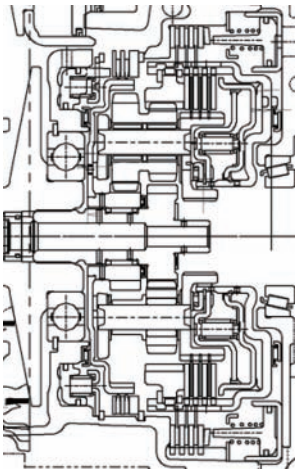


Fig. 6 Auxiliary transmission

The Ravigneaux planetary gear set adopted for the JF015E provides gear ratios of 1.821 in first gear, 1.0 in second gear and 1.714 in reverse. In relation to a conventional CVT, it adds one Low brake and one sun gear. These additional elements give the structure a size disadvantage compared with conventional units. To solve that problem, a configuration was selected that directly couples the planetary gear set when traveling in second gear and allows the gear set

ピッティング寿命の関係を精査することで，遊星歯車の歯幅を極限まで小さくし，レイアウト効率の良い構造を実現することができた.

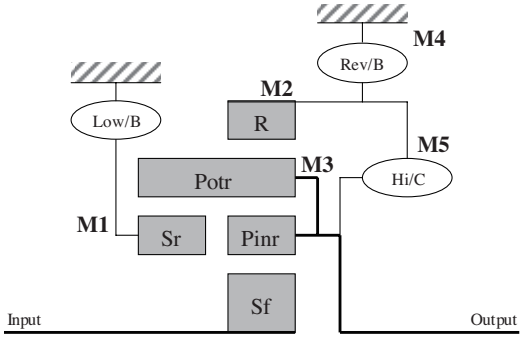


Fig. 7 Planetary gear trains

以上より，この遊星歯車部の変速比幅とバリエータ部の変速比幅との組合せにより，レシオカバレッジ 7.3 という 8 速 AT を越える世界最大の変速領域（Fig. 8）を持つ CVT が誕生した.

2.3.2. プーリの小型化

ベルト式 CVT はレシオカバレッジを大きくしようとすると通常はプーリ外径を大きくする必要があり，小型車の小さなエンジンルームに搭載するのが困難になる.

JF015E はベルト & プーリによる変速と遊星ギヤ式の副変速を併用することでプーリの小型化を実現した.

その他にも従来のボールスプラインからローラスプラインに変更することで軸長を短縮しており，車両搭載に有利な小型ユニットにすることができた.

プーリの重量は従来比 35% 低減（シーブ部のみでは 44% 低減）で世界最軽量である.（Fig. 9）

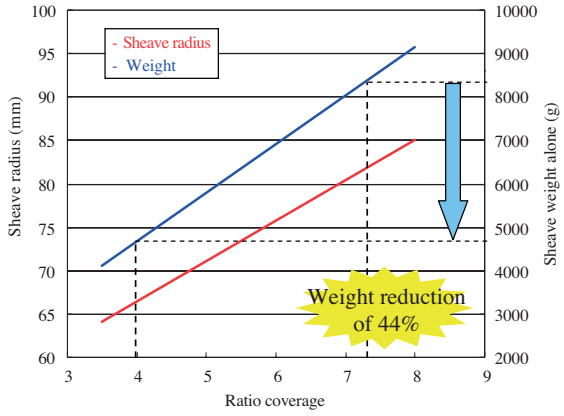


Fig. 9 Sheave weight benchmark

to transfer drive torque only when traveling in first gear or reverse. In addition, a structure with a highly efficient layout was achieved by reducing the tooth face width of the planetary gears as much as possible. That was accomplished by carefully examining the relationship between the flash temperature on the tooth face and pitting life.

The gear ratio range of the Ravigneaux planetary gear set combined with that of the variator results in ratio coverage of 7.3. As a result, the JF015E CVT has one of the world's widest ratio coverages, even exceeding that of 8-speed ATs (Fig. 8).

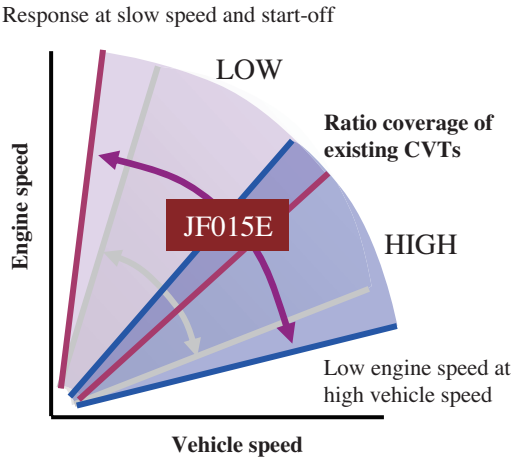


Fig. 8 Ratio coverage

2.3.2. Downsizing of pulleys

In order to expand the ratio coverage of a steel-belt CVT, it is generally necessary to increase the outer diameter of the pulleys. However, that results in a larger CVT, making it more difficult to mount the unit in the limited engine compartment space of a small car.

The size of the JF015E pulleys was reduced by adopting the planetary gear auxiliary transmission in parallel with the belt and pulley system for shifting. In addition, the previous ball spline was changed to a roller spline, which shortened the shaft length. These changes resulted in a more compact unit that is advantageous for vehicle mountability.

The pulley weight was reduced by 35% compared with that of previous pulleys to achieve the world's lightest weight. The sheave weight alone was reduced by 44% (Fig. 9).

The roller spline was also changed to make it easier to manufacture. Among other changes, the

また，ローラスプラインではスプライン溝を 3 溝から 1 溝へ変更，スナップリング溝の廃止などをおこない製造の簡易化を図っている．その他の部位に関しても，開発当初より製造部門とのクロスファンクショナルな活動により組立性の向上やそれにともなうコスト低減をすることができた．

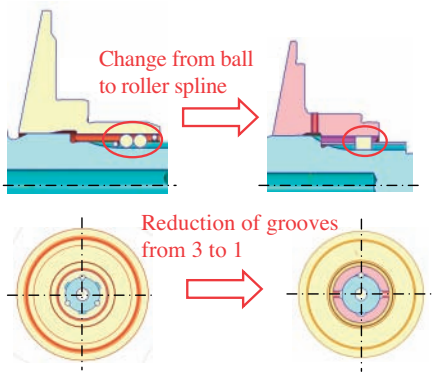


Fig. 10 Comparison of pulley size

2.3.3. トルクコンバータの小型化

トルクコンバータ全長 －12%

JF015E は 7.3 のレシオカバレッジを持つことで，スルーローにおけるトルクをギヤ側に分担して使用することができるため，トルクコンバータ（以下 TC と表記）の流体性能，特に必要トルク容量を小さくすることが可能となった．

またロックアップ（以下 LU と表記）領域の拡大により，流体でのトルク伝達領域を発進時のみに限定できたことも，必要トルク容量の低減につながった．

このメリットを最大限に発揮するため，TC としては，小型化（全長 －12%）を図った．

2.3.4. 小型化にともなう課題について

ポンプ，タービン，ステータ内を循環する油の流れる部分の横断面形状をトーラス形状と言い，一般的に流体性能はトーラス形状により，性能が大きく左右される．偏平化をすることでトルク容量およびトルク比は下がる傾向になる．これはエンジンからのトルクを流体に変換し，伝達するという機構上，循環する流量を大きくすることができなくなり，不利になってしまう．

Fig. 11 に従来のトーラス形状と今回新たに採用したトーラス形状の比較を示す．また，それぞれのトーラス形状での流体性能線図を Fig. 12 に示す．流体の

number of spline grooves was reduced from three to one and the snap ring groove was discontinued (Fig. 10). For other parts as well, cross-functional activities were carried out with the manufacturing division from the start of the development project to improve ease of assembly and reduce costs as a result.

2.3.3. Downsizing of torque converter: Reduction of overall torque converter length by 12%

With wider ratio coverage of 7.3, the JF015E allows ample torque transmission via the gears alone in the through low state. This made it possible to reduce the necessary torque capacity of the torque converter, while assuring ample hydrodynamic performance.

Expanding the range of lockup operation made it possible to limit the region of torque transfer by the fluid to vehicle launch alone, which also enabled the necessary torque capacity to be reduced.

These benefits were used to maximum effect in downsizing the torque converter by reducing the overall length by 12%.

2.3.4. Downsizing issues

The cross-sectional shape of the areas of the pump, turbine and stator through which the fluid flows is referred to as the torus form. Generally, the torus form substantially influences hydrodynamic performance. Flattening the torque converter tends to reduce the torque capacity and torque ratio. Since a torque converter is designed to convert and transfer engine torque by means of the fluid, this is a disadvantage because the flow rate of the circulating fluid cannot be increased.

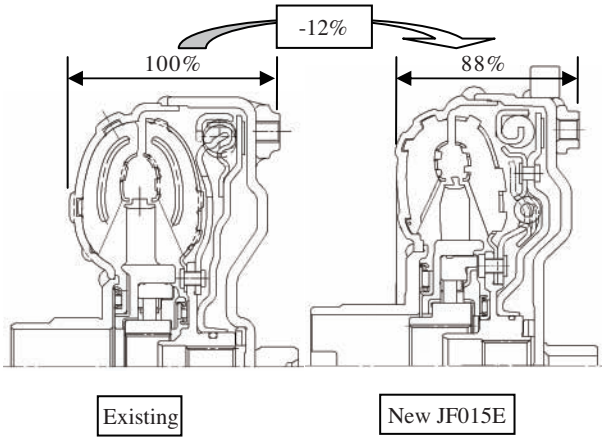


Fig. 11 Comparison of torus form

循環する領域が小さくなっていることがわかる.

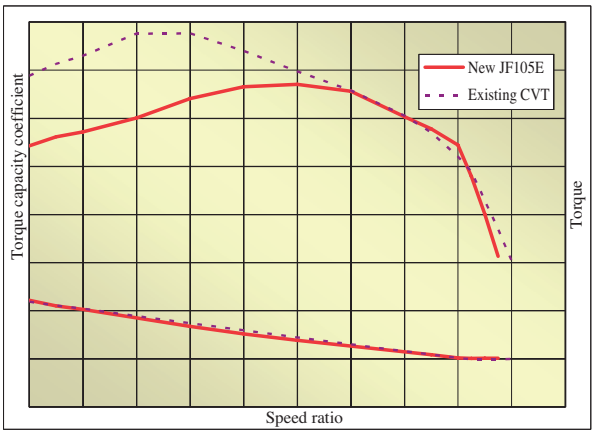


Fig. 12 Comparison of hydrodynamic performance curves

今回，トルク容量は車両必要特性にマッチさせることで適正化を図ることができたが，トルク比は伝達効率を決定する大きな要因であるため，トルク比の低下は避ける必要があった. 小型化に対して課題となったのは，トーラス形状を小さくしても，トルク比をいかに従来 CVT と変えないレベルとするかであった.

偏平化により，トルク比は速度比 0.8 のポイントで 13% の低下が見込まれた．また，カップリングポイントも速度比 0.82 から 0.80 まで下がってしまい，効率低下の恐れがあった.

これを改良（改善）するため，今まで培ってきた技術を投入し流体部品のブレード形状最適化や枚数適正化を進めた.

Fig. 13 にサイズを無次元化したときの断面積率に対するトルク比を示す．TC の伝達効率は，速度比とトルク比の積であり，速度比 0.8 でのトルク比が高いということは，伝達効率の高い TC という指標となる.

Fig. 13 にサイズに対する速度比 0.8 でのトルク比を示す．以上の対応により，従来以上の特性を実現することができた.

2.3.5. クラッチ搭載位置後方化

トランスミッション全長 −10%

JF015E のコンセプトとして世界最高レベルでのユニットの小型化があり，それを達成するための技術として，クラッチ，遊星の副変速機構をプーリの後方に配置した．これによりプーリの小型化が可能となり，

Figure 11 compares the conventional torus form with that newly adopted for the JF015E, and the hydrodynamic performance curve of each one is shown in Fig. 12. It is seen that the region of fluid circulation is smaller for the JF015E.

The torque capacity of the JF015E was successfully optimized to match the required vehicle performance characteristics. However, because the torque ratio is a major factor determining transmission efficiency, it was essential to avoid any decline in the torque ratio. One important downsizing issue was the question of how to keep the torque ratio at the same level as that of existing CVTs while at the same time reducing the torus form.

We estimated that flattening the torque converter would reduce the torque ratio by 13% at a speed ratio of 0.8. In addition, the coupling point would also decline from a speed ratio of 0.82 to 0.80, which could cause a drop in efficiency.

In order to improve performance, we drew upon the technologies accumulated to date and optimized the shape of the turbine and impeller blades as well as the number of blades used.

Figure 13 shows the torque ratio as a function of the cross-sectional area when the torque converter size is nondimensionalized. The transmission efficiency of a torque converter is equal to the product of the speed ratio and the torque ratio. A high torque ratio at a speed ratio of 0.8 indicates that the torque converter has high transmission efficiency.

Figure 13 shows the torque ratio at a speed ratio of 0.8 in relation to the converter size. As a result of adopting the measures explained here, the downsized torque converter achieves a better performance curve than that of existing CVTs.

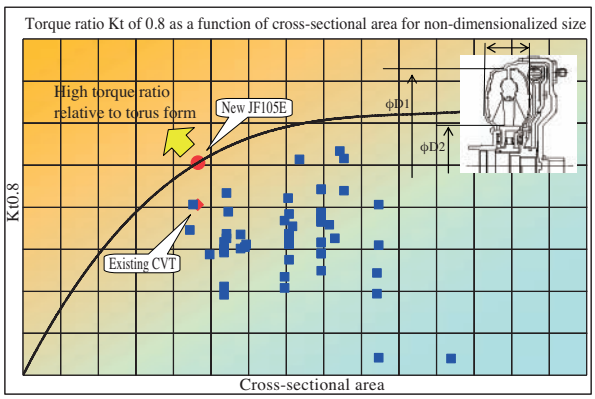


Fig. 13 Torque potential map for non-dimensionalized converter size

また，従来のユニットのように第 1 軸上に構造部品が集中することなく，ユニットのレイアウト効率を向上することができた．

上記のとおりプーリの後方に配置することによりユニット全体のレイアウト効率は向上するが，その反面，副変速機構には従来のユニットとは異なりプーリにて増幅されたトルクが入力されるため，強度面では不利な状況となる．また，ユニットの車両搭載性から第 1 軸部よりも第 3 軸部の許容隙間は厳しく，第3軸部の大幅な軸長短縮がユニットの商品性を向上するための大きな課題であった．今回 JF015E の開発をおこなうにあたり，上記課題を解決するため，副変速機構として以下の新技術を採用した．

2.3.6. ハイクラッチ（以下 HIGH ／C）のインターナルギヤ支持による全長短縮技術

副変速機構の成立に非常に重要な部品となる HIGH ／C は，変速の挙動だけでなく，トルク容量の面からも運転性ならびに燃費に大きく影響する．

そのため，従来の設計思想では軸方向，径方向ともに非常に大きな容積を確保する必要がある．

Fig. 14 に従来の構造と今回新たに採用した構造の比較を示す．従来の構造では HIGH ／C の動力を伝達するプレート類はドラムに取り付けられたスナップリングにより支えられる．スナップリングでプレートを支持する場合，プレート類の変形により，摩擦材の面圧の悪化ならびにプレートのたわみに対する強度が必要となるため，リテーニングプレートと呼ばれるドリブンプレートよりも厚みのあるプレートを使用する必要がある．

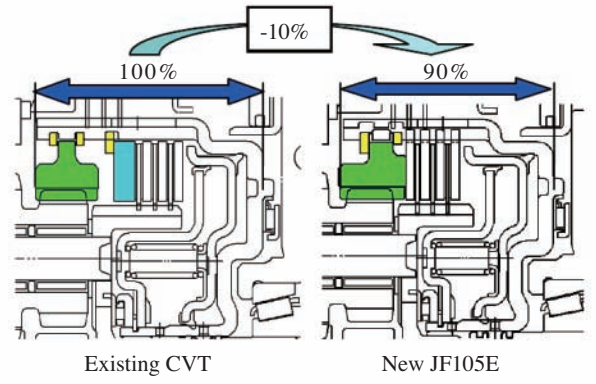


Fig. 14 High clutch layout

2.3.5. Rearward repositioning of clutch: Reduction of overall transmission length by 10%

The development concept for the JF015E was to achieve the world's highest level of performance in a downsized unit. One of the techniques employed to achieve that concept was to position the clutch and planetary gear auxiliary transmission behind the pulleys. That made it possible to downsize the pulleys and to improve the layout efficiency of the JF015E without concentrating the structural parts on the first shaft, as was done previously.

Positioning the clutch and auxiliary transmission behind the pulleys improves the overall layout efficiency, but at the same time it is also disadvantageous for the strength of the auxiliary transmission. The reason is that the pulleys amplify the torque input to the auxiliary transmission, unlike the situation in a conventional CVT. Moreover, in terms of vehicle mountability, the allowable clearance at the third shaft is a lot more severe than at the first shaft. Accordingly, substantially reducing the length of the third shaft was a major issue with regard to improving the marketability of the JF015E. In order to resolve this issue in the course of developing the JF015E, the following new technical features were adopted for the auxiliary transmission.

2.3.6. Reduction of overall length via the internal gear support of the high clutch

The high clutch is a critical part for the feasibility of the auxiliary transmission. Not only does it influence shift behavior, it also has a significant effect on fuel economy and driveability from the standpoint of torque capacity. Therefore, in the conventional design strategy it was necessary to secure an exceptionally large volume in both the axial and radial directions.

Figure 14 compares the conventional high clutch layout with that newly adopted for the JF105E. In the conventional layout, the high clutch plates that transmit driving force are supported by snap rings attached to the drum. With this support structure, it is necessary to ensure sufficient strength against deterioration of the surface pressure of the friction materials and plate deflection induced by plate deformation. For that reason, it has been necessary to use a retaining plate that is thicker than the driven

今回の構造では，軸方向のレイアウトに不利なリテーニングプレートを廃止し，インターナルギヤにてプレートを支持することとした．これにより，リテーニングプレートとインターナルギヤの隙間は不要となり，また従来の構造ではリテーニングプレート，インターナルギヤそれぞれに設けていたスナップリングも，インターナルギヤを拘束するための２本のみとなりそれにより軸方向の短縮が可能となった．さらに特筆すべき技術としては，インターナルギヤの支持による HIGH ／ C の接触面圧分布の向上である．

Fig. 15 に従来構造での面圧分布とインターナル支持での面圧分布を示す．

先に述べたとおり，副変速機構の挙動は HIGH ／ C の締結・開放特性に依存するところが大きく，インターナルギヤをプレートの支持に共用することにより，従来のユニットでは成し得なかった安定した面圧分布を確保することができた．この効果は性能だけにとどまらず，局部面圧を下げることにより，焼けに対する強度を飛躍的に向上することができ，プレートの枚数を最低限に抑えることができた．

結果として，ユニットの大幅な軸長短縮と性能向上を同時に達成できる技術となった．

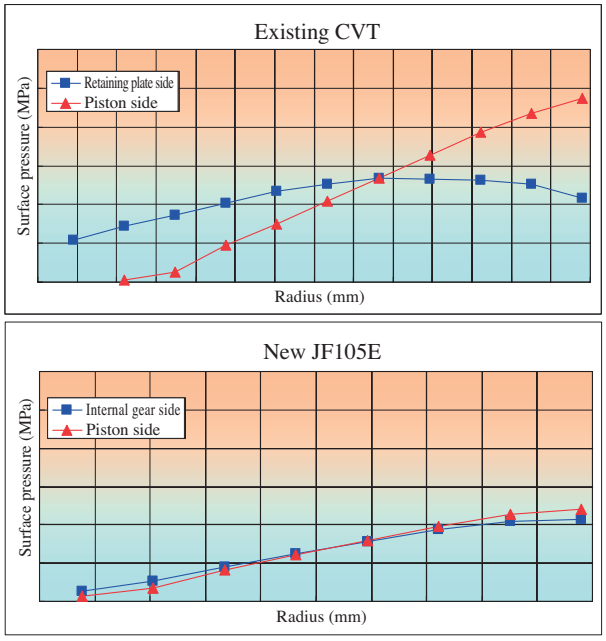


Fig. 15 Improvement of surface pressure distribution by changing support structure

2.3.7. 変速部のオイル攪拌抵抗低減

JF015E は，副変速機部を第 3 軸へ配置した．また，従来 CVT で一般的であった 4 点ギヤ構造を廃止し，

plate.

In the new layout, the retaining plate that was disadvantageous for the axial direction layout was discontinued and an internal gear was adopted instead to support the driven plate. That eliminated the need to allow any clearance between the retaining plate and the internal gear. The snap rings that were provided in the conventional structure for both the retaining plate and the internal gear were also reduced to just two rings for restraining the internal gear. As a result, that enabled the overall axial length to be reduced.

One noteworthy technical feature is that the support provided by the internal gear works to improve the contact pressure distribution of the high clutch. Figure 15 compares the pressure distribution of the previous structure with that obtained by the internal gear support.

As mentioned earlier, the behavior of the auxiliary transmission is greatly dependent on the engagement/disengagement characteristics of the high clutch. Using the internal gear as a common support for the clutch plates makes it possible to secure a stable surface pressure distribution, something that was not obtainable previously in existing CVTs. Besides being beneficial for performance, the reduction of localized surface pressure also dramatically improves resistance to plate surface scoring. That makes it possible to keep the number of plates to the necessary minimum. As a result, this technical approach substantially reduces the axial length of the unit and simultaneously improves its performance.

2.3.7. Reduction of oil churning resistance in the shift mechanism

The auxiliary transmission in the JF015E is positioned on the third shaft. The four-gear construction generally used in existing CVTs was also discontinued, and the gear pair consisting of the output gear and the idler gear is now positioned on the first shaft. As a result, the primary pulley shaft was moved upward compared with the previous position (Fig. 16).

This layout of the powertrain parts enables the primary pulley to rotate without touching the fluid surface, which reduces fluid churning for a reduction of friction loss.

従来のアウトプットギヤ，アイドラギヤと呼ばれるギヤ対を第 1 軸へ配置した．この結果，プライマリプーリ軸は従来に対しユニット上方へ移動することができた．(Fig. 16)

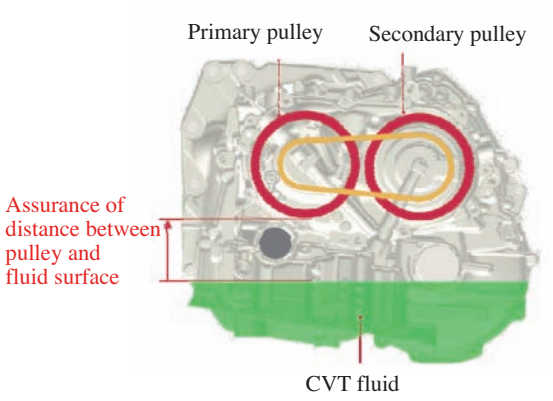


Fig. 16 Shaft layout

上記のパワートレーン部品配置により，プライマリプーリがオイル油面に接しない回転運動が可能となり，オイル攪拌によるフリクションロスを低減することを実現した．

2.3.8. 超小型高効率オイルポンプ

CVT 燃費性能向上のために，(1) 小型軽量化，(2) 低フリクション を開発の狙いとして設定した．オイルポンプレイアウトを Fig. 17 に示す．

Table 1 に JF009E と JF015E のオイルポンプ主要諸元を示す．従来 JF009E で採用していた内接型ギヤポンプをチェーン駆動方式の小型ベーンポンプへと変更した．

Table 1 Major specifications of oil pumps

Item	JF015E	JF009E
Torque capacity (Nm)	180	150
Installation configuration	External	Axis this wick
Speed increase ratio	1.088	1
Basic displacement (cc/rev)	13.1	14.8
Tooth type	Vane	Trochoid
Weight (g)	1050	3720

Table 1に示すように，重量で2.6kgfの軽量化を図った．重量低減はカバー部のアルミ化，固有吐出量低下による．また軸長では，吸入回路およびポンプ内部油路の最適化により，従来の JF011E 用ベーンオイルポンプに比べて 12mm 削減している．(Fig. 18)

ベーンポンプは，内接型ギヤポンプに比べ摺動抵抗が小さく，かつ容積効率が高く，理論吐出量を小さくすることができるため，ポンプ駆動トルクを大幅

2.3.8. Ultra-small, high-efficiency oil pump

The JF015E was developed with the aims of achieving a smaller, lighter CVT with a lower level of friction for the purpose of improving fuel economy. The oil pump layout adopted for the JF015E is shown in Fig. 17.

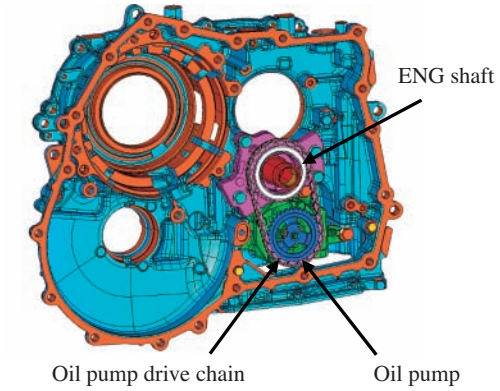


Fig. 17 Oil pump layout

Table 1 compares the major specifications of the oil pumps used with the JF009E and the JF015E. The trochoid gear pump adopted for the existing JF009E was changed to a small, chain-driven vane pump for the JF015E. As seen in Table 1, the pump weight was lightened by 2.6 kgf. This weight reduction was achieved by using aluminum for part of the cover and by lowering the inherent discharge rate. The axial length was also shortened by 12 mm compared with the vane oil pump used with the existing JF011E model (Fig. 18). That was accomplished by optimizing the suction circuit and the internal fluid passages in the pump.

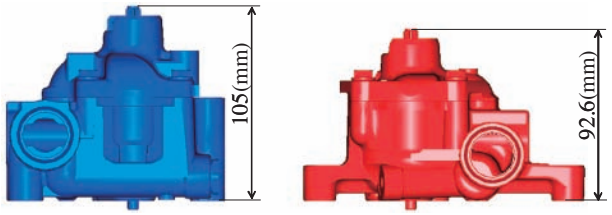


Fig. 18 JF011E and JF0015E oil pumps

A vane pump has less sliding resistance than a trochoid gear pump and its volumetric efficiency is also higher. Since that makes it possible to lower the theoretical discharge rate, the pump drive torque can be substantially reduced. One effective way to lower the oil pump drive torque is to reduce the rotor

に低減できる．オイルポンプの駆動トルクを下げるには，ロータの小径化が有効である．しかしながら一定の吐出量を確保するためには小径化した分ローター幅を厚くする必要があり，これによりベーン室への油の充填性が低下しキャビテーションが発生し易くなる．

そこで効率向上とキャビテーション発生の相反する性能を成立させるために，フローコントロールバルブを内蔵させた．ベーン室への油の充填性（スーパーチャージ性），ノイズ，対エロージョンを向上させるため，吐出流量と吸入側への戻し流量の配分を最適化した．

2.3.9. 3 段特性ダンパの採用

開発の目的

LU 領域の拡大をおこなうと，車両の重要な特性である静粛性の中で，LU 時のこもり音と車両の振動特性が悪化する懸念がある．LU 時のこもり音と車両の振動特性の改善策として，低剛性ダンパが必要となり，今回 3 段特性ダンパの開発をおこなった．

3 段特性ダンパの構造

従来構造の Long Travel Damper（以下　LTD と略す）の概念図および今回採用した 3 段特性ダンパの概念図を Fig. 19 に示す．またダンパ特性を Fig. 20 へ示す．

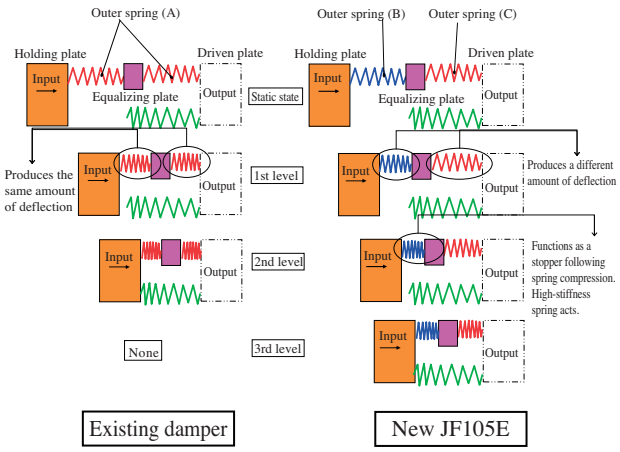


Fig. 19 Comparison of damper structure concepts

Fig. 19 に構造概念の比較を示す．

従来構造の LTD はホールドプレートを入力，ドリブンプレートを出力とした場合，イコライザプレートを挟んで隣り合った SPR を同じ剛性とし，直列に作動させて 1 段目の剛性を発生させていた．それに対

diameter. However, to ensure a certain desired discharge rate, the rotor width must be increased to the extent that the diameter is reduced. However, that has the effect of reducing the supercharging of the fluid into the vane chamber, making it easier for cavitation to occur.

An internal flow control valve was adopted to reconcile improved efficiency with the avoidance of cavitation, which are normally contradictory attributes. This control valve optimizes the distribution between the discharged flow and return flow to the suction side, thereby enhancing the supercharging of the fluid into the vane chamber, reducing noise and improving erosion resistance.

2.3.9. Adoption of a damper with three levels of damping characteristics Development aim

There was concern that expanding the lockup operation range might increase boom noise and vehicle vibration in that operating mode. That would degrade quietness, which is a critical vehicle characteristic. A low-stiffness damper is necessary as a means of improving boom noise and vibration characteristics during lockup operation. A damper with three levels of damping characteristics was developed for the JF015E.

Structure of damper with three damping levels

Figure 19 presents schematic diagrams comparing the structure of the conventional long travel damper (LTD) and that of the newly adopted damper with three levels of damping characteristics. The damping characteristics of the two dampers are shown in Fig. 20.

The conventional LTD is constructed with an input holding plate and an output driven plate. Two adjacent springs that sandwich an equalizer plate have the same stiffness. The springs operate in tandem to produce the first level of damping stiffness. In contrast, in the newly adopted damper with three levels of damping characteristics, the adjacent springs sandwiching the equalizer plate have different stiffnesses. When the springs operate in tandem, the stiffness of outer spring B is less than that of outer spring C.

As a result, the lower-stiffness spring first acts positively to produce the first level of damping

して今回採用した 3 段特性ダンパは，イコライザプレートを挟んで隣り合った SPR を異なる剛性とし，直列に作動させている.(この時 SPR の剛性は，外周 SPR (B) <外周 SPR (C))

これにより先に剛性の低いバネが積極的に作動することによって1段目の剛性を発生させている.

2 段目の剛性は, 1 段目の SPR が線間密着しストッパになることで剛性の高いバネが作動し発生させている.

JF015E は，燃費向上を目的に LU 領域の拡大を実現させるため，LU 時のこもり音と車両の振動特性の悪化が懸念された．従来ユニットとの LU 領域比較は Fig. 21 に示す.

3 段特性ダンパを採用することにより，ダンパ特性を低剛性化させることが可能となり，LU 時の車両の振動特性改善に寄与することができた.

また，従来と同等のスペースで，ダンパの部品点数を増加させることなくダンパ特性の低剛性化を実現した.

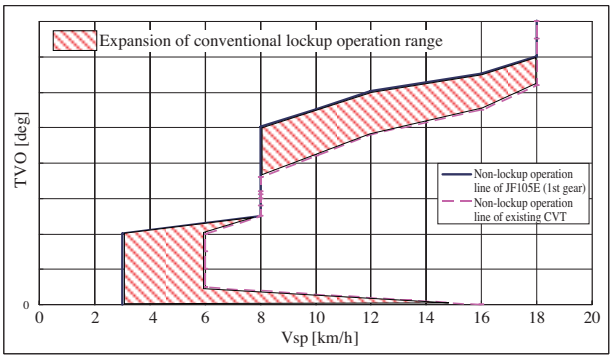


Fig. 21 Comparison of lockup operation range

2.4. 生産性向上活動

2.4.1. 組立工程の取り組み

組立工程では『シンプル』『QCT (Quality, Cost, Time) ハーフ』をキーワードに取り組んだ.

製品の小型化に応じて搬送トレーの小型化・シンプル化を図った．一例として，プーリ組立ラインではワークトレーの小型化により，トレー重量を従来中型 CVT 比で約 1 ／ 10 (投資額で 1 ／ 5) まで小型化すると同時に，搬送距離の短縮や手動搬送化による駆動レス化を実現した.

メイン組立ラインではプレス設備等の小型汎用化・電動化等をおこなうとともに，動力を用いないカラクリ装置や治具を組合せることで設備の削減を進め,

stiffness. The second level of damping stiffness is produced by the action of the higher-stiffness spring, as the first-level spring compresses tightly to become a stopper.

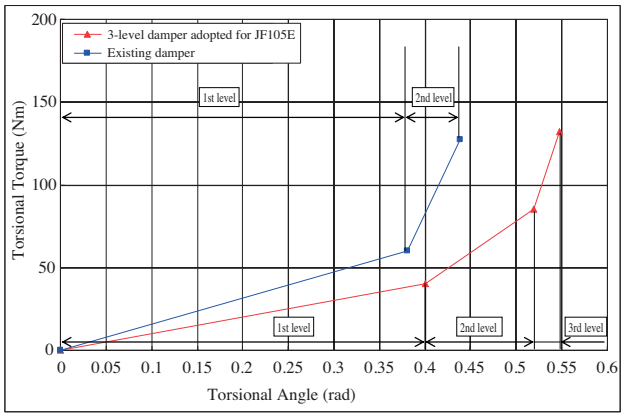


Fig. 20 Comparison of damper performance

In order to expand the lockup operation range of the JF015E for improving fuel economy, it was essential to prevent any increase in boom noise and vehicle vibration during lockup operation. The lockup operation range of the JF015E is compared with that of an existing CVT in Fig. 21.

The adoption of the new damper with three levels of damping characteristics allowed the damper stiffness to be reduced. That contributed to improving vehicle vibration characteristics during lockup operation. In addition, the lower damper stiffness was achieved without increasing the part count of the damper, thereby enabling it to be installed in the same space as the conventional damper.

2.4. Activities to improve productivity Assembly process activities

2.4.1. The efforts made in the assembly processes focused on the key themes of simplicity and halving of the investment to meet quality, cost and lead time (QTC) requirements. Transport trays were made smaller and simpler to match the downsizing of the product. For example, the workpiece trays used on the pulley assembly line were downsized such that their weight was reduced to approximately one-tenth that of the trays used for existing midsized CVTs and the capital investment required was reduced to one-fifth as much. Simultaneously, the transport distance

ライン長を短縮し省スペース化した．これらにより設備投資額を従来中型 CVT ライン比 1／2 へ下げるとともに，フレキシブル性も向上させた．

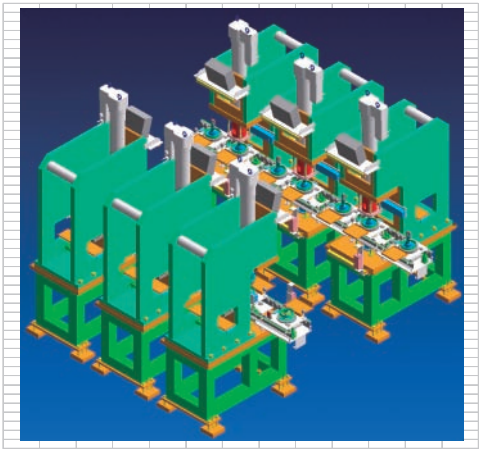


Fig. 22 Simple and compact machines

テスト工程では各構成部品・工程の工程能力向上活動をおこない，保証工程と方法の見直しをし，要求品質を確保しつつテスト設備台数の半減を両立した．

これらシンプル化・小型化・設備台数削減は，動力資源の削減にも貢献している．

2.4.2. 加工工程の取り組み

加工工程では既存資源（設備）の最大活用をコンセプトとし，ケース・プーリ・ギヤ加工設備全体で約 9 割を既存設備転用とした．

また同席設計による生産設計活動のフロントローディングで，部品仕様への加工代削減を織り込み，設備台数削減も同時に進めた．

プーリ加工ではシーブ裏鍛造肌化や軸端面鍛造肌化，研削長最小化，コロ溝削減等を部品仕様に織り込んだ結果，サイクルタイム 1／2 化が可能となり，設備台数を削減できた．

ギヤ加工ではダイバーシティ活動による既存機種部品との主要形状統合を促進し，結果既存機種とあわせ 3 機種混流生産を実現するとともに，新設備導入を防いで既存設備・ラインの最大活用をした．

ケース加工では切削工具のテンプレート化等による工具費低減を促進した．

これら部品小型化や鋳肌化による加工代削減は，設備台数の削減，消費電力の削減，廃棄する油や工具の削減にもつなげることができた．

was shortened and the use of manual transport eliminated the need for any drive system.

Smaller, general-purpose press machines and other facilities powered by electric motors were installed on the main assembly line (Fig. 22). In addition, mechanisms not requiring any motive power were combined with jigs to eliminate various equipment, thereby achieving a shorter line with a smaller footprint. These measures reduced the capital investment in facilities to one-half the amount required previously for a midsized CVT line and they also improved flexibility.

In the testing processes, activities were undertaken to improve the capacity of the test process for each component part. Test methods were revised along with those of the quality assurance processes so that the required quality could be assured, while at the same time reducing the number of test facilities by half.

These efforts to simplify and downsize the facilities and decrease their number also contributed to reducing the power sources needed.

2.4.2. Machining process activities

Existing facilities were diverted for approximately 90% of the overall equipment used for machining the case, pulleys and gears of the JF015E. The idea was to maximize the utilization of existing resources (facilities) in the machining processes.

Efforts were also made at the same time to promote the front-loading of design for production based on simultaneous design activities. As a result, reduction of the machining stock was incorporated into the part specifications, making it possible to reduce the number of facilities needed.

The cycle time in the pulley machining process was halved by incorporating various measures in the part specifications, enabling the number of facilities to be reduced. The measures included near-net-shape forging of the sheave backside and the shaft end faces, minimizing the grinding length and reducing the number of roller grooves.

Activities were undertaken to accommodate greater diversity in gear machining processes. Principal gear shapes were unified with those of the parts of existing CVTs. As a result, mixed production was achieved for the gears of three models, including existing CVTs. Moreover, maximum use of the

2.4.3. 熱処理工程の取組み

熱処理工程では『トンネル生産の追及』をキーワードに取り組んだ.

ギヤ・プーリともに，既存設備を 100% 流用し，投資を最小とした. 特にプーリにおいては, 熱処理シミュレーション等のツールを活用することで，歪（曲がり）を抑制する熱処理治具設計・条件設定をおこない, CVT として初の曲がり直し工程の廃止を達成した. (Fig. 23)

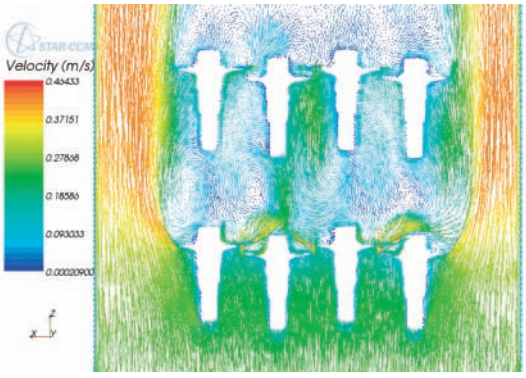


Fig. 23 Heat treatment simulation

2.4.4. 鋳造工程の取り組み

鋳造工程では生産準備リードタイム短縮を目指した取り組みをおこなった.

Fig. 24 IT tool used for cycle time reduction

生産設計活動における各種ＩＴツールの効果的な活用（Fig. 24) ならびに，ダイカスト金型製作における新技術（直彫り）適用により，金型準備リードタイムを従来実績比で，1.3 ヶ月短縮した.

また直彫り化によって，従来発生していた産業廃棄物（放電加工用電極材料）の大幅削減（−800 ﾘｯﾄﾙ／型）も達成した.

existing facilities and line avoided the need to install any new equipment.

In the case machining process, the use of templates with the cutting tools worked to reduce the tool cost.

The downsizing of parts and the reduction of machining stock through near-net-shape casting also led to reductions in the number of facilities, power consumption, waste cutting fluid and number of tools used.

2.4.3. Heat treatment process activities

The activities undertaken in heat treatment processes were focused on the pursuit of a transfer tunnel production system. Existing facilities were diverted 100% for the gears and pulleys of the JF015E so as to minimize capital investment in new equipment. A heat treatment simulation program was one of the tools used specifically for the pulleys to design heat treatment jigs and conditions that would suppress bending of the shaft (Fig. 23). As a result, the JF015E is our first CVT for which the pulley shaft straightening process has been eliminated.

2.4.4. Casting process activities

Activities were undertaken in the casting process with aim of shortening production preparation lead time. Various types of IT tools (Fig. 24) were effectively utilized in design for production activities and new technologies such as direct machining were applied in manufacturing the die casting dies. As a result, the lead time for preparing the dies was shortened by 1.3 months compared with previous projects.

In addition, direct machining also greatly reduced the volume of industrial waste (EDM electrode material) that occurred previously. The reduction amounted to 800 liters per die.

2.4.5. Plastic forming process activities

As a cost-cutting measure, the amount of material used for the pulleys was reduced by adopting a hermetically sealed forging process. In addition, near-net-shape forging of the sheave backside and reduction of the machining stock helped to reduce the process cycle time and the number of facilities needed.

Moreover, a cold forging operation was achieved in

2.4.5. 塑性加工工程の取り組み

コスト削減の取り組みとして，プーリの密閉鍛造化による材料使用量の削減をおこなった．

またシーブ裏等の鍛造肌化や取代削減により，加工サイクルタイム削減および設備の削減に貢献した．

さらに機械加工の難しいプーリ軸部の内径スプラインについてサイマル活動・新技術新工法 DR をおこない，加工工程内での冷間鍛造化を実現した．

2.5. 部品調達活動

近年，自動車業界は，全需の落ち込み／軽自動車へのシフト，原材料の高騰，販価競争の激化等の環境変化の渦の中にいる．

そのような中で，この JF015E は軽自動車と小型車に搭載されるためコスト競争力向上も最重要課題であった．

このため，ユニット原価についても今まで以上に厳しい目標を設定し，原価の 6 ～ 7 割を占める購入品の目標達成に向け諸活動を実施した．

特に発注先選定活動において，以下の視点での取り組みを実施することで，原価目標の達成に繋げることができた．

1) 他ユニットとの Bundling Sourcing

新小型 CVT だけでなく，他ユニットの発注先選定と組み合わせることで，まとめ発注によるコスト低減を追求した．

2) LCC（Leading Competitive Country）活用

中国，ASEAN 等の労務費競争力の高い地域にあるサプライヤから競争力のある部品調達を推進した．その結果として購入品の約 4 割が LCC サプライヤからの調達となった．(Fig. 25)

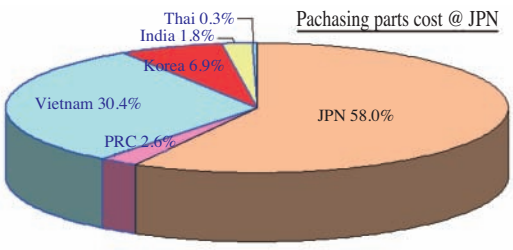


Fig. 25 LCC supplier region

the machining process for the difficult-to-machine spline on the inner diameter of the pulley shaft. That was accomplished through simultaneous engineering activities and a design review of new technologies and methods.

2.5. Parts procurement activities

The automotive industry has faced a maelstrom of changes in the operating environment in recent years, including declining vehicle demand, a shift to mini-vehicles, sharp increases in material costs and intensifying price competition, among other things. Given this situation, a priority issue was to improve the cost competitiveness of the JF015E so as to make the unit usable on both mini-vehicles and small cars.

Toward that end, a more severe unit cost than ever before was set for the JF015E. Rigorous activities were undertaken to achieve the targets set for purchased parts which account for 60-70% of the total cost. The following activities in particular were conducted in the course of selecting suppliers, which led to the attainment of the overall cost target.

1) Bundling sourcing with other CVT models
   Cost reductions were pursued through bundling sourcing whereby suppliers were selected not just for the new small JF015E but in combination with the selection of suppliers for other units as well.
2) Leading competitive country (LCC) program
   Procurement of parts with ample competitiveness was promoted from suppliers in China, ASEAN countries and other areas having high labor cost competitiveness. As a result, approximately 40% of the purchased parts are being procured from LCC suppliers (Fig. 25).
   Japanese, American and European suppliers have been establishing local operations in LCCs in recent years, accompanying the establishment of assembly plants by Japanese, American and European automakers and the growth of indigenous vehicle manufacturers. These moves have also improved the technical capabilities of indigenous suppliers. In short, the competitiveness of suppliers in LCC regions has improved markedly compared with before, and there are expectations of their potential for further improvement of their competitiveness.

近年，日米欧カーメーカーの現地進出／現地カーメーカーの成長にともない，日米欧サプライヤの現地進出が進み，現地サプライヤの技術力も向上している．

すなわち，LCC 地域のサプライヤの競争力は以前に比較し格段に向上しており，更なる競争力向上のポテンシャルも期待できる．

一方，日本では人件費のアップや合理化余地の減少により，競争力は急速に低下している．

このような状況下で，競争力を確保するためには，LCC 地域のサプライヤの活用が今後，益々重要になってくると考える．

3. まとめ

本ユニットは軽から小型まで　国内および海外の拠点での数多くの生産が計画され，JF011E と並び当社の収益の柱となる．本稿で述べたように他社製品と比べて極めて競争力の高い商品であり自信を持って市場投入するものである．

In contrast, supplier competitiveness in Japan has been declining rapidly owing to increased labor costs and the reduced latitude for further rationalization of their operations. Under these circumstances, it is expected that the use of suppliers in LCC regions will be increasingly important in the coming years with respect to ensuring competitiveness.

3. Conclusion

The FJ015E will be used on many vehicle models, from mini-vehicles to small cars, planned for production at plants in Japan and overseas, making it a mainstay pillar of JATCO's profitability along with the JF011E. We have put this new CVT on the market with the confidence that it has exceptionally high competitiveness compared with other companies' products, as described in this article.

■ Authors ■


Toshiki OHARA


Junichiro TATEISHI


Seiji OHNISHI


Kenichi MAKITA


Akira SHIMADA


Satoshi TERADA


Masami FUKUI


Masatsugu ENDO


Yuusuke TACHIBANA


Tomoaki SHIRAMIZU

前輪駆動用新型 4 速自動変速機の紹介

New 4-speed Automatic Transmission for Front-wheel-drive Vehicles

榊原　優* Yu SAKAKIBARA　岩谷　芳美* Yoshimi IWAYA　朝原　健仁* Takehito ASAHARA　脇　博宣* Hironobu WAKI

抄　録　ジヤトコ(株) は, グローバル市場をターゲットに，小型・軽量・低フリクション化を目的とした前輪駆動用新型 4 速自動変速機（以下，新型 FF4AT）を開発した.
本稿では，この新型 FF4AT の商品コンセプトとその詳細，および V-3P の取り組みについて紹介する.

Summary　JATCO developed a new 4-speed automatic transmission (JF414E) for use on front-wheel-drive vehicles, aiming for a compact, light-weight, low-friction unit suitable for global markets. This article describes the product concept and details of the JF414E, along with the V-3P activities carried out in the development process.

1. はじめに

近年，地球環境問題がクローズアップされ，車輌の省燃費化に対するニーズが高まってきている．また，コンパクトなエンジンルームに搭載可能とするために，AT の小型化も求められている.

本稿では，これらの要求を満足する新型 FF4AT の商品コンセプトとその詳細，および V-3P の取り組みについて紹介する.

2. 開発の狙い

新型 FF4AT は以下を主要コンセプトに掲げ開発した.

1) 軽量・コンパクト化（搭載性向上）
2) 低コスト化
3) 低フリクション化（省燃費）
4) 変速性能の向上

3. 主要諸元

新型 FF4AT の外観図を Fig. 1 に，従来の FF4AT（以下，F03B）との諸元比較を Table 1 に示す.

1. Introduction

The focus on global environmental concerns in recent years has heightened the need to improve vehicle fuel economy. There are also demands to downsize automatic transmissions for easier mounting in smaller engine compartments.

This article describes the product concept and details of the JF414E that has been developed to meet these requirements, as well as the V-3P (Value Up Innovation of Product, Process and Program) activities undertaken for this new 4-speed AT.

2. Development Aims

The JF414E was developed around the following principal concepts.

(1) To reduce the weight and size for improved vehicle mountability
(2) To lower the cost
(3) To reduce friction for improved fuel efficiency
(4) To improve shift performance

3. Major Specifications

The appearance of the JF414E is shown in Fig. 1, and its major specifications are compared with those of the existing F03B 4-speed AT for front-wheel-

* 商品開発室
Product Development Department

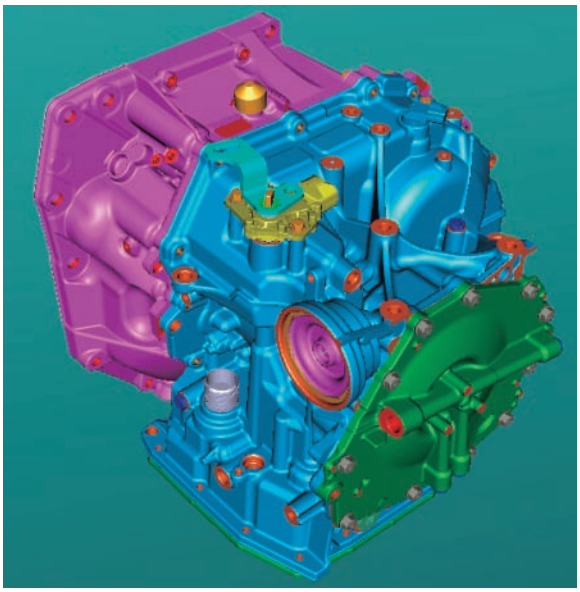


Fig. 1 Appearance

4. 軽量・コンパクト化

新型 FF4AT は F03B に対して，燃費と搭載性向上のため，クラッチとワンウェイクラッチを各々 1 セット削減（Table 2）し，レイアウトの改善，各部品のコンパクト化技術（Table 3）と併せて，全長で約 43mm の短縮，重量で約 10kg の軽量化を実現した．また，パッケージングの小型化により，約 32%の ATF 油量低減を実現し，軽量化に貢献した．

Table 2 Comparison between new FF4AT and F03B

Number of Components	New FF4 AT	F03B
Planetary Gears	2	2
Clutches & Brakes	5	6
One-Way Clutches	1	2

5. 低コスト化

前述の部品点数削減と軽量・コンパクト化によるコスト低減の他に，F03B や他ユニットとの部品共用化でコスト低減した部品と，新設計でコスト低減した部品とを最適に組み合わせる（部品新設率は全体の 36%）ことで，徹底的な低コスト化を実現した．

6. 省燃費化

6.1. 低フリクション化

新型 FF4AT では低フリクション化を実現するため

drive cars in Table 1.

Table 1 Comparison between new FF4AT and F03B

		New FF4AT	F03B
Torque capacity		150 Nm	←
Planetary gear ratios	1st	2.861	←
	2nd	1.562	←
	3rd	1.000	←
	4th	0.697	←
	Rev	2.310	←
Final gear ratio		3.410～4.351	3.605～4.342
Overall length		344.2 mm	387.5 mm
Weight (wet)		58 kg	68 kg
Distance between 1st and 3rd shafts		183 mm	186 mm

4. Reduction of Weight and Size

For the purpose of improving fuel efficiency and vehicle mountability, the JF414E is built with one less clutch-brake set and one less one-way clutch than the F03B (Table 2). The layout was also improved and the measures listed in Table 3 were taken to downsize various components. As a result, the JF414E is approximately 43 mm shorter in overall length than the F03B and weighs about 10 kg less. In addition, downsized packaging allowed the automatic transmission fluid (ATF) volume to be reduced by approximately 32%, which also contributes to the lighter weight.

Table 3 Technologies contributing to weight savings and compactness

	Part	Item	Downsizing	Weight Reduction
①	Case	3D optimization analysis		●
②	Torque Conerter	Ultra-flat in length	●	●
③	Control Valve	Minimization of size	●	●
④	Output Gear	Optimization of position		●

5. Lower Cost

Cost savings were attained by sharing parts with the F03B and other units. Further cost reductions were achieved by redesigning approximately 36% of all the parts. Both groups of parts were optimally combined for thorough-going cost reductions, in addition to the lower costs achieved by reducing the part count, weight and size, as described above.

6. Improvement of Fuel Efficiency

6.1. Reduction of friction

Detailed studies were made of the components of the JF414E with aim of reducing friction levels. As a

に，構成部品の細部に渡って検討を行ない，ユニットトータルで約 40%のフリクション低減を実現した.

以下に，フリクション低減のために採用した主な項目を説明する.

6.1.1. オーバーランクラッチ廃止

オーバーランクラッチの廃止により, ドラグトルク(解放時）と，シールリング抵抗（締結時）を低減した.

6.1.2. 油攪拌抵抗の低減

リダクション軸の上方配置と，バッフルプレートの採用，および ATF 油量低減効果により，油の攪拌抵抗を低減させた.

6.1.3. ドライブプレート油溝形状の改良

ロークラッチとローアンドリバースブレーキのドライブプレート油溝形状を改良し，油の排出性を向上させて，ドライブプレート，ドリブンプレート間の引き摺りトルクを低減した.

6.1.4. オイルポンプの駆動トルク低減

オイルポンプギヤのサイドクリアランスを最適化することで，オイルポンプの駆動トルクを低減した.

6.1.5. 省燃費 ATF EJ-1 の採用

従来 ATF に比べて，粘度を約 25%低減させた省燃費 ATF EJ-1 を採用し，フリクション低減を行った.

6.2. ロックアップ制御

燃費向上のため, 新型 FF4AT では, 2 速からのロックアップを可能とした． また, 2 速からのスリップロックアップ制御により，運転性の改善と燃費向上の両立を図った.

6.3. ニュートラルアイドル制御

車輌停止時，セレクトレバーが D レンジにあってもブレーキを踏んでいる時は，前進のためのクラッチを開放し AT 内部をニュートラル状態に近づけることで，アイドリング状態でのエンジン負荷を軽減し燃費を向上させる“ニュートラルアイドル制御” を可能とした.

result, the total friction of the unit was reduced by approximately 40%. The major measures adopted to reduce friction are explained below.

6.1.1. Discontinuation of overrun clutch

Discontinuation of the overrun clutch has reduced drag torque at the time of release and seal ring resistance at the time of engagement.

6.1.2. Reduction of ATF churning resistance

Fluid churning resistance was reduced by positioning the reduction shaft higher, by adopting a baffle plate and by the effect of reducing the ATF volume.

6.1.3. Improvement of oil groove shape of low clutch and low & reverse brake

The shape of the oil grooves in the low clutch and low & reverse brake was improved for better fluid drainage, thereby reducing drag torque between the drive and driven plates.

6.1.4. Reduction of oil pump drive torque

The drive torque of the oil pump was reduced by optimizing the side clearance of the oil pump gear.

6.1.5. Adoption of fuel-efficient EJ-1 ATF

The fuel-efficient EJ-1 ATF, with approximately 25% lower viscosity than the previous ATF, was adopted to reduce friction.

6.2. Lockup control

The JF414E allows torque converter lockup from second gear for improved fuel economy. In addition, the application of slip lockup control from second gear improves both driveability and fuel economy.

6.3. Neutral idle control

Neutral idle control releases the forward clutch when a vehicle is stopped and the brake pedal is depressed, even though the selector lever is in Drive. This creates a state inside the transmission that resembles neutral, which reduces the engine load during idling to improve fuel economy.

7. 変速性能の向上

2 つのクラッチと 2 つのブレーキを 3 個の大容量 3 方リニアソレノイドで直接コントロールすることで，適切な変速と最適な運転性能を実現した．また大容量 3 方リニアソレノイドの採用は，バルブ本数を削減し，非常にコンパクトなサイズのコントロールバルブ（約 31%の軽量化）の実現にも貢献した．

8. V-3P の取り組み

8.1. V-3P の適用成果

新型 FF4AT のプロジェクトは，開発の初期段階より V-3P を適用しクロスファンクショナルな活動を行うことで，V-3P 適用プロジェクトとして大きな成果を上げることができた．以下に，その主な項目を説明する．

8.1.1. DMDR (Digital Mockup Design Review)

V-3P オペレーションの中で，DMDR の実施により，デジタルロットで作り込み，検証・評価をすることで，開発初期のデジタルフェーズ内で早期に課題を抽出し対策することができた．また DMDR の実施にあたっては，以下の取り組みや，ツールの活用，および IT 化も行った．

8.1.2. データユニテック

3D モデルを活用したデジタル試作を行ない，部品設計・生産技術・工場関係者等が同席にて 3D データを基に生産性を確認する“データユニテック” を行った（Fig. 2）．これにより，開発と生産間の相互理解を深め，難作業の改善や生産要望を取り入れた設計など，クロスファンクショナルな取り組みでプロジェクトを推進した．

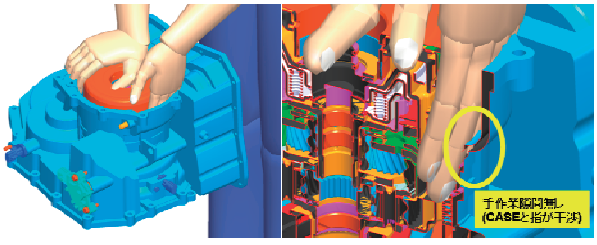


Fig. 2 Typical example of Data UNITEC application No space for manual work (interference between case and fingers)

7. Improvement of Shift Performance

Two clutches and two brakes are directly controlled by three large-capacity 3-way linear solenoids, which achieves suitable shifting and optimal driveability. The adoption of large-capacity 3-way linear solenoids also reduced the number of valves, thereby contributing to the exceptionally compact size of the control valve, which is approximately 31% lighter than the previous one.

8. V-3P Activities

8.1. Results of applying V-3P program

V-3P methods were applied to the JF414E project from the initial development stage to carry out cross-functional activities. This produced significant results for a project conducted under the V-3P program. The major V-3P activities are explained here.

8.1.1. Digital mockup design review (DMDR)

Among the V-3P activities, this design review involves the creation, validation and evaluation of a digital transmission model, making it possible to identify and solve issues early in the digital phase of the development process. The following discussion explains the activities undertaken, the tools used and the creation of IT tools.

8.1.2. Data UNITEC study

A Data UNITEC (Unit Trial Production Meeting) study was conducted in which digital prototyping was performed using 3D models (Fig. 2). In this study, parts designers, production engineers, plant personnel and other people involved worked together to confirm productivity on the basis of 3D data. As a result, it promoted better mutual understanding between product development and production personnel. This led to a product design that improved difficult assembly tasks and incorporated the desires of the production side. The JF414E project was promoted through this kind of cross-functional teamwork.

8.1.3. Use of potential issues list (creation of IT tool)

The potential issues list was digitized in a renewed effort to make it easier to use. The development of

8.1.3.　不懸リストの活用（ツールの IT 化）

不懸リスト（不具合懸案リスト）の使い易さ向上のため，新たに“不懸リストの IT 化”に取り組んだ．

この IT ツールの開発により，「課題の見える化・共有化」と「入力・検索等の作業能率向上による業務効率化」を実現することができ，開発・生産部門の枠を超えて課題を共有化することで問題の早期解決を図ることができた．（Fig. 3）

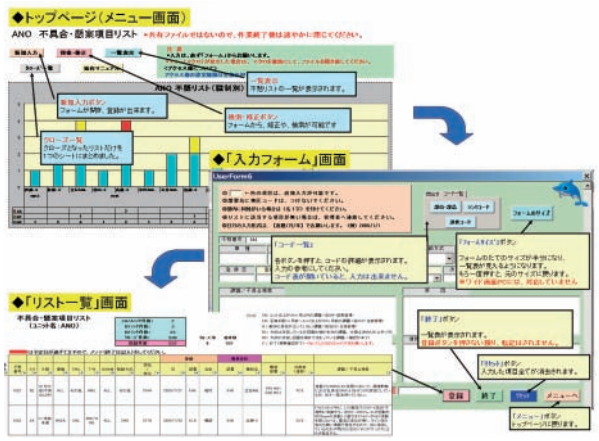


Fig. 3 Potential issues list manual

8.1.4. 統合仕様表の活用（ツールの IT 化）

要求仕様，設計検討項目決定の見える化により，検討精度向上，手戻りの削減が図れた．

8.1.5. 設計変更手配管理リストの活用（ツールの IT 化）

V-3P の重点目標の 1 つである正規手配以降の設計変更ゼロ化の取り組みとして，変更が発生した手配は“設変管理リスト”で一元管理・見える化し全社で共有化した．これにより，スムーズな設変対応を取ることができた．

8.2. 組立体験会，オフサイトミーティング

工場試作段階の実際の組立ラインに，開発担当者が入り組立作業を自ら体験することで，自身が設計したものを実感し，新しい原低アイディアを発掘することができた．この組立体験会は，ジヤトコとして初の試みであり，ボトムアップ的に企画が生まれ，生産と開発の相互理解を深められた成功体験の一例である．

また組立体験後のオフサイトミーティングでは，製造部門，開発部門，商品企画部門を含めたクロスファ

this IT tool has improved workplace efficiency by enabling employees to work more efficiently, including the visualizing and sharing of issues as well as data input and retrieval. It is now possible to solve problems more quickly because issues can be shared cross-functionally between the product development and production departments (Fig. 3).

8.1.4. Use of integrated specification tables (creation of IT tool)

The accuracy of design studies was improved and the amount of rework was reduced by making visible the required specifications and the process for determining the items to be examined in design studies.

8.1.5. Use of design change management list (creation of IT tool)

One of the key goals of the V-3P program is to have zero design changes after the official design release. A design change management list was created for centralized control of design drawings that have been changed. This list makes design changes visible, enabling them to be shared throughout the company, which facilitates their smooth accommodation.

8.2. Hands-on assembly experience and off-site meeting

At the plant production trial stage, the product developers responsible for the JF414E worked on the actual assembly lines and personally experienced the assembly operations. That gave them first-hand experience with the parts they had designed, and it led to the discovery of new cost-cutting measures. This was JATCO's first attempt at hands-on assembly experience and it gave birth to bottom-up initiatives. This is one example of success in deepening mutual understanding between product development and production personnel.

After the hands-on assembly experience, the cross-functional team members from manufacturing, product development, product planning and other departments held an off-site meeting. Through their discussions they came up with various measures for reducing costs and improving the ways assembly work is done. This unified activity formed stronger

ンクショナルなメンバーで「原価低減や仕事のやり方改善」のアイディアを出し合うことで更なる信頼関係が醸成され, 今後につながる一体感のある活動となった.

9. まとめ

軽量・コンパクト化，低コスト化，省燃費化，運転性向上を目標に新型 FF4AT を開発した.

1) レイアウトの改善，各部品のコンパクト化技術の採用，ATF 油量低減により，軽量・コンパクト化を実現した.
2) 部品点数削減，部品共用化と部品新設の最適組み合わせにより，低コスト化を実現した.
3) フリクション低減アイテムの採用とロックアップ領域の拡大等により，燃費性能向上を実現した.
4) 大容量 3 方リニアソレノイドによるクラッチ，ブレーキ圧の直接コントロールにより，スムーズな変速性能を実現した.

最後に新型 FF4AT の開発，並びに製品化にあたり，多大なご協力をいただいた社内外の多くの方々に深く感謝いたします.

ties of mutual trust that should lead to further results in the future.

9. Conclusion

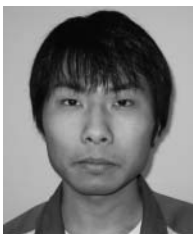
The JF414E was developed with the aims of reducing the weight and size, lowering the cost, improving fuel efficiency and enhancing driveability.

(1) A lighter, more compact AT was achieved by improving the layout, adopting measures to downsize various parts and reducing the ATF volume.
(2) Cost savings were achieved through an optimum combination of measures that included part count reductions, sharing of parts with other ATs and redesigning of parts.
(3) Fuel efficiency was improved by implementing measures for reducing friction and by expanding the lock-up operating range, among other improvements.
(4) Using large-capacity 3-way linear solenoids to directly control clutch and brake hydraulic pressures provides smooth shift performance.

Acknowledgments

The authors would like to thank many individuals inside and outside the company for their tremendous cooperation in connection with the development and commercialization of the JF414E.

■ Authors ■


Yu SAKAKIBARA


Yoshimi IWAYA


Takehito ASAHARA


Hironobu WAKI

究極のハイブリッド用変速機の実現に向けた取り組み

Activities to Achieve the Ultimate Hybrid Transmission

石井　繁* Shigeru ISHII　大曽根　竜也* Tatuya OSONE　平林　雄二** Yuji HIRABAYASHI　三戸　康裕* Yasuhiro MITO　山中　剛*** Tsuyoshi YAMANAKA

抄　録　本稿ではハイブリッド用パワートレンとして、変速機の基本諸元値である，レシカバ，フリクションに注目してハイブリッド化の燃費ポテンシャルを最大限発揮できる変速機の要件について述べる.

Summary　This article presents a study of an ideal hybrid transmission, focusing on ratio coverage and friction as fundamental transmission specifications. It describes the requirements of a transmission capable of maximizing the fuel economy potential obtainable with a hybrid powertrain system.

1. ハイブリッド（HEV）技術を取り巻く環境

'97 年市場投入された HEV 車は，今年累計 200 万台の販売を達成した.（トヨタ調べ）今や政府の環境政策（エコ減税）等の後押しも受け，“ECO”技術として拡大期を迎えつつあると言っても過言ではない.

この為，燃費，動力性能，低コストを高い次元で両立し，かつ広いラインアップ搭載が可能なハイブリッドシステムの登場が強く待たれている.

そこで，HEV 化による，燃費ポテンシャルを最大化する為に，変速機の基本諸元であるレシカバとフリクションについてパラメータスタディを行い，理想の変速機像について検討した.

2. HEV の燃費効果の仕組み

HWV システムの燃費改善は，次の 2 点に因ると考えられる.

2.1. 車両減速エネルギの回収による燃費改善

2.1.1. エンジンフリクション，TM 効率と燃費改善代

図 -1 に車速毎の回生エネルギの大きさとその内訳を示す.

1. Environment Surrounding HEV Technology

According to a survey done by Toyota, cumulative sales of hybrid electric vehicles (HEVs) reached the two million mark in 2009 since they were put on the market in 1997. It would be safe to say that HEVs are currently undergoing a period of expansion as an eco-technology. One of the factors driving this expansion is the government's environmental policy of providing a tax break on eco-friendly vehicles.

Consequently, there are strong expectations for the appearance of hybrid systems that achieve an optimum combination of fuel economy, power performance and low cost and can be applied to a wide lineup of vehicles. We conducted a parametric study of the ideal hybrid transmission using the fundamental transmission specifications of ratio coverage and friction as the parameters. The aim of this work is to maximize the fuel economy potential obtainable by adopting a hybrid system.

2. Fuel Economy Benefits of an HEV System

The effects of an HEV system on improving fuel economy are assumed to be ascribable to the following two factors.

2.1. Fuel economy improvement by recovering the vehicle's kinetic energy during deceleration

* 商品開発本部 Product Development Department
** プロジェクト推進室 Project Promotion Office
*** 日産自動車パワートレイン開発本部 Powertrain Engineering Division, Nissan Motor Co., Ltd.

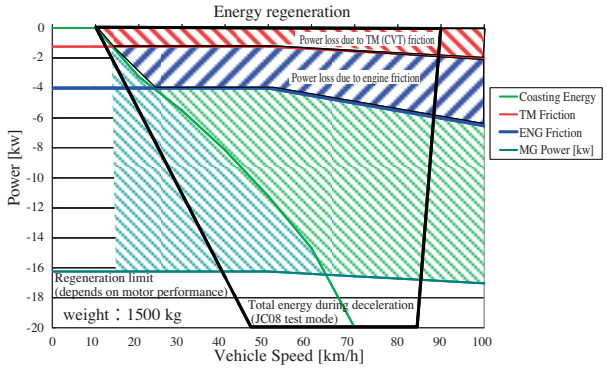


Fig. 1

パワートレーンとしては，T／M フリクション，ENG フリクションによる影響が大きいことが分かる．図 -2 にこれらの要因に対する燃費改善率を示す．エンジンの継断が可能な，1 モータ 2 クラッチの優位性が高い事が分かる．一方変速機効率の改善も重要な事がわかる．

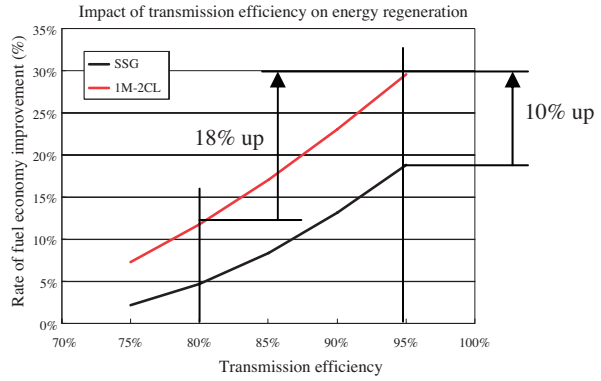


Fig. 2

変速機効率の影響が大きいのは，図 -3 に示すように，変速機を経由する度に回収量が減少してゆくからである．

表 -1 に主要モードにおける，回収に基づく燃費改善代を示す．平均車速の低いモード程改善効果は大きく，1 モータ 2 クラッチで，約 12 ～ 25%程度の改善が見込まれる．

2.2. エンジン最良燃費点での運転による燃費改善

2.2.1. 最良燃費点運転の効果

HEV ではエネルギ貯蔵が可能な為，EV 走行に備えてエンジン運転時に，充電付加を加える事で最良燃費点での運転が可能になる．ベースの運転点や充

2.1.1. Fuel economy improvement related to engine friction and transmission efficiency

Figure 1 shows the amount of energy regenerated at various vehicle speeds and the share attributable to different factors. With regard to the powertrain, transmission friction and engine friction have a large impact on fuel economy.

Figure 2 shows the rate of improvement in fuel economy ascribable to these factors. The results indicate the outstanding superiority of a one-motor-two-clutch (1M-2CL) system that allows the engine to be engaged and disengaged.

It is also clear that improving transmission efficiency is important as well. The reason why transmission efficiency has a large impact is that the quantity of energy recovered is reduced every time it passes through the transmission, as can be seen in Fig. 3.

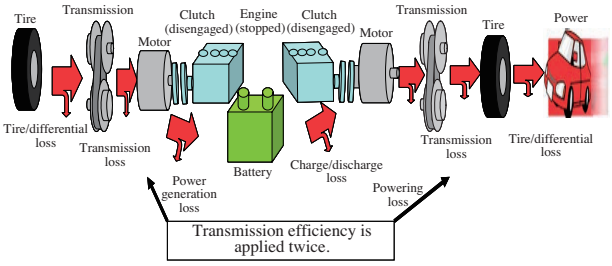


Fig. 3

Table 1 shows the amount of improvement in fuel economy based on energy recovery during vehicle operation in several major test modes. The effect on improving fuel economy increases as the average vehicle speed decreases. Improvement of approximately 12-25% can be expected for the one-motor-two-clutch system.

Table 1

Test mode	Recovered energy (kJ)		Fuel economy improvement (%)	
	SSG	1M-2CL	SSG	1M-2CL
JC08	**481**	**1509**	**- 7.8**	**- 24.6**
LA4	**769**	**1794**	**- 8.2**	**- 19.1**
HWY	**574**	**1202**	**- 5.8**	**- 12.1**

2.2. Fuel economy improvement obtained by operating the engine at its most fuel-efficient point

2.2.1. Effect of operating engine at its most fuel-efficient point

放電効率により効果代は変わるが，大きな改善効果が期待出来る.(図 -4, 図 -5)

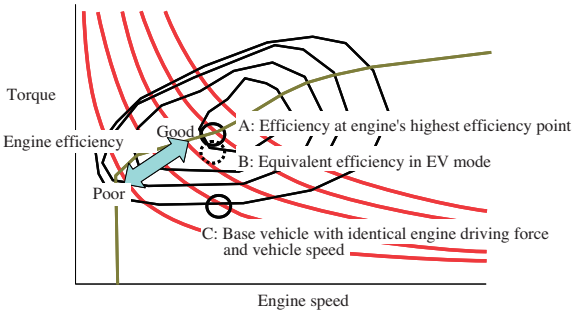


Fig. 4

EV走行による燃費改善率 ＝

$$1 - \frac{B \times EV走行率 + A \times ICE走行率}{C}$$

＊ B ＝ A×充放電効率

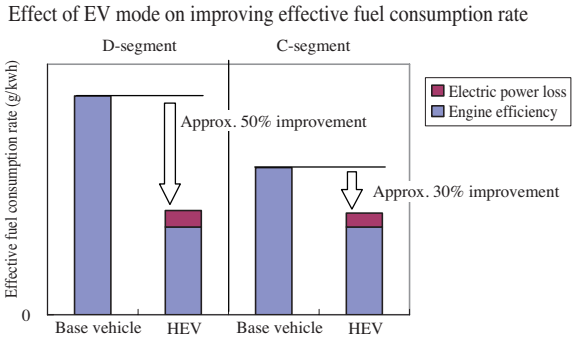


Fig. 5

2.2.2. レシカバと燃費改善効果

図 -6 に伝達効率，レシカバと燃費改善効果の関係を示す．平均車速の低いモードでは，前述の回収効率の影響が大きくレシカバより伝達効率の改善効果が大きい．一方 HWY では，エンジン効率が良くなるため伝達効率よりレシカバの選択を適切に行う方が燃費改善効果は大きい.

3. 理想のハイブリッド用変速機要件

上記要求に基づき，現状の変速機について得失をまとめると表 -2 のようになる.

Since an HEV allows energy storage, the engine can be operated at its most fuel-efficient point during the engine-propelled mode by adding the load for charging the battery, in preparation for subsequent EV mode operation. While the benefit varies depending on the base operating point and battery charge-discharge efficiency, a large improvement in fuel economy can be expected (Figs. 4 and 5).

Rate of fuel economy improvement due to EV mode =

1 - B x EV mode share + A x ICE mode share/C

where B = A x battery charge-discharge efficiency

2.2.2. Ratio coverage and fuel economy benefit

Figure 6 shows the fuel economy benefit as a function of transmission efficiency for three ratio coverage values. In the JC08 test mode conducted at a low average vehicle speed, the energy recovery efficiency discussed above has a large impact, and improvement of transmission efficiency has a greater effect on fuel economy than ratio coverage. In contrast, in the Highway mode, selection of a suitable ratio coverage value has a larger effect on improving fuel economy than transmission efficiency because of higher engine efficiency.

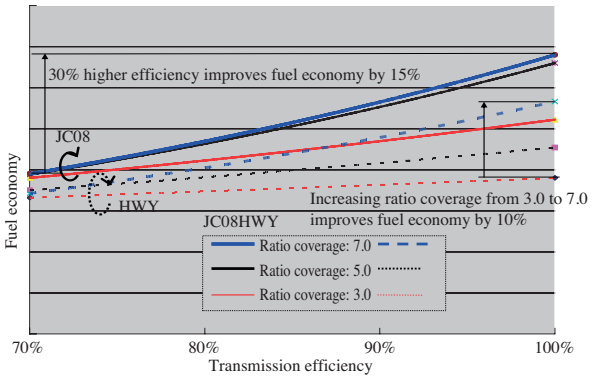


Fig. 6

3. Requirements of an Ideal Transmission for HEVs

Table 2 summarizes the relative advantages and disadvantages of various current transmissions with respect to the requirements mentioned above.

Table 2

	Torque-split type	DCT base	AT base		CVT base
			RWD	FWD	
City fuel economy	Good	Good	Good	Good	Fair
Highway fuel economy	Fair	Fair～Good	Good	Fair～Good	Good
Mountability/layout ability	Good	Poor	Good	Fair	Good
Cost	Fair	Fair	Good	Good	Good
Total	Fair	Poor	Good	Fair	Good

●エンジンの引きずり防止には，以下の図のような 1M-2 クラッチが効果的.

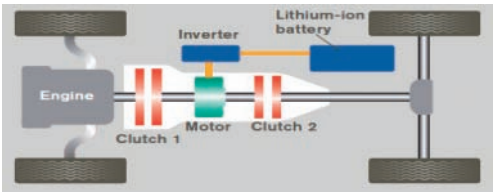


Fig. 7 One-motor-two-clutch system

●高速燃費を重視すれば, レシカバの広さがポイント
FR には，7 速 AT
FF には, コスト，搭載性も考慮して CVT が有利.

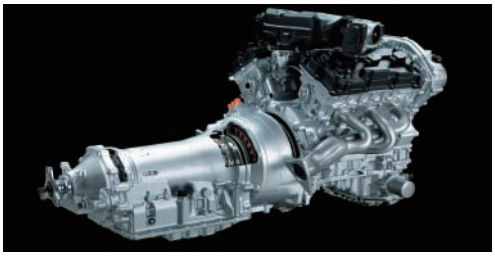


Fig. 8 Appearance of powertrain

4. 終わりに

ハイブリッド車両に対する，顧客満足度調査からは，一層の市街地燃費や高速燃費に対する改善要望の声が聞こえてくる．一方自分の買いたい車種にハイブリッドがある事等，車種展開に対応できる汎用性と低コストなシステムが待ち望まれている．本検討を通して回生量を改善する為には，変速機の効率改善や，そもそもの伝達効率を改善できるレイアウト等が重要な事が分かった．DCT も小型化が達成できればポテンシャルは高い事が判明した．さらに普及が見込まれる電動車両も視野に入れ新型変速機の製品化に向けて開発を推進してゆく所存である.

● The one-motor-two-clutch system is effective in preventing engine drag torque (Fig. 7).
● If priority is put on fuel economy in high-speed highway driving, wide ratio coverage is a key factor. A 7-speed automatic transmission is advantageous for rear-wheel-drive vehicles, whereas a CVT is better for front-wheel-drive vehicles, taking cost and vehicle mountability into account as well.

4. Conclusion

Customer satisfaction surveys concerning hybrid vehicles reveal that there are demands for further improvement of fuel economy in both city and highway driving. Meanwhile, there are desires for low-cost hybrid systems with broad applicability to a wide range of models, including wishes for the availability of a hybrid version of the car models individuals want to buy.

The results of this study indicate that improving transmission efficiency and the adoption of a layout that allows improvement of inherent power transfer efficiency are among the key factors for increasing the level of energy regeneration obtained. It was found that the dual clutch transmission (DCT) also has a high potential if it can be further downsized. We plan to move ahead with the development and commercialization of new types of transmissions, keeping in mind other electrified vehicles that are also expected to become popular in the future.

Fig. 9 Hybrid car

■ Authors ■


Shigeru ISHII


Tatsuya OSONE


Yuji HIRABAYASHI


Yasuhiro MITO


Tsuyoshi YAMANAKA

ECOを支える最新制御技術

Latest Control Technologies Supporting Eco-friendly Transmissions

野口　幸弘* Yukihiro NOGUCHI
高取　和宏* Kazuhiro TAKATORI
佐藤　理* Osamu SATO
若山　英史* Hideshi WAKAYAMA
田中　寛康** Hiroyasu TANAKA
泉　徹也*** Tetsuya IZUMI
城崎　建機* Tateki JOZAKI

抄　録　昨今，日々の生活の中でECOの文字を目にしない日は無く，当社においてもECOに貢献する商品を数多くお客さまに届けている．本稿では，車両のECO（燃費向上）を支えながら形として目に見え難いユニット制御技術と，実験評価技術に焦点を当て，最近の具体的実施事例を，解り易く紹介する．

Summary　Recently, a day has not gone by without seeing the word "eco" in everyday life. At JATCO, we supply our customers with many products that contribute to eco-friendliness. This article focuses on transmission control technologies and experimental evaluation technologies that support the eco-friendliness of vehicles by improving fuel economy, although they are not readily visible. It explains in simple terms several specific examples of such technologies that have been implemented lately.

1. はじめに

近年，全世界的な環境意識の高まりに加え，各国の低公害車への補助金制度導入により，商品としては「燃費がよい」ことが最大の競争力であり，必須条件となってきている．また，CO_2排出量規制も厳格化しており，開発・製造過程に排出されるCO_2の削減にも，取り組まねばならない状況となっている．

ここで，当社の環境対応技術について，Fig. 1に簡単に整理してみた．

これらの実現には影で支える制御技術が不可欠であり，ここ最近の燃費向上の多くは制御技術のおかげ，と言っても過言ではない．

本稿では，この中からいくつかの事例を紹介する．

2. 小型軽量化を支える技術

当社は，次世代CVTとして，従来のベルト＆プーリによる無段変速機構（以下，バリエータ

1. Introduction

Good fuel economy has become an essential requirement for products today and can be their biggest competitive edge. This situation has resulted from heightened environmental awareness worldwide in recent years and the introduction of subsidy programs for low-emission vehicles in many countries. Regulations on CO_2 emissions have also become tighter, making it necessary to take steps to reduce emissions of CO_2 in product development and manufacturing processes as well.

Figure 1 outlines JATCO's technologies for achieving environmentally friendly transmissions. The support of control technologies from behind the scenes is indispensable to the attainment of these measures. It would be safe to say that much of the recent improvement in fuel economy can be attributed to control technologies.

This article describes several typical examples of the control technologies applied to JATCO's transmissions.

* 制御システム開発部 Control System Development Department
** 実験部 Experiment Department
*** プロジェクト推進室 Project Promotion Office

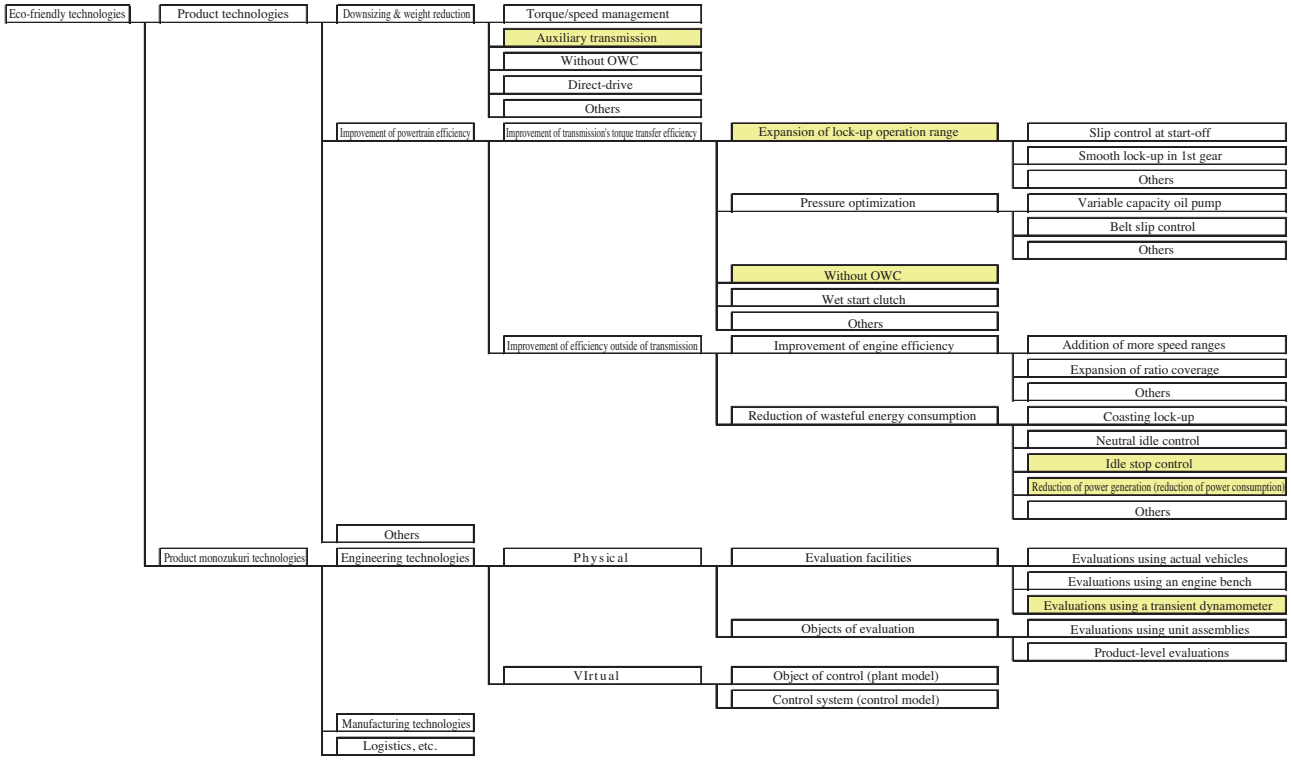


Fig. 1 JATCO's technologies for environmentally friendly transmissions

とする）に副変速機を組み合わせた，世界初の副変速機付き CVT を開発した．この構造の採用により，従来の CVT と比較して 20％以上変速比幅を拡大し，加速性能向上と燃費向上を両立した上で，小型軽量化を実現した．

この次世代 CVT を商品化する際の大きな課題の一つが，いかに副変速機を CVT と同じフィーリングで変速させるか，という点であり，そのために，次の 2 つの課題を制御技術で解決した．

2.1. OWC レスでのショックのない変速

副変速機は OWC 機能を廃止して小型軽量化を図っているため，変速時にクラッチにかかる油圧が適切でないと，容量過多による引きショック大や容量不足による吹け上がりに繋がる．クラッチトルク配分制御により，入力トルクに対する最適な各クラッチへのトルク配分をリアルタイムに行い，トルク－油圧特性を個体毎に最適化する学習制御により，最適な油圧を供給し，ショックレスを実現した．尚，学習制御については，生産技術チームと連携し，製造段階で精度よく学習できる仕組みを構築し，お客さまに渡す前に，所定の性能を達成できるようにしている．

2. Technologies Supporting Size and Weight Reductions

JATCO has developed the world's first CVT that features an auxiliary transmission. This next-generation CVT combines the auxiliary transmission with the conventional belt and pulley system that provides the stepless shift mechanism, i.e., variator. Compared with conventional CVTs, this structure widens ratio coverage by more than 20% and improves both acceleration performance and fuel economy, while achieving a smaller and lighter package.

One of the biggest challenges in commercializing this next-generation CVT was the question of how to shift the auxiliary transmission so as to provide the same shift feeling as an ordinary CVT. To accomplish that, the following two issues were resolved by means of the control technology.

2.1. Shock-free shifting without a one-way clutch

The one-way clutch (OWC) function was discontinued in the auxiliary transmission to achieve a smaller and lighter package. Consequently, if the pressure applied to the clutches during a shift is not suitable, excess capacity can induce large jerkiness or insufficient capacity can lead to engine flare-up.

2.2. クラッチ架け替えでエンジン回転段差のない変速

オートアップの場合を例にとると（Fig. 2），副変速機が Up シフトを始めると，副変速機の入力回転（＝バリエータの出力回転, 以下 Ns という）が低下し，それに伴い入力軸回転数（以下 Np という）も低下するので，エンジン回転の変化につながる．このとき，バリエータを Down シフトさせると Ns が上昇するので，先の Ns 低下を防ぐことができる．この原理に着目して，副変速機が変速する際にはバリエータを逆側に変速させ, 回転数フィードバック制御によってクラッチ圧を制御して，緻密に各回転数を合わせる協調制御を開発し，エンジン回転段差のない変速を実現した．

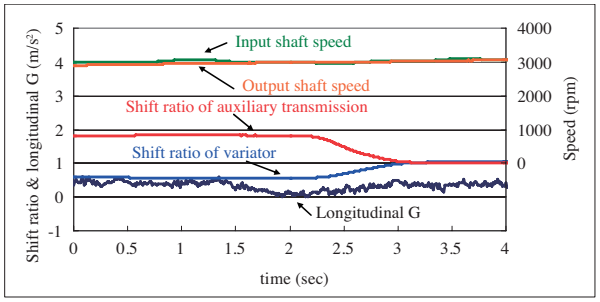


Fig. 2 1. Waveforms for automatic upshift

3. トランスミッションの効率向上技術

トランスミッションの伝達ロスの大きな要因の 1 つが，トルクコンバータの滑りによるトルク伝達ロスである．このロスを低減することで，伝達効率が向上し，大きな燃費向上効果を得ることができるが，その方策の 1 つとして，ロックアップ（以下 LU とする）領域の拡大があげられる．

しかし，LU 領域拡大を行うと，こもり音などの騒音や振動といった副作用が発生するため，この課題の解決が鍵である．これまで当社では，インテリスリップ制御を代表とするスリップ制御技術により，これらの問題を解決してきた結果，世界最高水準の LU 領域拡大を達成している．

更に燃費のよい商品をお客さまに提供するために，更なる LU 領域拡大に取り組んでいる．AT では，1 速から LU の締結を開始し（Fig. 3），CVT では，発進直後からの LU の締結を開始させる（Fig. 4）． これらを実現するために新たな

Clutch torque distribution control was adopted to distribute the optimal torque split to each clutch in real time in relation to the input torque. Adaptive learning control was applied to optimize the torque-pressure characteristic for each element, enabling the optimum pressure to be supplied to achieve shock-free shifting. In cooperation with the production engineering team, a system was put in place for tuning adaptive learning control accurately at the manufacturing stage so that the specified performance is achieved before the transmission is delivered to the customer.

2.2. Shifts free of engine speed discontinuities caused by switching of clutches

An automatic upshift is explained here as an example (Fig. 2). When the auxiliary transmission begins to upshift automatically, its input speed, i.e., variator output speed (Ns), decreases accompanied by a decline in the input shaft speed (Np) as well, causing the engine speed to change. Having the variator downshift at that time raises Ns, so that a decline in Ns can be avoided. Focusing on this principle, we developed a cooperative control technique that has the variator shift in the opposite direction of a shift by the auxiliary transmission and uses rotational speed feedback control to manage clutch pressures so as to precisely align the rotational speeds. This control achieves shifts free of engine speed discontinuities.

3. Technologies for Improving Transmission Efficiency

Torque transfer loss due to slipping of the torque converter is one of the major causes of transmission loss in automotive transmissions. Reducing the loss that occurs in the torque converter increases transmission efficiency, which has a large effect on improving fuel economy. One way to reduce that loss is to expand the range of lock-up operation.

However, expanding the lock-up operation range causes various side effects such as noise and vibration, including boom noise. Resolving these side effects is therefore a key issue. JATCO has previously solved these problems by applying slip control technology represented by intelligent slip control. As

技術開発を進めている．

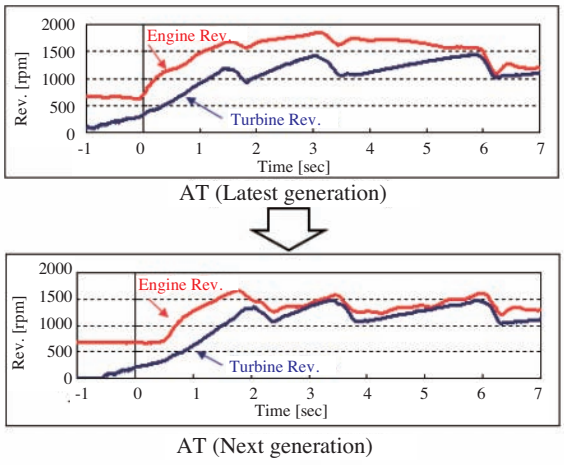


Fig. 3 Expansion of AT lock-up operation range

4. トランスミッション以外の効率向上技術

ここでは，無駄なエネルギー消費を減らすための技術を 3 つほど紹介する．

4.1. アイドルニュートラル

車両停車中の燃費向上手段として，D レンジ停車中のトルクコンバータ損失を低減させるために，前進クラッチを中間状態まで開放するものである．燃費効果の追求のためには，このクラッチを中間状態ではなく，完全開放状態にすることが望ましい．しかしながら，アイドルニュートラル状態からの発進時にはクラッチを再締結させる必要があるため，クラッチを完全開放させると締結までのクラッチストロークが長くなり発進レスポンスが低下する，これを防止するためにクラッチを急締結させるとショックが発生する．これらの問題を解決するため，アイドルニュートラル中のクラッチの状態を燃費と運転性が両立可能なストローク位置に管理するための学習制御や，スムーズな発進を実現するためのエンジンとのトルク協調制御が採用されている．

4.2. アイドルストップ

車両停止中の燃料消費そのものゼロにするためにエンジンを停止させるアイドリングストップ機構も普及しはじめている．D レンジでドライバがブレーキを踏んで止まっている際など，

a result, this has made it possible to achieve one of the widest lock-up operation ranges anywhere in the world.

We are working to expand the lock-up operation range even further so as to provide customers with more fuel-efficient transmissions. For our next-generation ATs, we want the lock-up clutch to engage from first gear (Fig. 3). For our next-generation CVTs, our goal is to have the lock-up clutch engage right after vehicle launch (Fig. 4). New technologies are now being developed to achieve that performance.

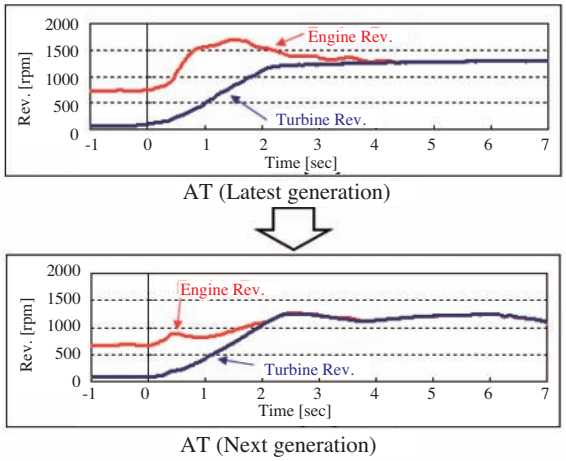


Fig. 4 Expansion of CVT lock-up operation range

4. Technologies for Improving Efficiency Outside of the Transmission

This section describes three control technologies for reducing wasteful energy consumption.

4.1. Neutral idle control

This control is a measure for improving fuel economy when a vehicle is stopped with the engine idling and the shift lever in the Drive position. This is done by disengaging the forward clutch to a state resembling neutral so as to reduce torque converter loss. In the pursuit of improved fuel economy, it would be desirable to disengage the clutch fully, rather than emulating a neutral state. However, that would mean re-engaging the clutch when starting off from the neutral idle state. Engaging the clutch from a fully disengaged state would require a longer clutch stroke, thereby degrading launch response. To avoid that, it would be necessary to engage the clutch

ドライバの発進意図がない場合には自動的にエンジンを切り，ブレーキを解放した際にはエンジンを自動的に再始動させる機構である．信号待ちなど，走行シーンの中に車両停車が占める割合の大きい都市部では，燃費向上のために非常に有効な手段である．

一般的に，AT／CVT のアイドルストップ機構にはアイドルストップからの発進レスポンスを向上させるために電動オイルポンプを追加している．エンジン停止中も電動オイルポンプで AT／CVT へ油圧を供給し，発進クラッチの締結状態を維持することで，エンジン再始動時のクラッチ締結制御を不要としている．こうすることで，エンジン始動と同時にエンジントルクを駆動力として伝達でき，アイドルストップからの発進においても違和感のないレスポンスを実現している．

4.3. ステップモータへの通電停止

近年，燃費向上アイテムの新たな切り口として，消費電力を削減することでオルタネータの発電量を減らすことができ，エンジンの負荷を減らすことが注目されている．ここでは，当社固有のアクチュエータであるステップモータ（以下 S／M とする）の消費電力に着目し，その通電を停止し消費電力を低減することで，燃費向上への貢献を実現したので紹介する．

CVT の変速用アクチュエータである S／M は 4 相のコイルを有しているが，常にそのうちの 2 相に通電した状態で使っており，条件にもよるが約 30W の電力を消費している．しかし，改めて用途を精査したところ，停止時や R／L の時には通電停止できる可能性があることが分かった．まずは比較的取り組みやすい停止時に条件を絞って検討を行った結果，課題は通電復帰時に脱調しないか，という点であった．これに対して，通電停止時と同じ位相パターンで復帰すれば脱調はしないとの解を見出し，それを制御として実装し採用につなげることが出来た．燃費向上の効果としては，10 － 15mode で約 0.1% だが，他システムへの展開も含め，今後の可能性が期待される技術である．

suddenly, causing an unacceptable shock. This problem has been solved by adopting two control features. During neutral idle, an adaptive learning control keeps the clutch at a stroke position that achieves both improved fuel economy and driveability; and a cooperative control modulates the engine torque to facilitate a smooth vehicle launch.

4.2. Idle stop control

An idle stop system for shutting off the engine while a vehicle is at rest has started to become popular as a means of reducing fuel consumption to zero. This system automatically shuts off the engine when the vehicle is stopped with the shift lever in Drive and the driver is pressing the brake pedal and shows no intention of starting off. Then, when the driver releases the brake pedal, the system automatically restarts the engine. This is an extremely effective means of improving fuel economy in city driving where waiting at traffic lights and other stopping situations account for a large portion of the total driving time.

Usually, an electric-powered oil pump is added to the idle stop system used with ATs and CVTs in order to improve start-off response from the idle stop state. The electric-powered oil pump supplies hydraulic pressure to the AT or CVT while the engine is shut off so as to keep the start clutch engaged. This eliminates the need to control clutch engagement when the engine is restarted. As a result, as soon as the engine is started, engine torque can be transmitted as driving force to provide a natural launch response even from the idle stop state.

4.3. Current cut-off to stepper motor

A new approach to improving fuel economy that has attracted attention in recent years is to reduce onboard electric power consumption. This lightens the engine load by reducing the amount of electric power that the alternator has to generate. We focused on the power consumption of the stepper motor that is used as an actuator with our CVTs. This section explains how cutting off the current to the stepper motor so as to reduce its power consumption contributes to improving fuel economy.

The stepper motor used as the actuator for shifting a CVT has a four-phase coil. Since current is

5. 燃費効果確認技術

実験としては，商品自体の燃費向上技術自体を開発していくことに加えて，開発した制御を，効率良く効果確認，フィードバックを行なうことが求められる．従来は，実車を用いた燃費計測シャシーダイナモや，VRS（Virtual Real Simulator）を用いた絶対値測定をする必要があり，設備数や工数の制約等で，タイムリーな確認・開発サイクルが実現できていなかった．

そこで上記を改善すべく，当社に現有するエンジンダイナモを活用した，効率的な燃費効果確認技術を確立したので紹介する．

燃費測定は 10・15 や JC08 と呼ばれる燃費モードにて評価される．しかし台上で行う場合，これらのモードは条件が厳しく数十分という長い時間を要し，また測定も複数回連続して行う為，現有設備のパターン運転や人の操作による運転ではバラツキが大きく，操作ミスによるデータの取り直しが発生するといった工数面と測定精度面の課題がある．

解決手段として，Rapid 制御開発ツールである AutoBox を用いて，エンジンダイナモの外部指示による自動運転化を考えた（Fig. 5）．まずハードシステム構成は，ブレーキ操作は AutoBox からの必要ブレーキ力に比例した電気信号を直接制御盤へ入力，アクセル操作は AutoBox から ECM へ直接入力する構成とし，従来設備から独立した加減速操作制御を可能とした．

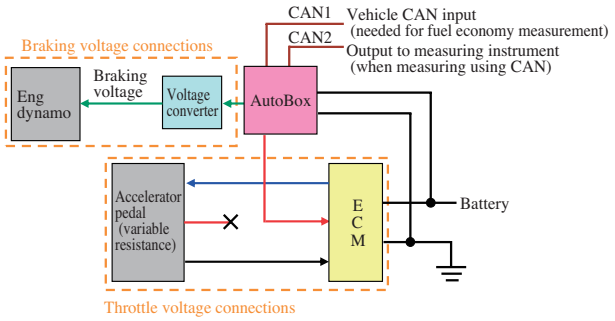


Fig. 5 Diagram of connections for automatic operation

次に，10・15 や JC08 モードなどの燃費測定モードの車速パターンを目標車速とし，実車速との差からアクセルやブレーキ操作量を決定するフィードバック制御系を構築して AutoBox に実

constantly fed to two of the four phases, the stepper motor consumes approximately 30 watts of electric power, depending on the operating conditions. However, we carefully investigated the operation of the motor anew and found that the current can be cut off when the vehicle is at rest and when traveling under a steady road load. A further investigation was conducted that focused first on the condition when the vehicle is at rest, which would be relatively easy to address. The results revealed that the main issue was a possible loss of synchronism when the current supply was resumed. The solution found for preventing any loss of synchronism is to resume current supply under the same phase pattern as that when the current was cut off. A control procedure for accomplishing that was incorporated in the control system and has been adopted for vehicle implementation. This control has the effect of improving fuel economy by approximately 0.1% under Japan's 10-15 test mode. It is a promising control technology that is expected to be extended to other systems in the future.

5. Evaluation Technologies for Confirming Fuel Economy Benefits

Experiments are carried out in the course of developing technologies for improving the fuel economy obtained with our transmissions. In addition, experiments must also be conducted to confirm the effects of developed control technologies so that the results can be fed back to the development stage. In the past, dynamometer tests were performed to measure the fuel economy of actual vehicles, and it was necessary to measure absolute values using a virtual and real simulator (VRS). Owing to limitations on the number of facilities, available manpower and other conditions, the confirmation-development cycle could not be conducted in a timely manner.

This section describes the evaluation technologies that we established to improve that situation. These technologies make use of our existing engine dynamometer and enable efficient confirmation of fuel economy benefits.

Fuel economy is measured and evaluated under the 10-15 test mode and JC08 test mode used in Japan.

装した．このシステムに車速パターンを与えることによって，それに追従すべき最適なアクセル操作およびブレーキ操作が自動で行なわれるようにした（Fig. 6，Fig. 7）．

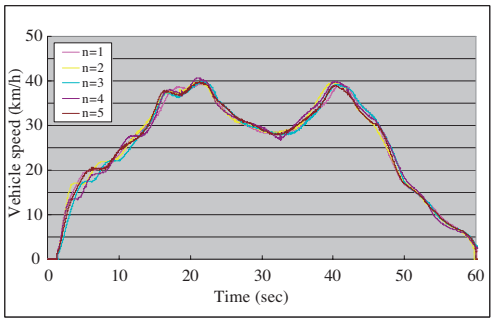


Fig. 6 Waveforms for manual operation
(to 1st peak of JC08 test mode)

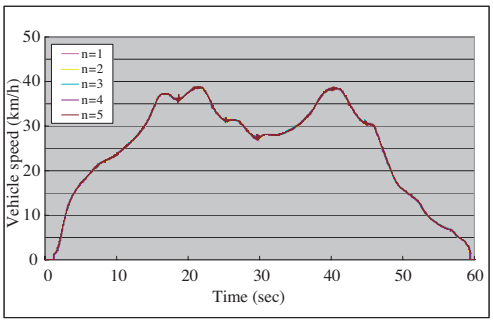


Fig. 7 Waveforms for automatic operation
(to 1st peak of JC08 test mode)

次に燃費効果の判断であるが，実車とは違いエンジンダイナモ単体では燃費の絶対値は得られない為，ECM 内部値から得られる瞬間燃料消費量，燃料カット時間，T／C ロス評価として LU 締結時間，フリクション評価として CVT から発生する油圧の面積値，電気ロス評価として CVT ソレノイドで消費される電力を自動計測＆自動データ処理し分析することで，パワートレーンでの燃費相対値評価としてロジック，定数変更の際にも，繰り返し精度の高いデータを，より短い時間でタイムリーに得ることが可能となった（Fig. 8）．

However, these test modes involve rigorous conditions and require long measurements extending over several tens of minutes when evaluations are performed on a dynamometer. In addition, continuous measurements must be taken multiple times. Consequently, the programmed driving patterns of the existing facilities and manual driving by human test drivers can produce wide variation in the test results. Moreover, data must be acquired again if operational mistakes are made. These are typical issues related to manpower aspects and measurement accuracy.

As a solution to these problems, we devised an automatic driving system (Fig. 5) based on the input of external instructions to an engine dynamometer using an AutoBox, which is a tool for rapid control development. In terms of the configuration of the hardware system, the AutoBox inputs an electric signal directly into the control panel to actuate the brake pedal. This signal is proportional to the necessary braking force. To actuate the accelerator pedal, the Autobox inputs a command directly to the engine control module (ECM). This configuration allows acceleration/deceleration operations to be controlled independently from the existing facilities.

A feedback control system was also constructed and implemented in the AutoBox. The vehicle speed patterns for measuring fuel economy under the 10-15 test mode, JC08 test mode and other modes are set as the target vehicle speed. If the actual vehicle speed differs from the target, the feedback control system determines the amount the accelerator pedal or brake pedal should be manipulated based on the difference. By inputting the desired vehicle speed patterns into this system, the accelerator pedal and brake pedal can be automatically manipulated to the optimum amount for following the set speed patterns.

Absolute fuel economy values cannot be obtained with a dynamometer alone, unlike the situation for an actual vehicle. Therefore, the effect on fuel economy is judged on the basis of real-time fuel consumption and the fuel cut-off duration, which are obtained from the internal values of the ECM. The lock-up clutch engagement time is used in evaluating torque converter loss; the area of the hydraulic pressure generated by the CVT is used in evaluating friction; and electrical loss is evaluated by automatically

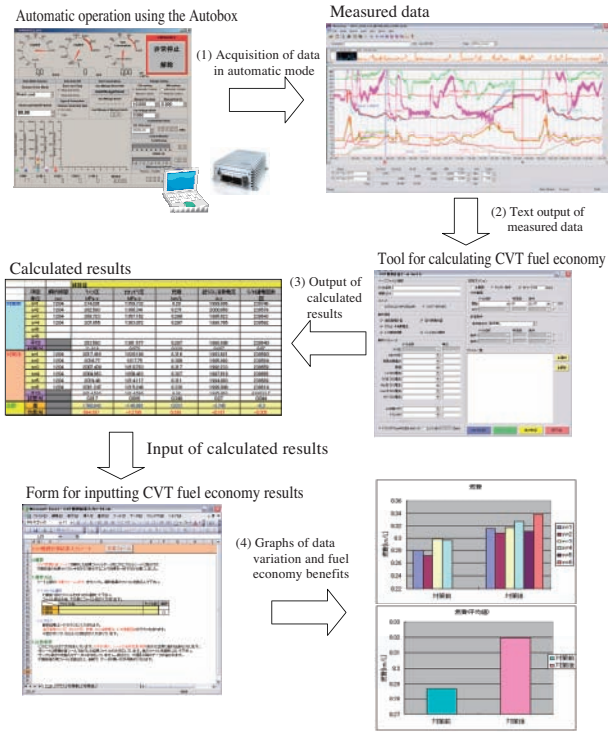


Fig. 8

6. まとめ

以上述べてきたとおり，様々な制御技術の積み上げによって，商品の燃費向上を実現している．

しかし，制御技術だけで実現できることには限界があり，更なる燃費向上を行うためには，制御対象＝トランスミッション本体ハード自体の制御性をあげる，そのポテンシャルを把握し使い切ることが重要であり，そこに力をいれていく必要がある．

また，燃費向上技術としては HEV／EV が話題の中心であるが，制御技術の観点からすれば，制御対象が変わるのみと捉えられ，今後も制御技術を磨いていきたい．この活動を通じて，商品力の向上，お客さまへの新しい価値の提供に繋げていきたい．

measuring the power consumption of the CVT solenoids and analyzing the automatically processed data. Using this procedure, highly accurate data on the relative fuel economy of the powertrain can be obtained repeatedly and more quickly in a timely manner even when the control logic or constants are changed (Fig. 8).

6. Conclusion

As explained here, the fuel economy obtained with our transmissions has been improved through the accumulation of various control technologies. However, there is a limit to the improvement that can be attained with control technologies alone. In order to improve fuel economy further, it is necessary to enhance the controllability of the transmission hardware itself that is the object of control. It is essential to ascertain the hardware's potential and to make full use of it. Further efforts must be devoted toward that end.

HEVs and EVs are widely talked about as technologies for improving fuel economy. However, from the standpoint of control technologies, it merely means changing the object of control. There is a need to continue to refine the control technologies used. Through such activities, we intend to improve the marketability of our products and create new value for our customers.

■ Authors ■


Yukihiro NOGUCHI

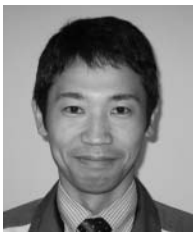

Kazuhiro TAKATORI


Osamu SATO


Hideshi WAKAYAMA


Hiroyasu TANAKA


Tetsuya IZUMI


Tateki JOZAKI

AT，CVTの環境負荷物質削減の取り組み

Activities for Reducing the Use of Environment-Impacting Substances in ATs and CVTs

安保　佳寿*
Keiju ABO

抄　録　日本自動車部品工業会の製品環境部会では人的に発生する環境への影響（地球温暖化，環境負荷物質排出，資源枯渇）を環境負荷と定義している．当社で積極的に進めているAT，CVTの環境負荷物質削減の取り組み，および資源枯渇対応について紹介する．

Summary　The Product Environmental Working Group of the Japan Auto Parts Industries Association defines environmental impact as the effect of human activity on the environment in the form of global warming, discharges of environment-impacting substances and resource depletion. This article describes JATCO's vigorous efforts to reduce environment-impacting substances in our ATs and CVTs as well as activities for addressing resource depletion.

1. はじめに

人々の生活の質を向上させるために発明された多くの化学物質の中には，数十年後にその環境影響が判明する化学物質がある．自動車用エアコンの冷媒に使用されたCFC※1はその一例である．開発者が1941年にプルーストリー※2賞を受賞したCFCは，1974年にオゾン層破壊およびその結果人，生態系への影響を指摘され，1987年にモントリオール議定書で製造および輸入の禁止が決定された．

当社ではグローバルな環境法規に基づき，AT，CVTで使用している化学物質の内，有害性が評価されているハザード物質に限らず，環境影響懸念の高いリスク物質の使用も積極的に削減している．

※1：クロロフルオロカーボン，無味，無臭，無毒，熱伝導率小

※2：1774年に酸素を発見した英国の化学者

2. 環境法規の動向

2.1. 2020年までに化学物質の適正管理を完了

環境政策を理解すると，法規動向は予見し易くなる．1992年開催のリオ・サミットで採択されたAgenda21

1. Introduction

Among the many chemical substances invented to improve human quality of life, there are some whose environmental impact does not become clear until several decades later. One example here is chlorofluorocarbons (CFCs), a class of tasteless, odorless, nontoxic chemicals with a low heat transfer coefficient that have been used as refrigerants in automotive air conditioners. In 1941, the developer of a CFC refrigerant was awarded the Priestley Medal, named after the British scientist Joseph Priestley who discovered oxygen in 1774. However, it was pointed out in 1974 that CFCs deplete the ozone layer, causing harmful effects on human life and ecosystems. The Montreal Protocol, adopted in 1987, banned the production and importation of CFCs.

In line with global environmental regulations, JATCO is vigorously striving to reduce the use of risky chemical substances in ATs and CVTs, for which there is high concern about their environmental impact, in addition to reducing those regarded as hazardous substances based on evaluations of their toxicity.

* エンジニアリング管理部
Engineering Administration Department

の第 19 章では，有害化学物質の適正管理を予防的原則に基づき実施する事とした．2002 年のヨハネスブルグ会議では，第 19 章の完了目標時期を 2020 年[1]とし， 2007 年 6 月から発効している EU-REACH 規則の実施スケジュールの背景にもなっている．

2.2. 廃棄フェーズ規制から開発フェーズ規制へ

製品の環境負荷物質を廃棄フェーズで除去するより，開発フェーズで削減する方が低コストであり，廃棄フェーズの除去工程における CO_2 排出量を削減できる．

EU の環境法規では，廃車を対象とする EU-ELV 指令（2003 年 7 月施行）に続き，部品の原料を対象とする EU-REACH 規則が発効されている．製品の開発フェーズから，環境影響を考慮した部品設計が求められている．

2.3. ハザード物質規制からリスク物質規制へ

EU-ELV 指令は，その有害性が評価されているハザード物質である重金属 4 物質（鉛，六価クロム，水銀，カドミウム）を規制対象[2]としている．

EU-REACH 規則は，新規化学物質（約 5000 物質）に加えて既存化学物質（約 10 万物質）を対象とし，環境影響が懸念される化学物質を SVHC※3 として公開している．環境法規はハザード物質規制に加え，環境影響が懸念されるリスク物質を含めた規制へ拡大している．

※ 3：Substances of Very High Concern，高懸念物質

3. 当社の環境負荷物質管理と削減

3.1. 技術標準規格と管理対象部品

当社では AT，CVT 内の環境負荷物質を，GADSL※4 と化審法をベースに，世界各国の環境法規を加えた技術標準規格 JES-M9001 で特定物質として規定している． Fig. 1 に特定物質を含む当社の削減対象部品数の推移を示し，使用期限設定済部品を優先的に削減してきた．

2005 年の対象部品の内，六価クロムを含有する約 1800 部品を削減し，2006 年の対象部品の内，鉛を含むベアリング類，約 100 部品を削減した結果，2007 年までにハザード物質を含む約 1900 部品を削減した．2008 年に，鉛はんだを含む約 340 部品に

2. Trends in Environmental Laws and Regulations

2.1. Completion of environmentally sound management of chemical substances by 2020

Having a good understanding of environmental policy makes it relatively easy to foresee regulatory trends. Chapter 19 of Agenda 21 adopted at the Rio Earth Summit in 1992 called for environmentally sound management of toxic chemical substances in accordance with preventive principles. At the 2002 Johannesburg Conference, the year 2020 was set as the target time frame for completing the implementation of Chapter 19.1) That provided the background for the implementation schedule of the EU REACH Regulation which took effect on June 1, 2007.

2.2. Transition from disposal phase regulations to development phase regulations

Reducing the use of environment-impacting substances in products in the development phase is more cost effective than trying to recover them in the end-of-life disposal phase. It also reduces CO_2 emissions that occur in processes for recovering such substances in the disposal phase.

Among the environmental regulations enforced by the EU, the EU ELV Directive pertaining to end-of-life vehicles came into effect on July 1, 2003. The EU REACH Regulation now in effect extends the requirements to the raw materials of auto parts. This requires that the environmental impact be factored into the design of parts in the product development phase.

2.3. Expansion from hazardous substance regulations to risky substance regulations

The EU ELV Directive regulates the use of lead, hexavalent chromium, mercury and cadmium, four heavy metals regarded as hazardous substances based on evaluations of their toxicity.2) The EU REACH Regulation publicly lists substances of very high concern (SVHC) for which there is worry about their environmental impact. This includes approximately 100,000 existing chemical substances in addition to some 5,000 newly added ones. The regulation expands the control framework to include risky substances that might have an adverse effect on the environment, in addition to the control of hazardous

使用期限を設定し計画的に削減中である．またリスク物質である SVHC を含む 96 部品を削減対象部品に加えた．

※ 4：Global Automotive Declarable Substance List，統一化学物質リスト

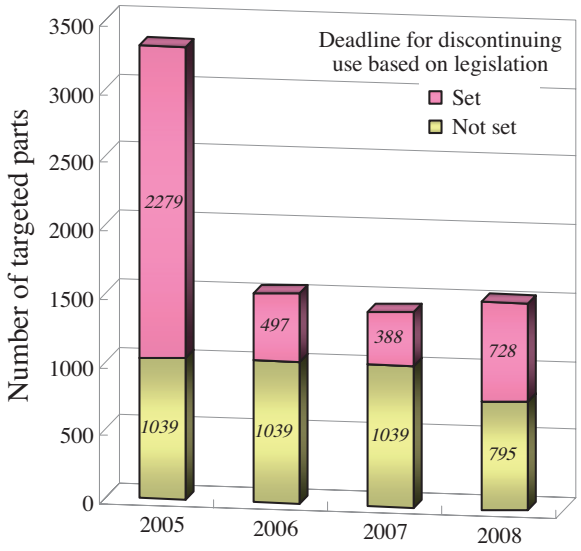


Fig. 1 Trend in the number of parts targeted for reduction

3.2. IMDS による化学物質データの管理

当社は AT，CVT を構成する部品の含有している化学物質を IMDS※5 で管理し，データベース化している．

本データベースは，AT，CVT を構成する部品の化学物質データに加えて，生産組み立て時に製品内に意図して付着させる副資材（ワセリン等）の化学物質データを完備している．ハザード物質やリスク物質を含む部品や副資材の検索に社内で活用されている．

Fig. 2 に 2008 年の本データベース内の部品数を示す．約 16,000 部品の内，特定物質と SVHC を含む部品は約 9.5％である．この部品数は，Fig. 2 の 2008 年削減管理対象の 1523 部品である．

※ 5：International Material Data System

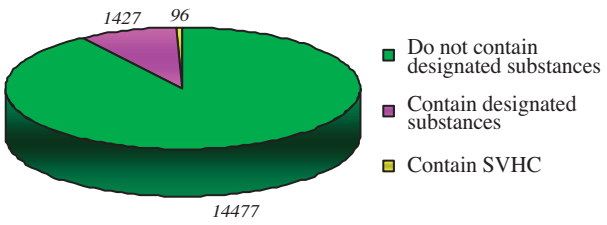


Fig. 2 Number of parts subject to chemical substance management (2008)

substances.

3. JATCO's Efforts to Manage and Reduce Environment-Impacting Substances

3.1. Technical standard and targeted parts

At JATCO, we regulate the environment-impacting substances used in our ATs and CVTs as designated substances under an internal technical standard, JES-M9001. This standard incorporates the provisions of environmental legislation adopted in countries around the world and is based on Japan's Chemical Substances Control Law and the Global Automotive Declarable Substance List (GADSL), a common list of declarable substances in the global automotive industry. Figure 1 shows the change in the number of JATCO parts targeted to be reduced for containing designated substances. Priority has been given to those parts for which a deadline has been set for discontinuing their use.

Among the targeted parts in 2005, approximately 1,800 parts containing hexavalent chromium were reduced, and approximately 100 bearing parts containing lead were reduced among the targeted parts in 2006. As a result, some 1,900 parts containing hazardous substances were reduced by 2007. In 2008, a deadline was set for discontinuing use of approximately 340 parts containing lead solder and systematic efforts were made to reduce them. Moreover, 96 parts containing risky SVHC were added to the parts targeted to be reduced.

3.2. Management of chemical substance data under IMDS

JATCO has compiled a database of the chemical substances contained in AT/CVT parts and manages them under the International Material Data System (IMDS). In addition to data on the chemical substances used in AT/CVT parts, the database also contains complete data on the chemical substances of secondary materials (Vaseline, etc.) that are intentionally applied inside products during production on the assembly line. The database is used to conduct searches for parts and secondary materials containing hazardous or risky substances.

Figure 2 shows the total number of parts contained in the database in 2008. Of some 16,000 parts, approximately 1,523, or 9.5%, contained designated

Fig. 3 に CVT ケース部品の IMDS データ画面例を示す．本画面例では，ケース部品で使用している材料（ADC 12），化学物質（アルミ，銅，他）を表示している．赤文字の化学物質は原則的に使用禁止物質を表示している．

本画面例の赤文字は不純物レベルとして法規適合している鉛である．青文字は要申告物質を表示している．

各社の CSR※6 は，AT，CVT で使用している化学物質の法規適合エビデンスとして，製品納入前に IMDS データを承認申請することを要求している．本データベースは，TS16949 の CSR 対応にも広く活用されている．

※ 6：Customer Specific Requirements，お客さま固有の要求事項

substances or SVHC. This number corresponds to the 1,523 parts targeted for reduction in 2008 in Fig. 1.

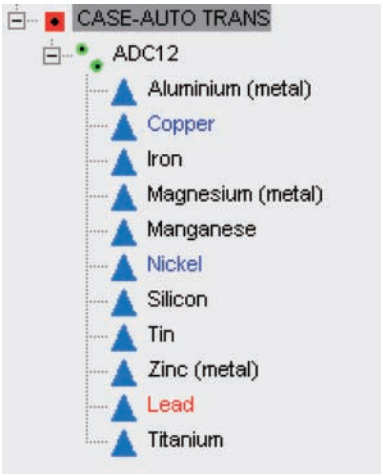


Fig. 3 Example of IMDS data screen

Table 1 SVHC list

No.	Substance identification		CAS No.	Reason for inclusion
	Substance name (English)	EC		
1	Triethyl arsenate	427-700-2	15606-95-8	Carcinogenic (article 57a)
2	Anthracene	204-371-1	120-12-7	PBT (article 57d)
3	4,4'-Diaminodiphenylmethane (MDA)	202-974-4	101-77-9	Carcinogenic (article 57a)
4	Dibutyl phthalate (DBP)	201-557-4	84-74-2	Toxic for reproduction (article 57c)
5	Cobalt dichloride	231-589-4	7646-79-9	Carcinogenic (article 57a)
6	Diarsenic pentaoxide	215-116-9	1303-28-2	Carcinogenic (article 57a)
7	Diarsenic trioxide	215-481-4	1327-53-3	Carcinogenic (article 57a)
8	Sodium dichromate	234-190-3	7789-12-0 10588-01-9	Carcinogenic, mutagenic and toxic to reproduction (articles 57a, 57b and 57c)
9	5-tert-butyl-2,4,6-trinitro-m-xylene (musk xylene')	201-329-4	81-15-2	vPvB (article 57e)
10	Bis (2-ethylhexyl) phthalate (DEHP)	204-211-0	117-81-7	Toxic to reproduction (article 57c)
11	Hexabromocyclododecane (HBCDD) and all major diastereoisomers identified:	247-148-4 221-695-9		PBT (article 57d)
	Alpha-hexabromocyclododecane	-	134237-50-6	
	Beta-hexabromocyclododecane	-	134237-51-7	
	Gamma-hexabromocyclododecane	-	134237-52-8	
12	Alkanes, C10-13, chloro (Short Chain Chlorinated Paraffins)	287-476-5	85535-84-8	PBT and vPvB (article 57d - e)
13	Bis (tributyltin) oxide (TBTO)	200-268-0	56-35-9	PBT (article 57d)
14	Lead hydrogen arsenate	232-064-2	7784-40-9	Carcinogenic and Toxic to reproduction (articles 57a and c)
15	Benzyl butyl phthalate (BBP)	201-622-7	85-68-7	Toxic to reproduction (article 57c)

3.3. リスク物質を含有する部品の削減

Table 1 に 2008 年 10 月公開の SVHC[4] リストを示す．水色背景の化学物質は，今後，欧州化学物質庁からの認可取得が義務付けられる候補物質[5] である．

IMDS データベースで確認した SVHC に基づくリスク物質は下記 3 種であり（Table 1，赤文字化学物質），当社 AT，CVT 部品のインヒビタースイッチ，ブリーザパイプ，　ATF フィルターなどに含有している．

Figure 3 shows an example of the IMDS data that appear on the database screen for the CVT case. This screen example lists the ADC 12 aluminum alloy from which the case is manufactured and the chemical substances used, such as aluminum, copper and so on. The chemical substance noted in red is one whose use is prohibited in principle.

Lead noted in red here is subject to regulation at

・DBP　：フタル酸ブチル
・DEHP：ビス（2 －エチルヘキシル）フタラート
・BBP　：フタル酸ベンジルブチル

Fig. 4 に，リスク物質を含む部品数の削減推移を示す．2008 年削減対象の 96 部品を 2009 年 7 月までに 35％削減した．今後，欧州化学物質庁は SVHC を随時追加公開する予定であり，当社は継続的にリスク物質を含む部品の削減を推進していく．

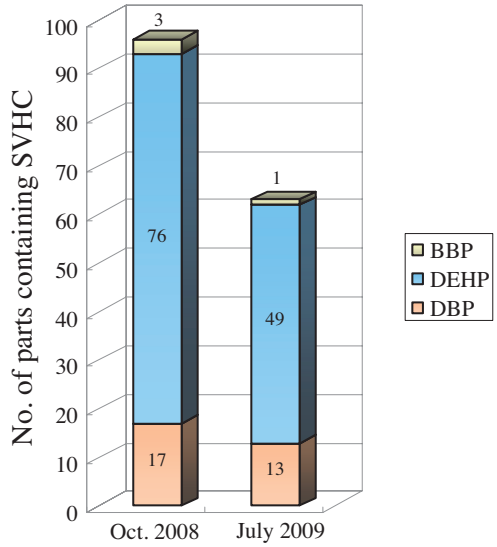


Fig. 4 Reduction of parts containing risky substances

4. 地球環境に優しい CVT

4.1. 環境負荷物質を含む部品の削減

Fig. 5 に，当社 CVT 内の特定物質を含む部品数の比率推移を示す．2005 年製 CVT の特定物質を含む部品数は全部品数の約 20%であった．特定物質の継続的な削減により，2008 年製 CVT では，特定物質を含む部品数比率を約 3%まで低減させた．

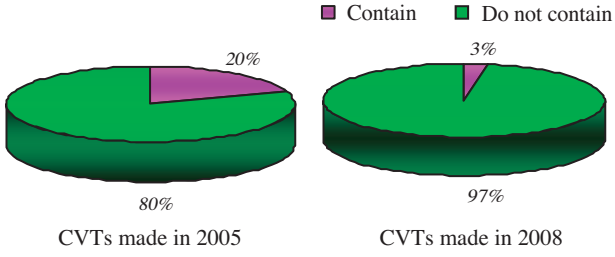


Fig. 5 Share of JATCO CVT parts containing designated substances

the impurity level. The substances listed in light blue are ones that require declaration.

The Customer Specific Requirements (CSR) of our customer companies require us to apply for approval of our IMDS data before delivering our products to them. This serves as evidence that the chemical substances used in our ATs and CVTs comply with regulatory requirements. This in-house database is also extensively used for compliance with the CSR provisions of the TS-16949 Standard.

3.3. Reduction of parts containing risky substances

Table 1 shows the SVHC list4) that was announced in October 2008. The substances with a light blue background are candidate items for which companies will be obligated to obtain approval from the European Chemicals Agency (ECHA) in the near future.5)

The three substances noted below are risky substances based on the SVHC list (chemical substances noted in red in Table 1). From the IMDS database, it has been confirmed that they are contained in some of our AT/CVT parts such as the inhibitor switch, breather pipe and automatic transmission fluid (ATF) filter.

- Dibutyl phthalate (DBP)
- Bis (2-ethylhexyl)phthalate (DEHP)
- Benzl butyl phthalate (BBP)

Figure 4 shows the change in the reduction of the number of AT/CVT parts containing risky substances. Of the 96 parts targeted for reduction in 2008, 35% had been reduced by July 2009. ECHA will be continually adding and announcing further SVHC candidates in the future. JATCO intends to continually promote the reduction of parts containing risky substances.

4. CVTs Friendly to the Global Environment

4.1. Reduction of parts containing environment-impacting substances

Figure 5 shows the change in the ratio of the number of our CVT parts containing designated substances. For CVTs manufactured in 2005, about 20% of the total number of parts contained

4.2. レアメタルの使用削減

Fig. 6 に当社 CVT 内の化学物質別の含有率を示す．鉄とアルミの合計で 92.7%を占める．開発フェーズからレアメタルの使用削減を推進した結果，コバルト，バナジウム，ビスマス等のレアメタル（Fig. 6 “その他”の内数）は約 0.025%である．

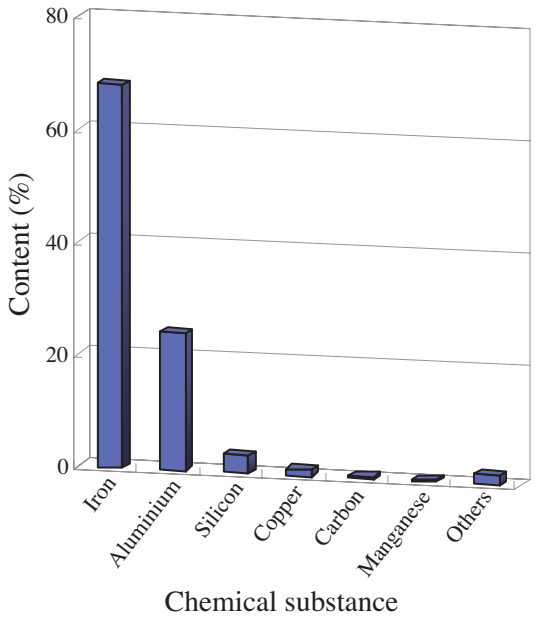


Fig. 6 Breakdown of contents by chemical substance in JATCO CVTs (mass ratio)

4.3. リサイクル可能率は約 99%

EU-ELV 指令ではリサイクル可能率を 95%以上 [3]（重量比，うち，エネルギー回収分は 10%以内）としている．

Fig. 7 に当社 CVT 本体で使用している材料分類を示す．金属系化学物質（鉄鋼系，軽金属系）をリサイクル可能として，CVT のリサイクル可能率は約 99%である．当社の AT も同等なリサイクル可能率であり，自動車のリサイクル可能率向上に貢献している．

5. まとめ

2000 年に，国連で正式に創設された「グローバル・コンパクト」では企業による自主行動 10 原則の 1 つとして「環境に優しい技術の開発と普及を奨励すべきである」 ことを提唱している（原則 9）．

当社の環境方針では，企業理念の使命「お客さま・クルマ文化・社会への価値の提供」達成に向けて

designated substances. Through the continuous reduction of parts containing designated substances, the ratio of parts incorporating such substances was reduced to approximately 3% in our CVTs produced in 2008.

4.2. Reduction of the use of rare metals

Figure 6 shows a breakdown of the content of the chemical substances used in our CVTs. Iron and aluminum together account for approximately 92.7% of the materials. As a result of activities undertaken from the development phase to reduce the use of rare metals, their total content, including that of cobalt, vanadium, bismuth and others, has been lowered to about 0.025%, which is included in "Others" in the figure.

4.3. Recyclable rate of approximately 99%

The EU-ELV Directive specifies a recyclable rate of at least 95%3) by weight, of which the portion recovered as energy is to be less than 10%. Figure 7 shows the types of materials used in JATCO CVTs. Since metals such as iron, steel and light alloys are recyclable among the chemical substances used, the recyclable rate of our CVTs is approximately 99%. JATCO's ATs also achieve an equal recyclable rate, thus contributing to improving the recyclable rate of vehicles.

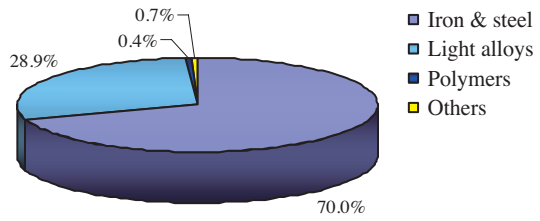


Fig. 7 Breakdown of types of materials used in JATCO CVTs

5. Conclusion

In 2000, the United Nations officially adopted the Global Compact that sets forth ten principles of autonomous action by businesses. Principle 9 proposes that "Businesses should encourage the development and diffusion of environmentally friendly technologies."

One principle of action specified in JATCO's

「環境負荷低減を可能にする技術開発を積極的に推進します」を行動規範の一つに規定し，これまで，製品内の環境負荷物質を開発フェーズから積極的に削減してきた.

今後もグローバル環境法規動向を先取りし，地球環境に優しいクリーンな AT，CVT の開発を推進していく.

6. 参考文献

1) Tetsuya Matsuura, The Future and the Influence of EU's Directives of RoHS and ELV. JSAE Vol. 60, No.11, pp 77-82, 20064708.
2) Kazuhito Asakawa, Progress in the Reduction of Environmental Impact Substances Used in JapaneseVehicles, JSAE Vol. 60, No.11, pp 10-14, 20064694.
3) Kazuhito Asakawa, Amendments of the EU End-of-Life Vehicle Directive Since Issue, JSAE Vol. 60, No.11, pp 4-9, 20064693.
4) ECHA Press Release 09.October.2008, Home Page http://echa.europa.eu.
5) ECHA Press Release 02.June.2009, Home Page http://echa.europa.eu.

environmental policy is "to vigorously promote the development of technologies that can reduce environmental impacts." This is aimed at achieving the mission defined in JATCO's corporate philosophy, which is "to provide value to our customers, automotive culture and to society through our corporate activities." Concerted efforts have been made to date to reduce the use of environment-impacting substances in the company's products beginning from the development phase.

JATCO will continue to promote the development of clean ATs and CVTs friendly to the global environment in anticipation of future trends in global environmental legislation.

■ Authors ■

Keiju ABO

マネジメントシステムによる環境と業務の改善

Improvement of Environment and Business Operations through Management Systems

梅里　和生*
Kazuo UMESATO

抄　録　環境マネジメントシステムとして，国際規格であるISO14001が知られており，当社はその認証を取得している．
加えて当社は，自動車業界用品質マネジメントシステムISO／TS16949の認証も取得しており，認証を維持することから，システムを活用して業務改善することへ脱皮すべく，再構築活動を実施している．
本稿では，マネジメントシステム活用の課題と，環境・品質の両マネジメントシステム統合に向けての取組について述べる．

Summary　JATCO is certified to ISO 14001, the well-known international standard for environmental management systems. The company is also certified to ISO/TS 16949 that specifies the quality management system requirements specific to the automotive industry. We are working to reconstruct these management systems so as to move beyond mere continuation of certification and use the systems effectively for improving our business operations.
This article describes the issues involved in using these systems effectively and the activities under way to integrate both our environmental and quality management systems.

1. 環境マネジメントシステム（EMS）

環境マネジメントシステム（以下EMS）とは，「組織が自主的に環境保全に関する取組を進めるにあたり，環境に関する方針や目標を自ら設定し，これらの達成に向けて取り組んでいくための体制・手続きなどの仕組みのこと」をいう．

EMSには，環境省が策定したエコアクション21や，地方自治体，NPOや中間法人等が策定したものなどもあるが，国際規格としてのISO14001が良く知られており，当社はその認証を取得している．

1.1. 当社のISO14001認証

当社は，1998年から1999年にかけて，旧ジャトコ株式会社，分社前の三菱自動車京都製作所・水島製作所、日産自動車富士工場がそれぞれISO14001の認証を取得しており、分社合併後の2001年，2003年，2006年に更新審査を受けて現在に至っている．

1. Environmental Management System

An environmental management system (EMS) refers to a system under which an organization establishes its own environmental policies and goals for promoting self-initiated environmental protection activities and which includes the structures and procedures of the efforts undertaken to accomplish those policies and goals.

There are various types of EMS certification, including Eco-Action 21 established by Japan's Ministry of the Environment and programs adopted by local government bodies, nonprofit organizations (NPOs) and intermediate corporations, among others. ISO 14001 is the best known international standard concerning EMS, and JATCO has obtained EMS certification under this standard.

1.1. JATCO's ISO 14001 certification

During the time of the previous JATCO Corporation, the Kyoto Plant and Mizushima Plant of Mitsubishi Motors Corporation and the Fuji Plant of Nissan Motor Co., Ltd. all obtained ISO 14001 certification during

* 品質企画管理部
Quality Planning and Administration Department

2006 年の登録更新後，2007 年 12 月と 2009 年 1 月の 2 回の定期サーベイランスは，全般的には良好な評価であったが，いくつかの不適合と，観察事項指摘を受けている．具体例を挙げると，

◆間接部門で本来業務の側面評価
◆部門独自の活動目標と実施計画
◆不適合並びに是正処置及び予防処置とその有効性レビューの仕組みの改善
◆力量・教育訓練対象者とその内容の明確化・充実
◆外部文書の管理
◆著しい環境側面に関連する施設・設備の管理
◆緊急事態への準備及び対応
◆内部監査実施結果の対応の間延び
◆マネジメントレビューにおけるアウトプット

などである

2. 品質マネジメントシステム（QMS）

EMS：ISO14001 に対峙する品質マネジメントシステム（以下 QMS）としては，ISO9001 が良く知られており、数多くの企業がその認証を受けているが，当社は自動車業界用 QMS である ISO／TS16949 の認証を取得している．

ISO／TS16949 要求事項の構成は，Fig. 1 に示すように ISO9001 をベースに，自動車業界固有の要求事項 155 項目を追加したものとなっている．

更に，自動車メーカー個別の有要求事項（CSR）への適用も審査対象となるのが特徴である．

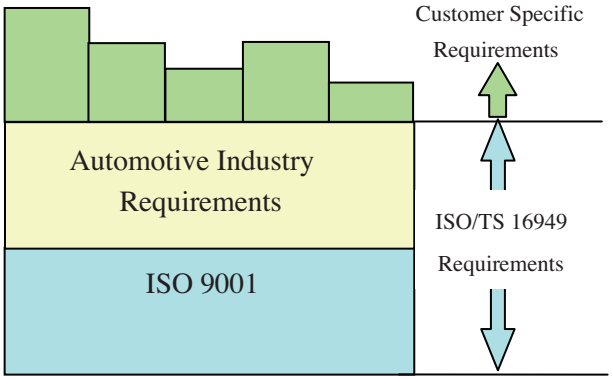


Fig. 1 Structure of ISO/TS 16949

2.1. 当社の ISO／TS16949 認証

当社は，2005 年に ISO／TS16949 の認証を受け

1998 and 1999 prior to being spun off. After the spin-off and merger with JATCO, renewal audits were conducted in 2001, 2003 and 2006, and ISO 14001 certification is still in effect at present.

Following renewal of JATCO's ISO 14001 registration in 2006, regular surveillance assessments were conducted in December 2007 and in January 2009. While JATCO received good evaluations overall, some non-conformities and opportunities for improvement were pointed out. The following are some specific examples:

◆ Assessment of the environmental aspects of basic business operations in indirect departments
◆ Activity objectives and execution plan of individual departments
◆ Improvement of the review system for non-conformities, their corrective and preventive measures and the effectiveness of the measures
◆ Clarification of the employees targeted for skills training and improvement of educational content
◆ Management of external documentation
◆ Management of facilities/equipment with respect to strict environmental aspects
◆ Preparations and system for dealing with emergency situations
◆ Slowness in acting on results of internal audits
◆ Output of management reviews

2. Quality Management System

Corresponding to ISO 14001 for EMS, ISO 9001 is the well-known international standard for quality management systems (QMS). While many companies are certified to this standard, JATCO is certified to ISO/TS 16949 that specifies the QMS requirements for the automotive industry.

Figure 1 shows the composition of the requirements specified by ISO/TS 16949. Based on ISO 9001, this standard adds 155 requirements specific to the automotive industry. Another characteristic of this standard is that audits also include the application of the Customer Specific Requirements (CSRs) of individual automakers.

2.1. JATCO's ISO/TS 16949 certification

After being certified to ISO/TS 16949 in 2005, JATCO undertook a program of activities beginning

た後，2007 年から TS プロセス再構築活動に取組んでいる（JATCO Technical Review No.7 参照）.

2007 年 10 月の ISO/TS16949 更新審査において，いくつかのマイナー不適合指摘を受けたが，うち QMS 特有の要求事項を除くと、以下のような指摘内容であった.

◆顧客固有の要求事項の特定・コミュニケーション・教育
◆効果的な記録の管理，電子文書の管理
◆有効性と効率の管理指標として，最適で現実的な目標値の設定
◆工場のマネジメントレビューでのインプット
◆教育・訓練の必要性をポジションに応じて定める
◆地震以外の緊急事態対応計画の具体化
◆内外不適合に応じた内部監査の実施
◆継続的改善のプロセス明確化
◆是正・予防処置のトリガーの設定

これを見ると，ISO14001 の審査指摘項目と驚くほど共通していることがわかる．その理由を以下に述べる.

3. EMS と QMS の関係

3.1. マネジメントシステムとしての共通性

そもそも ISO14001 と，ISO ／ TS16949 のベースである ISO9001 はマネジメントシステム（以下 MS）としての共通性を有しており，例えば ISO9001：2000 年版の序文 04. には「この規格は，規格利用者の便宜の為, ISO14001 と両立するように構成されている.（中略）この規格は，組織が品質マネジメントシステムを，関連するマネジメントシステム要求事項に合わせたり，統合したりできるようにしている.」と記述されている.

同様の記述が，ISO14001：96 年版にも記載されており，2004 年度版では直接的な表現は削除されたものの，内容の共通性は維持されている.

これをイメージで表すと，Fig. 2 のようになり，MS に共通骨格があると捉えることができる.

3.2. MS の共通骨格

ISO14001 と ISO9001 では要求事項の章立てや表現は若干違うものの，MS の共通骨格は，概ね以下

in 2007 to reconstruct TS processes as explained in a related article in JATCO Technical Review No. 7. At the time of the ISO/TS 16949 renewal audit in October 2007, several minor non-conformities were pointed out. Excluding requirements specific to QMS, the non-conformities pertained to such matters as those noted below.

◆ Identification, communication and employee education concerning CSRs
◆ Effective management of records and management of electronic documents
◆ Setting of optimal and feasible targets as management indexes of effectiveness and efficiency
◆ Plant input to management reviews
◆ Determination of necessary education/training matching employee positions
◆ Specific planning for dealing with emergency situations other than earthquakes
◆ Implementation of internal audits according to internal/external non-conformities
◆ Clear articulation of the process for continuous improvement
◆ Setting of triggers for corrective and preventive measures

These non-conformities clearly overlap the items pointed out in the ISO 14001 audit to a surprising extent. The reason for that is explained below.

3. Relationship between EMS and QMS

3.1. Commonality as management systems

From the beginning, ISO 14001 and ISO 9001, which is the basis of ISO/TS 16949, have possessed a common framework with respect to management systems (MS). For example, section 0.4 of the Foreword to the ISO 9001:2000 version states that:

"This International Standard has been aligned with ISO 14001:1966 in order to enhance the compatibility of the two standards for the benefit of the user community. (omission) This International Standard enables an organization to align or integrate its own quality management system with related management system requirements."

A similar description was also included in the ISO 14001:1996 version and the commonality of content is continued in the 2004 version, although a direct expression has been deleted. This commonality can be represented as illustrated in Fig. 2. It is seen that

の手順であると受け止めればよい.

◆ MS の共通骨格（共通手順）

（1）方針及び目標を決定する

（2）体制及び責任と権限を明確化する

（3）必要な文書・記録を定め，管理する

（4）力量の必要性を認識し、教育訓練する

（5）パフォーマンス評価及び内部監査を行う

（6）マネジメントレビューを実施する

（7）不適合に対する是正処置・予防処置を実施する

一読して理解できるように，この手順は環境・品質に限らず，様々な目的達成のマネジメントに活用できるものである.

4. システム認証から業務改善へ

ISO14001，ISO／TS16949 のような MS の認証はなんのために取得するのであろうか.

もちろん環境に対する時代の要請や，グローバルな自動車部品サプライヤーとして販路を拡大していく為には，QS9000 や ISO／TS16949 のような国際品質規格の認証が必要である，と言う背景も見逃せない.

しかし，認証を取得すること自体が目的化してしまうと，取得が出来たことで安心し，その後の維持活動は形式的になり，内部監査や外部審査の前になってあわてて資料を取り繕ったり，マニュアルや基準を読んだりすることになる.

認証の取得時には，規格要求事項を満足する為に，従来保持していた基準に追加して基準整備が行われるのが通常であり，それをそのままにすると業務を阻害する重荷にもなりかねない.（Fig. 3 参照）

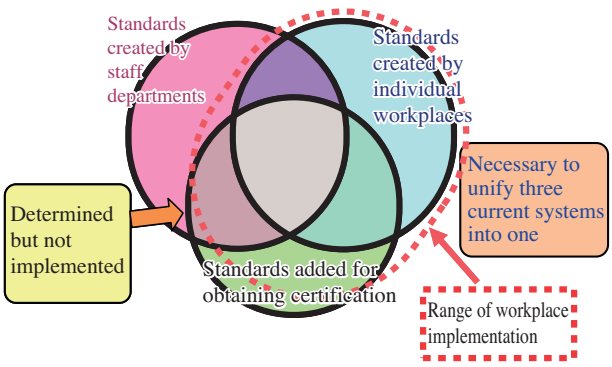


Fig. 3 JATCO's three systems of standards

2007 年から取組んだ TS プロセス再構築プロジェ

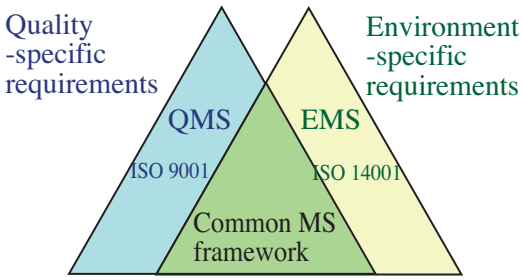


Fig. 2 Relationship between EMS and QMS

these MS have a common framework.

3.2. Common MS framework

Although the chapter themes and expressions used differ slightly between ISO 14001 and ISO 9001, their common MS framework can be generally summarized in the procedure noted below.

◆ Common MS framework (common procedure)

(1) Determine policy and goals

(2) Clarify the system and responsibilities and authority

(3) Determine and manage the necessary documents and records

(4) Recognize the necessity of skills and undertake education/training

(5) Carry out performance evaluations and internal audits

(6) Conduct management reviews

(7) Implement corrective and preventive measures to deal with non-conformities

As is clear from one reading, this procedure is not limited to the environment and quality, but can also be used to manage the attainment of a variety of goals.

4. Transition from System Certification to Business Operations Improvement

What is the purpose for acquiring MS certification to ISO 14001 and ISO/TS 1649? Naturally, certification is necessary to meet the demands of the times regarding the environment. Being certified to international quality standards like QS 9000 and ISO/TS 16949 is also essential for a global auto parts supplier in order to expand sales channels. That background should not be overlooked.

However, if certification itself becomes the objective, complacency may set in once it is obtained. Subsequent activities to maintain that certification

クトでは，それまでの活動が認証目的になっており，プロセス改善を目的とする活動への進化が必要であるという認識を持っていたが，現場にそれを理解してもらうことがなかなか進まずにいた．

しかし，2008 年のサーベイランスにおいて，審査機関から

①「JATCO では 3 つの仕組みが回っている，これを一つにする必要がある（認証の為の仕事をしている）」

②「マネジメントシステムの要求は，シンプルに言うと『この仕事は何の為にやっているのか?』『それはうまく行っているのか?』の 2 点である」

と言う指摘を受けた．これを会社の重要課題と受け止めて全工場で論議を重ねた結果，外部審査でいかに指摘を受けないかではなく，QMS の概念で仕事をすることが重要という認識が一気に進み，全社で QMS の理解，手順の改善に取組むことができた．

その成果があって，2009 年春のサーベイランスでは，大幅な改善が認められたと評価され，不適合指摘なしも実現することができた . 現在は、その結果に安心することなく，QMS を活用して本来業務を改善するために，更なる理解の促進とプロセス改善の活動を継続している．

5. ジヤトコ統合 MS の構築に向けて

先に述べたように，MS の骨格は共通であるため，QMS を活用して本来業務の改善が出来ればそれを EMS にも同じように活かすことができる．

業務のパフォーマンスが向上し，ムダが削減されれば品質にも環境にも貢献できるということである（Fig. 4）．

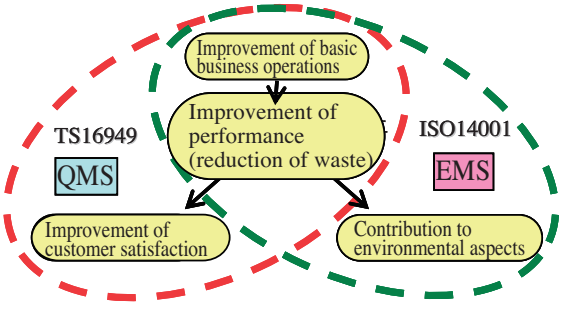


Fig. 4 MS and improvement of basic business operations

これが EMS でよく言われる「ゴミ，紙，電気」か

may then become mere formalities, with hurried efforts made just before an internal or external audit to fix up the documentation and read through the standards and manuals.

In order to acquire certification, it is a common practice to create additional standards besides the ones adhered to previously, so as to be sure to satisfy all the requirements. The addition of such new standards may become a burden that interferes with a company's operations (Fig. 3).

The aim of our activities prior to launching the project in 2007 to reconstruct our TS processes had been to obtain certification. Although it was recognized that we needed to advance to activities aimed at improving work processes, it was not easy to get workplaces to understand that necessity. However, at the time of the 2008 surveillance assessment, the auditing body made the following observations:

(1)JATCO has three systems of standards working toward certification. They should be unified into one system.

(2)Two points were mentioned concerning MS requirements. Simply put, "what is the purpose of this work? Is it going well?"

These points were regarded as crucial issues for the company and were repeatedly discussed at all the plants. As a result, noticeable progress was made in recognizing the importance of doing work according to QMS concepts, rather than simply trying to avoid having things pointed out in an external audit. That led to a better understanding of QMS and to company-wide improvements in procedures.

Thanks to those results, it was recognized in the surveillance assessment conducted in the spring of 2009 that substantial improvements had been made and no non-conformities were pointed out. Without becoming complacent about the results, we are now continuing to use our QMS to improve our basic business operations by promoting an even better understanding among the employees and by undertaking process improvement activities.

5. Toward Construction of an Integrated JATCO MS

As explained in the previous section, since the MS have a common framework, if our basic business operations can be improved through the QMS, the EMS can be used in the same way to make similar

らの脱却であり，この理解を進めることにより，EMS審査で指摘を受けた「間接部門で本来業務の環境側面評価」の改善にもつなげることができる．

以上の判断で，QMS と EMS のシステム統合に向けた検討を実施中である．ISO14001 と ISO9001 の統合審査は実現しているものの，現時点では ISO／TS16949 と EMS の統合審査はないため，外部審査の一元化が出来ないのは残念ではあるが，マネジメントの為の基準や組織・会議，内部監査の統合などによる負担低減効果と，認証維持が目的でない業務改善の促進が期待できる．

MS を，本来業務の改善のツールと捉えれば，環境・品質に留まらず，安全や情報，その他経営全体のマネジメントに適用することが可能である．EMS と QMS の統合を足がかりに，本来業務の改善を続けることで，企業理念である「お客様・クルマ文化への価値の提供」「世界一のオペレーションで世界一の商品」の実現に前進し，同時に環境や品質，安全の改善効果を生み出していく，経営と一体となった真のジヤトコ統合マネジメントシステムを目指して行きたい（Fig. 5）．

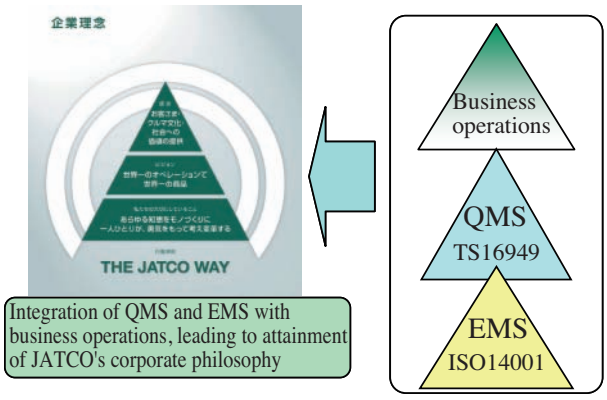


Fig. 5 Integration of MS and business operations

improvements. Improving the performance of our operations and eliminating waste will also contribute to improvements in quality and the environment (Fig. 4).

This means breaking away from "waste, paper and electricity" that are often mentioned in the context of EMS. Promoting a better understanding will lead to improvement in the area of "assessment of the environmental aspects of basic business operations in indirect departments," which was pointed out in the EMS audit.

Based on that judgment, we are now conducting a study with an eye toward integrating our QMS and EMS. While integrated audits have been achieved for ISO 14001 and ISO 9001, there are currently no integrated audits for ISO/TS 16949 and EMS. Unfortunately, we cannot unify our external audits for that reason. It is expected that integrating the standards, organizations, meetings and internal audits used for management purposes would have the effect of reducing costs and promoting activities not for the purpose of maintaining certification but for actually improving business operations.

If MS are regarded as tools for improving basic business operations, they can be applied not only to the environment and quality, but also to safety, information and the management of the company's business in general. Using the integration of our EMS and QMS as a springboard for continuing to improve basic business operations will propel us toward the accomplishment of The Jatco Way in terms of "providing value to our customers and to automotive culture" and producing "the best products in the world by the smoothest operations." Simultaneously, it will have the effect of improving the environment, quality and safety. We will continue to work toward a truly integrated JATCO MS that is unified with our business operations (Fig. 5).

■ Authors ■

Kazuo UMESATO

デジタル化によるモノづくりの変革

Monozukuri Innovation through Digital Engineering

矢部　康志 *　繁田　大倫 *　谷口　光一 **　鹿内　建志 **　北川　裕樹 **　新明　正弘 *
Yasushi YABE　Tomotsugu SHIGETA　Kouichi TANIGUCHI　Takeshi SHIKAUCHI　Hiroki KITAGAWA　Masahiro SHINMYO

抄　録　ジヤトコにおいて，製品開発～生産準備の各技術領域でデジタル技術を活用したモノづくりの推進をおこなってきた．一方，環境変化･お客様のニーズの多様化等へスピーディ且つ効率的に対応する為，部門・部署間を越えたデジタル技術の連携・全体最適が課題となってきている．“コンカレント・エンジニアリング”をキーワードに取り組んできた，部門間連携・全体最適を狙った本活動を紹介する．

Summary　JATCO has been implementing monozukuri processes that utilize digital tools in each technical area from product development to production preparations. However, overall optimization of these tools and cross-functional teamwork transcending division, department and section lines are issues that must be addressed in order to meet operating environment changes, diversifying customer needs and other challenges speedily and efficiently. This article describes the activities that our groups have undertaken to achieve such teamwork and optimization based on the key methodology of concurrent engineering.

1. はじめに

The Jatco Way を実現する為の一方策として，モノづくりプロセスの改革活動「V-3P」を全社にて取り組んでいる．この V-3P を達成する為の方策として，CAD・CAM・CAE 等のデジタルツールの導入と適用を各部門で進めてきた．近年のコンピュータの処理能力の飛躍的な向上，CAD・CAM・CAE の高精度化・信頼性向上に合わせ，その適用効果が着実に出てきている．一方，部門・部署個別でデジタルツールの導入を進めてきた結果，個別最適化されたデジタルツールが乱立する状態となっており，全社的な視点では決して効率の良い全体最適された仕組みになっていないのが現状である．本稿では，この課題を解決する為に，開発部門と生産部門間で全体最適化に向けておこなった活動について解説する．

1. Introduction

A program of V-3P activities for reforming our monozukuri processes is under way throughout the company as one approach to accomplishing The Jatco Way that expresses our corporate philosophy. Every division has been introducing and applying various CAD, CAM, CAE and other digital tools as the means for carrying out the V-3P program. The application of these digital tools has produced steady results, along with the dramatic improvements seen in computer processing power in recent years and the improved accuracy and reliability of CAD, CAM and CAE software. However, because divisions and departments have implemented digital tools separately, a situation now exists where there is a plethora of individually optimized digital tools. There is currently no efficient digital engineering system optimized from a company-wide perspective.

This article explains the activities undertaken by the product development and production divisions to optimize our overall digital engineering system for the purpose of resolving this issue.

* 解析技術センター
Engineering Analysis Technology Development Center Manufacturing
** 生産戦略部
Strategy Planning Department

2. 活動前の状況と課題

近年では製造業の製品開発～生産準備における全てのモノづくりプロセスで，CAD・CAM・CAE 等のデジタル技術を活用するのが一般的となっている．ジヤトコにおいても，製品設計の 3D モデル化を皮切りに，開発・実験での構造解析・流体解析等の各種シミュレーション，生産準備での鋳造湯流れ解析・組立での作業性検証等のデジタルツールを導入してきた．各デジタルツールはトライアル等で事前にその効果を確認した上で実務に適用，各業務単位で効果をあげてきている．具体的な効果として，現物の試作工数の削減，生産ラインの立ち上がり段階での手戻り削減，型・設備準備期間の短縮等が確認出来ている．

一方，いくつかの主要プロジェクトに適用してきた後，これらデジタルツールをモノづくりプロセス全体の視点から改めて俯瞰して見た場合，いくつかの課題があることが分かってきた．

2.1. 個別最適化されたデジタルツール

デジタルツール間のデータ授受の効率性，操作性の統一等の面を考慮すると，導入するツールは極力統一パッケージ（CAD・CAM・CAE を統一プラットフォーム上で実現）から選択すべきである．しかし導入当時，全ての業務領域の機能要件を満たすことが出来るパッケージソフトが無く，各部門・部署或いは業務に対して，その業務要件に特化した個別ツールの導入を進めてきた．その結果，現在課題となっているのが，

①個々のツール間でのデータ授受が困難（変換工数・リードタイム大）

②少しの機能差があるだけで，似たようなツールが社内に多数存在（管理維持コスト・工数大）

③ツール毎に操作性がことなり，都度教育，専門オペレータが必要（工数大）

等のシステム課題である．

2.2. 業務プロセス間での連携不足

上述したとおり，部門・部署毎に個別最適化しながらデジタルツールの導入を進めてきたが，その結果，仕事のプロセスとしてみた場合でも，いくつかの業務課題がある．

①部門・部署間でデジタルツールに関する情報・

2. Situation and Issues before Initiating Improvements

The use of CAD, CAM, CAE and other digital tools has become commonplace in manufacturing industries in recent years in all monozukuri processes from product development to production preparations. Like other companies, JATCO first introduced digital tools beginning with 3D product design models. Subsequently, various simulation programs were implemented for performing structural analyses, fluid analyses and other studies in product development and testing processes. Digital tools were also introduced at the production preparations stage for performing melt flow analyses in the casting process and workability validations in assembly operations, among other studies. The effectiveness of each digital tool was confirmed in advance through trial use before applying it to actual work operations. The tools adopted to date have produced benefits in individual work areas. Specific examples of the benefits obtained include the reduction of trial production man-hours involving the use of physical prototypes, reduction of rework at the production line launch stage, and the shortening of the lead time needed to prepare dies, molds and production facilities.

After applying the digital tools to several major projects, they were assessed comprehensively once again from the standpoint of our overall monozukuri processes. The results revealed the existence of several issues.

2.1. Individually optimized digital tools

The digital tools selected for introduction should have a unified software package as much as possible. That means CAD, CAM and CAE tools should all run on a unified platform in consideration of the efficiency of exchanging data between tools, consistency of operating procedures and other aspects. However, when we began adopting digital tools, there were no software packages capable of satisfying the functional requirements of all work areas. Accordingly, individual divisions, departments and workplaces implemented tools separately that were specifically designed to meet their own work requirements. As a result, that has given rise to the following system-related issues at present:

(1) It is difficult to exchange data between individual tools, resulting in the need for time-consuming data conversion and longer lead time.

技術が共有化されていない．結果として，社内にある技術を有効活用出来ていない．
具体例：生産にて課題視している加工の切削時におけるビビリ振動を，開発にておこなっている音振解析を応用することで解析可能であるが，実際には活用がされていない．

②各ツール間で共有・活用すべきデータの連携が取れていない．
具体例:解析メッシュモデルや検討パラメータ（工程情報，生産サイクルタイム等）の共有が出来ておらず，作成工数の重複や手戻りが発生している．

2.3. 複雑化する開発における効率化

お客様に喜ばれる商品開発において，高性能・高品質・低コストを達成すべく，商品は複雑化してきている．その結果，開発プロセスとして，いくつかの課題がある．

①莫大な情報の共有不足．
②複雑化する商品の開発費用の増加．
③多種多様の商品開発による工数不足．
等の開発課題である．

これらの業務・システム課題を解決する為，開発・生産の各部門で CAD・CAM・CAE を推進している解析技術センターと生産戦略部間で共同にて取り組みをおこなってきた．具体的には，定期的に打ち合わせの場を設定して互いの目標と活動を見える化，最終的にはあるべき姿の作成・共有化のアウトプットを目指したアナログ的な活動である．次項以降で，その具体的な活動の一部を紹介する．

3. 活動の状況

3.1. ものづくり CAD・CAM・CAE マップの作成

本活動の第一ステップとして，“モノづくり CAE・CAM・CAE マップ”を作成した．Fig. 1 にそのマップを示す．このマップにて，ジヤトコのモノづくり領域に存在する全てのデジタルツールをマッピングして見える化し，ツールの分布や偏り，重複や不足等を明らかにした．

その作成手順は以下のとおり．

①縦軸に素材～加工～組立～工場といった業務領域軸を置き，横軸に製品設計～工程設計～型・

(2) There are many similar tools in use within the company that differ only slightly in functionality, thereby increasing the cost and man-hours needed for their management and maintenance.
(3) Operating procedures differ from one tool to the next, thus requiring frequent training and specialized operators, which also increases man-hours.

2.2. Insufficient teamwork between work processes

As described above, the digital tools introduced to date have been optimized to meet the needs of individual divisions and departments. As a result, there are also a number of work-related issues when viewed from the standpoint of our overall work processes.

(1) Information and techniques concerning digital tools are not shared between divisions or departments. Consequently, the technologies possessed by the company are not being utilized effectively. The following is a specific example. Chattering during machining operations is viewed seriously by production personnel. Such vibration could be analyzed by applying the noise/vibration analysis software used in the production development division. In actuality, though, the software is not being used for that purpose.
(2) Data are not coordinated for shared used between different tools. One example of this is that there is no sharing of simulation mesh models or study parameters such as process information, production cycle time and other aspects. This results in duplication of man-hours for model creation and the occurrence of rework.

2.3. Improvement of efficiency in increasingly complex development work

The need to achieve higher performance, enhanced quality and lower costs in developing products that please customers is leading to more complex products. This situation has given rise to several issues in the product development process.

(1) Insufficient sharing of massive volumes of information
(2) Higher development costs for increasingly complex products
(3) Insufficient man-hours for developing a wider range of product variations

The Engineering Analysis Technology Development Center and the Manufacturing Strategy Planning Department, which are promoting the use

設備設計等のモノづくり時間軸を設定する.

②ジヤトコのモノづくり領域で使用しているデジタルツールを，業務軸・時間軸で整理しながらマッピングする.

③それぞれのツールの導入難易度，効果も合わせて記入する.

④さらに，業務課題がありニーズのあるもの，既存の技術でシーズとして提案できるものを，それぞれ色を変えて着色してマッピングする.

上記の作業を両部署共同にて実施し作成したマップを Fig. 1 に示す．このマップを分析した結果，いくつか気づきを得ることが出来た.

・デジタルツールの抜け，偏り，重複

・ニーズやシーズの有無，分布

・データや業務の流れ，つながり

・社内にある既存技術のニーズへの転用

また生産でニーズがある課題を，開発で既に適用している解析技術を応用することで，解決が可能である案件を発掘するといった，具体的な業務連携にも繋げることが出来た.

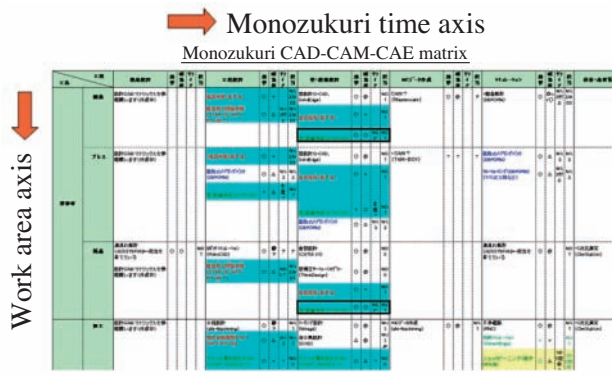


Fig. 1 Monozukuri CAD-CAM-CAE map

3.2. Navi-CAD の作成

開発期間，設計工数の増加の課題を解決する為，ナレッジマネージメントに着目し，業務遂行に必要な知識・情報を組織全体で共有できるニーズを洗い出した.

①設計の手順をシステム化.

②業務プロセス・日程管理の見える化.

③莫大な情報と個別資料の共有化.

上記をまとめた Navi-CAD を作成したシステムを Fig. 2 に示す.

of CAD, CAM and CAE tools in product development and production processes, have been working together to resolve the system- and work-related issues mentioned above. Specifically, regular meetings have been held to make the goals and activities visible to each other. These are analog-type activities aimed at creating and sharing a desirable framework for the use of digital tools as the final output. The following section presents some specific examples of the activities being pursued.

3. Activity Status

3.1. Creation of a monozukuri CAD-CAM-CAE map

The first step of this activity was to create a monozukuri CAD-CAM-CAE map, which is shown in Fig. 1. All of the digital tools now in use in JATCO's monozukuri operations are indicated in this map. This mapping exercise made clear the distribution, over-concentration, duplication, insufficiency and other aspects of our digital tools. The procedure followed in creating the map is explained below.

(1) The various work areas such as casting/forging, machining, assembly and logistics were arranged along the vertical axis. A monozukuri time line was defined along the horizontal axis in terms of product design, process design, die-mold-facility design and so on.

(2) The digital tools used in JATCO's monozukuri processes were then arranged and mapped along the work axis and the time axis.

(3) The relative difficulty of implementing each tool and its benefits were also entered in the map.

(4) Needs for digital tools to resolve work-related issues and existing technologies that could be proposed as potential solutions were also mapped in different colors.

The map shown in Fig. 1 was created as a result of the two groups jointly carrying out the procedure outlined above. The map was then analyzed and the results revealed the following points.

- The absence, over-concentration and duplication of digital tools
- The presence or absence of needs and potential solutions and their distribution
- The flow of data and work operations and their interconnections
- Possibilities for diverting existing technologies in the company to meet the needs

The map also led to concrete forms of

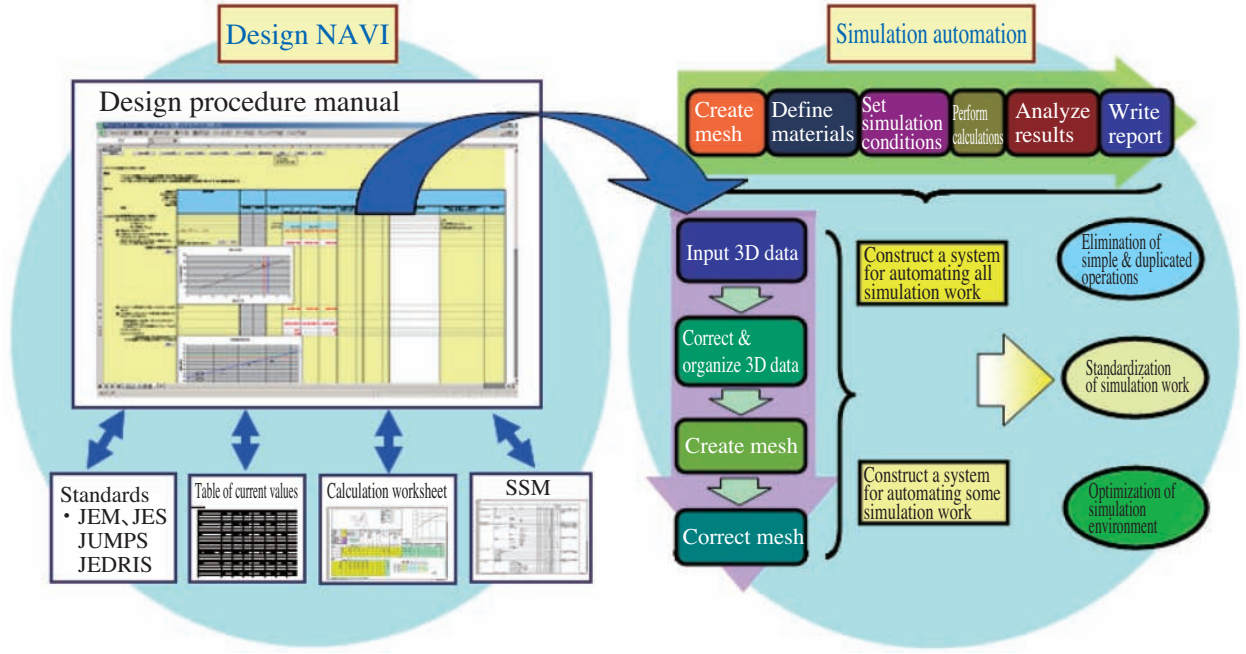


Fig. 2 Configuration of Navi-CAD system

3.3. バーチャルテストの推進

開発期間の増加，開発費削減の課題を解決する為にフィジカル実験のバーチャル化について取り組み課題を洗い出した。

①フィジカル実験とバーチャル化の区分明確化.

②フィジカル実験からバーチャル化への効果見える化.

③バーチャル化の計画作成.

④フィジカル実験の効率化

上記を軸にしたV-3P解析実験分科会の方策の明確化を進めている。バーチャル化の事例をFig. 3に示す.

collaboration between different operations. For example, it was found that certain production-related issues for which digital tools were needed could be resolved by applying the analysis tools already being used in the product development division.

3.2. Creation of a Navi-CAD system

Attention was focused on knowledge management for the purpose of addressing the issues of longer development periods and increasing design man-hours. An effort was made to identify what was needed to enable the entire organization to share the

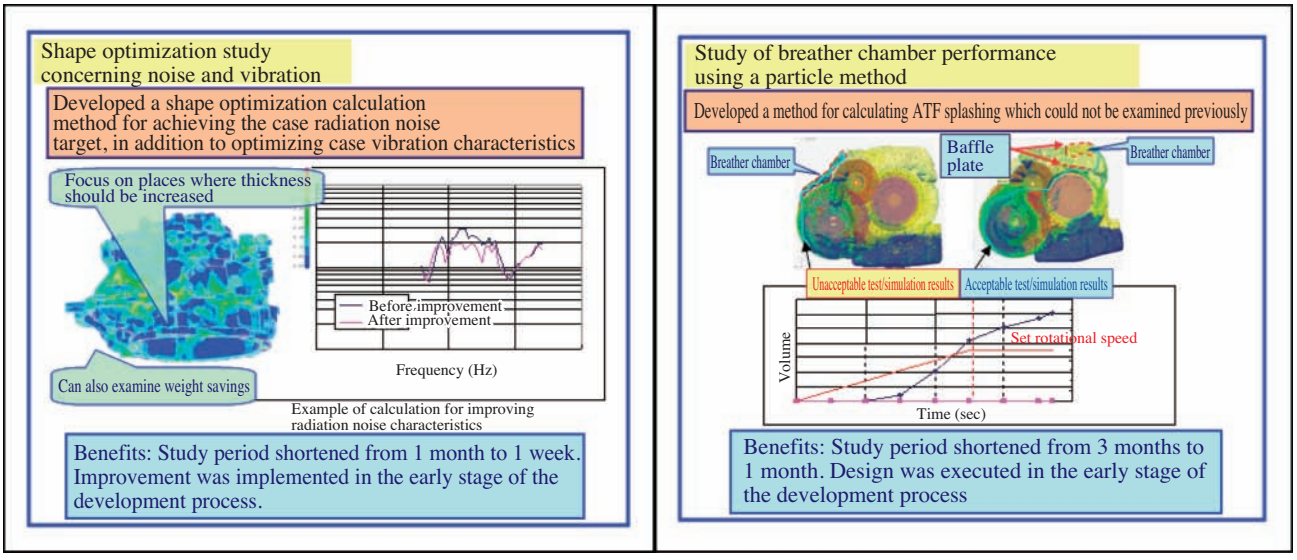


Fig. 3 Example of virtual testing

4. 個別戦略の共有と全体戦略の作成

前項で紹介したマップの作成と並行しておこなったのが，個別戦略の共有と全体戦略の作成である．開発，生産各領域では各々のデジタル化戦略を持っていたが，本活動以前は互いに共有が出来ていなかった．そこで最初に互いの戦略やその考え方の共有化をおこなった．

解析センターからは製品設計の CAD 領域，構造・流体・制御解析の CAE 領域の戦略を提示，生産戦略部からは生産領域，主に加工・組立領域のデジタル戦略を提示して共有化した．デジタルツールの重複や補完はモノづくり CAD・CAM・CAE マップで共有化出来たが，戦略の共有化ではそれに加え，ヒト・カネ・モノ等のレベルでの課題の共有化と実行が出来た．

成果に繋げられた具体的な事例としては，デジタルツールの更なる拡大を狙った“デジタル技能塾”の開講である．開発・生産共にCADスキルの拡大を狙っており，両者で協業することで，本講座を短期間且つ効率的に開講することが出来た．本講座は工場の技能員を対象としており，“デジタルツールを使って業務を変革出来る人づくり“を狙い，09 年度より開講している（Fig. 4）．

Fig. 4 Digital skills training course

また，本活動では共同で全体戦略の作成もおこなった．モノづくりの変革を狙った方策としてのデジタル化を，

・バーチャルデザイン（製品設計）
・バーチャルテスト（実験）
・バーチャルファクトリー（生産）

necessary knowledge and information for executing work operations. The following needs were identified.

(1) Systematizing design procedures
(2) Making work processes and schedule management visible
(3) Sharing of massive volumes of information and individual documents

Figure 2 shows the Navi-CAD system that was created which incorporates the items above.

3.3 Promotion of virtual testing

The following issues involved in changing from physical to virtual testing were identified, as one approach to resolving the problem of longer product development periods and the need to reduce development costs.

(1) Clarifying the respective areas for physical testing and virtual testing
(2) Making the benefits of changing from physical to virtual testing visible
(3) Creating a plan for virtual testing
(4) Improving the efficiency of physical testing

The CAE Analysis and Experiment Team is seeking to find definite methods for addressing these issues. A virtual testing example is illustrated in Fig. 3.

4. Sharing of Individual Strategies and Creation of an Overall Strategy

In parallel with the creation of the maps described in the previous section, efforts were made to share individual strategies and to create an overall strategy. The product development division and the production division each have their own strategy for using digital tools. These strategies were not shared between the divisions before the initiation of the activities described in this article. Therefore, it was decided to share the strategies and associated concepts as the first step.

The Engineering Analysis Technology Development Center presented its strategy for the use of CAD in product design and the use of CAE tools in conducting structural, fluid and control analyses. The Manufacturing Strategy Planning Department presented its strategy for using digital tools in production processes, mainly in machining and assembly operations. These strategies were shared between the two groups. The monozukuri CAD-CAM-CAE map enabled both groups to reach a shared understanding of the duplication of digital tools and the need for complementation where tools

以上3つの領域に分け，3D製品設計を軸とした“全員設計・全員モノづくり”のコンセプトを作成した．“市場要望･客先メーカー要求”をインプット，“世界一の商品・世界一のオペレーション”をアウトプットとし，実現する為の方策を“コンカレント・エンジニアリング”とした戦略である（Fig. 5）．

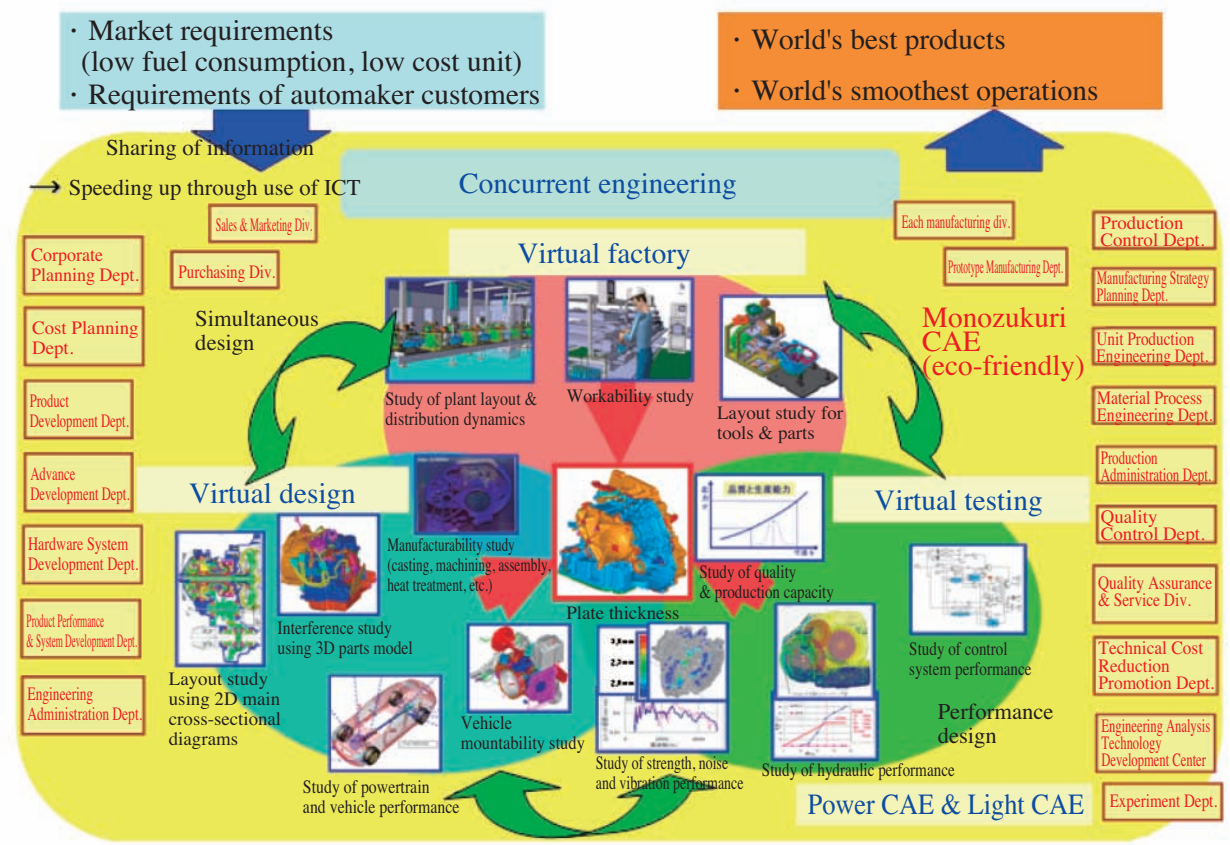


Fig. 5 Digital engineering strategy

今後は，この戦略を軸に各領域を推進し，常に情報を共有・デジタル化の全体最適を意識しながら，モノづくりの変革を推し進めていく．

5. 今後の活動

以上，開発・生産両部門共同でおこなってきた活動を紹介した．デジタル化の課題ではあるが，それを推し進めながら変革していく為には，本稿で解説したようなアナログ的な手法が非常に重要であり，今後も両部門で協力をしながら進めていきたい．

しかし一方，3Dデータの軽量化や製品・生産設備の3Dデータの共有化等，技術的な課題も多く残っている．目指すべきは，モノづくりに係わるデータを

were missing. In addition to that understanding, issues regarding personnel, funds and materials were shared in the process of arriving at a common strategy.

One concrete example that led to specific results was the initiation of a digital skills training course aimed at further expanding the use of digital tools. Both the product development and production divisions aim to expand CAD skills and their teamwork here enabled this training course to be established efficiently in a short period of time. The training course is for technicians at the plants and is aimed at developing people who can use digital tools to innovate work processes. The course was first conducted in fiscal 2009 (Fig. 4).

An overall strategy was also jointly created in this effort. The following three areas were identified for achieving monozukuri innovations through the use of digital tools:

- Virtual design (product design)
- Virtual testing (testing)
- Virtual factory (production)

A concept was then formulated for all design and monozukuri process employees for pursuing their work along an axis of 3D product design in each

上流～下流で繋げて活用出来るPLM（Product Lifecycle Management）の実現である．その視点では本活動はまだ極一部の取り組みであり，今後は工場や営業，管理部門等を巻き込みながら，ジヤトコ全体の変革に結び付けていきたい．

area. This strategy calls for the input of market demands and the specific requirements of our automaker customers and the output of the world's best products and finest operations, using concurrent engineering as the methodology for accomplishing this task (Fig. 5).

Efforts are being promoted in line with this strategy in each area to achieve monozukuri innovations, while consciously striving at all times to share information and achieve overall optimization of the digital tools.

5. Future Activities

This article has described the activities being undertaken jointly by the product development and production divisions to achieve overall optimization of our digital tools. While this issue pertains specifically to digital tools, the analog approaches explained here are crucial for accomplishing innovations as we push ahead with these activities. Both groups will continue to work closely together in this regard in the future.

However, there are still many technical issues to be addressed, including reducing the massive volumes of 3D data and the sharing of 3D data between products and production facilities, among other things. The aim is to accomplish product lifecycle management (PLM) whereby all data related to monozukuri can be input and used effectively from upstream to downstream processes. In that respect, the activities described here represent just a tiny fraction of the work involved. In the future, we want to involve the plants, sales and marketing, and administrative departments in integrated efforts to achieve innovations throughout JATCO's entire organization

■ Authors ■


Yasushi YABE


Tomotsugu SHIGETA


Kouichi TANIGUCHI


Takeshi SHIKAUCHI


Hiroki KITAGAWA


Masahiro SHINMYO

バーチャルテスト

Virtual Testing

横山　嘉昭 *　浅野　日出夫 *　小泉　耕司 *　片山　佳津男 *　熊田　治郎 *
Yoshiaki YOKOYAMA　Hideo ASANO　Kouji KOIZUMI　Kazuo KATAYAMA　Haruo KUMADA

抄　録　昨今の複雑化したAT，CVTの開発において，実験検証の効率化が必要である．このため，実験をCAE解析に，置き換えていくことが重要となっている．JATCOでは，この置き換えをバーチャルテストと呼び，取り組んでいる．

Summary　There is a need to improve experimental verification efficiency in the development process of ATs and CVTs, which have become much more complex in recent years. Toward that end, it is essential to substitute CAE simulation for physical testing. At JATCO we are proceeding with activities to accomplish this substitution, which we refer to as virtual testing.

1. はじめに

バーチャルテストとは，実験を解析に置き換えて，実験レスにしていくことを意味している．

トランスミッションの製品開発の妥当性確認実験の最終形態は実車走行実験で，これは，信頼性を確保する意味で必要であろう．

ただし，その途中の過程は，実験レス化することは可能であり，CAE解析への置き換えによる実験レス化をすることでの実験業務の効率化は急務である．

バーチャルテストはこのような取り組みであり，基本は，以下の3項目である．

①実験によるCAE解析への置き換えの公認活動
②部品，性能実験の実験レス化
③制御走行実験の実験レス化(実車実験の台上化)
以下にその内容ついて述べる

2. 公認活動について

公認活動とは，CAE解析手法で検証し，それが実験の代用になるから試作品によるフィジカルテストを行わなくて良いと判定していくことである．ここで，以下のランクを解析手法の精度として用いる．

1. Introduction

Virtual testing means substituting simulation for physical testing, thereby eliminating the need to conduct tests using physical prototypes. In the course of developing an automotive transmission, driving tests are conducted with an actual vehicle as the final stage of the testing process. Such tests are necessary to confirm reliability. However, there is an urgent need to improve testing work efficiency by substituting CAE simulation for physical testing wherever such substitution is possible during the development process.

Virtual testing is aimed at improving efficiency and basically involves efforts in the following three areas:

(1) Activities to validate CAE simulation as a substitute for physical testing
(2) Elimination of physical testing for components and performance
(3) Elimination of physical testing of transmission control systems in vehicle driving tests (migrating from vehicle tests to bench tests)

The following sections describe the activities being pursued in each of these areas.

2. Validation Activities

Validation activities involve the process of verifying and judging that CAE simulation methods can be

* 開発部門 実験部
R & D Division Experiment Department

ランク “0”　絶対値として置き換え可
ランク “1”　適用範囲内の相場値解析
ランク “2”　傾向解析ができる
ランク “3”　実験が必要

図 1 に公認ランクの考え方を示す．なお，公認は，性能，制御，部品といった実験機能軸の技術のトップの者の判断で行なう．

Validation ranking	Definition	Details
“0”	Substitution is possible at the level of absolute values.	Verification is possible by simulation alone.
“1”	Simulation of prevailing values is possible within the range of application.	Accumulated experimental equations are used within the application range.
“2”	It can be used for tendency analysis.	New experimental coefficients are found and used within the application
“3”	Physical testing is required.	This applies to new technologies, etc.

Fig. 1 Validation ranking

3. 部品・性能実験レス化

部品・性能実験に向けて，前記の公認ランクにより評価された解析手法を用いて，実験レスとするものを決めている．

このため，実験検証手法と，解析（＝設計）手法のマトリックスを蓄積しており，実験の企画時に判断している．具体例を図 2 に示す．このプロセスの責任は，実験による問題点見逃し防止の観点で，実験に置いている．

また，結果的に，実験することが，早くなるようでは，意味が無い．効率的な解析規模で，開発に間に合うように計算を終わらせることも，重要なポイントとなる．

4. 制御走行実験の実験レス化

制御実験においては，変速性能の適合開発が占める割合が大きく，かつ，その大部分を実車走行に頼っている．そこで，開発期間短縮，最適化，確実化，一発化を実現するためには，実車走行テストを実施する過程における自動化／バーチャル化が不可欠である．

このために，JATCO では，次に示すような 3 段階

substituted for physical testing and that it is not necessary to conduct any tests using physical prototypes. The following validation rankings are used in this regard.

0 : Substitution is possible at the level of absolute values.
1 : Simulation of prevailing values is possible within the range of application.
2 : It can be used for tendency analysis.
3 : Physical testing is required.

The concept behind these validation rankings is outlined in Fig. 1. It will be noted that validation judgments are made by the engineering executives responsible for the testing functions regarding performance, control systems and components.

3. Elimination of Physical Testing for Components and Performance

Decisions are made regarding which component and performance tests can be eliminated by substituting simulation methods that have been evaluated on the basis of the validation rankings explained in the foregoing section. For that purpose, a matrix of experimental verification methods and simulation (i.e., design) methods is accumulated and used to identify which tests can be eliminated at the time physical testing is planned. This process is carried out from the perspective of which tests are essential in order to prevent potential issues from being overlooked.

If it should turn out that physical testing can be done faster than the simulation, then virtual testing would be meaningless. It is important to use an efficient simulation scale so that the calculations can be completed in time for the results to be used in the development process.

	Simulation items				Judgment of necessity of physical testing
	Item #1	Item #2	Item #3	Item #4	
Accuracy (validation ranking)	0	1	3	2	
Test #1	○				No testing needed
Test #2			○		
Test #3	○	○			No testing needed
Test #4			○		
Test #5			○	○	

Fig.2 Validation matrix for elimination of physical testing

の進め方を経て，制御バーチャルテストに至るように進めている．すなわち，図 3 の制御開発 V プロセス図において実車実験を，

1. オンラインキャリブレーション，
2. 自動キャリブレーション，
3. 性能実験の台上化

と進める事でバーチャルテストの比率を増やすことである．

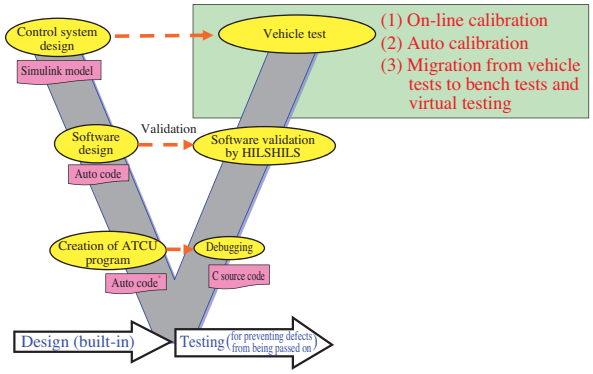


Fig. 3 V-shaped process for control system development

4.1. オンラインキャリブレーション

オンラインキャリブレーションとは計測用 PC から直接 ATCU と通信をしながら定数変更を行なうことである．

これにより，即座にデータ解析，定数変更をすることによって実車適合実験のスピードアップが図れるだけでなく，HILS（Hardware In the Loop Simulation）と組み合わせた自動キャリブレーションや台上化での自動運転等，幅広く応用できる．

図 4 にオンラインキャリブレーションの概要を示す．

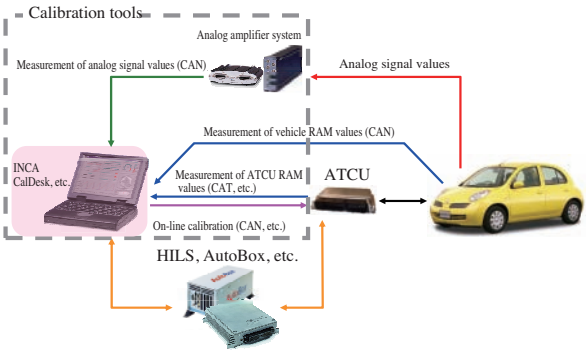


Fig. 4 On-line calibration

4. Elimination of Vehicle Driving Tests for Control Systems

Development work to optimize shift performance to match the target model accounts for a large portion of control system testing. Moreover, much of this work relies on vehicle driving tests. There is a need to automate and incorporate virtual testing in the process of conducting vehicle driving tests.

Toward that end, we are pursuing the following three-stage process in our efforts to achieve the virtual testing of control systems at JATCO. Figure 3 shows the V-shaped process for the development of control systems.

1. On-line calibration
2. Automatic calibration
3. Migration from vehicle tests to bench tests and virtual testing

4.1. On-line calibration

On-line calibration involves varying the constants of the automatic transmission control unit (ATCU) during driving. At present, hardware-in-the-loop simulation (HILS) and other simulation tools are used, but that level of virtual testing is not sufficient to complete the verification process. In the end, it is still necessary to confirm control system quality by checking the system performance in actual vehicle driving tests.

On-line calibration plays an important role in the process of varying the ATCU constants during an actual vehicle driving test.

4.2. Automatic calibration

A key aspect of automatic calibration is to have a system for automatically determining the evaluation points. The following steps are performed automatically to incorporate the targeted performance, which eliminates the need to conduct vehicle driving tests.

1. The constants, test conditions and other parameters are varied using the design of experiment method.
2. Instructions are given to the ATCU to change the constants.
3. The evaluation points are found automatically from the test waveforms.

4.2. 自動キャリブレーション

自動キャリブレーションにおいて，ポイントとなるものは，自動評点システムである．この評点を用い，以下のステップを自動的に行い，狙いの性能に持ち込む．これによって，実車走行実験レスとしていく．

①実験計画法を用い，定数や実験条件などのパラメータを変化させる．

②定数変更を ATCU に指示する．

③実験した波形から自動的に評点を求める．

④最適設計値を求める．

図 5 に自動キャリブレーションの概要を示す．

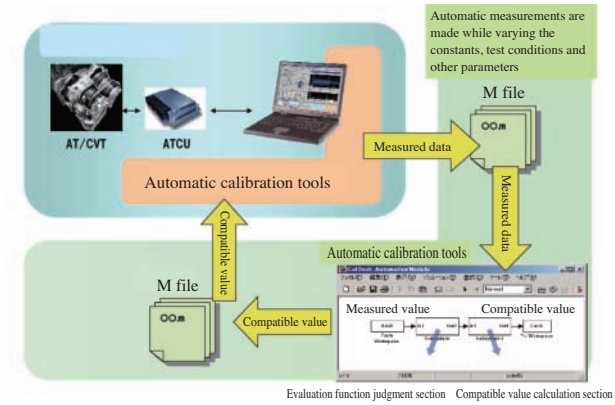


Fig. 5 Automatic calibration

4.3. 実車実験の台上化とバーチャル化

従来からのトランスミッション＋ダイナモの単体ベンチでの台上化に加えて，最近，実車を台上でテストするタイプの台上化の手法が開発されている．いずれの方式もその車両やエンジンを CAE モデル化してバーチャル化が可能である．現時点では，実車を台上でテストするタイプの方が，スタンバイの時間を省けるため，好ましいと考えている．

図 6 に，この実験システム図を示す．

4.4. 制御実験の目指す姿

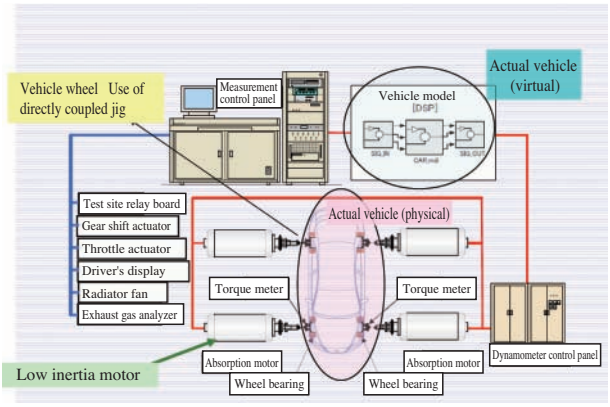
以上，制御実験においては，今後，3 年程度で，オンラインキャリブレーション，自動キャリブレーション，実車実験の台上化による実車実験のバーチャル化を進め，HILS を用いた制御ソフト検証を併用することで，工数の大幅削減を図っていく予定である．

この場合，実車実験と，HILS による制御ソフト検証は，ほぼ同程度の比率となり，実車実験のみの工数と比較して，全体としての効率が大幅に向上するも

4.3. Migration from vehicle tests to bench tests and virtual testing

A bench test procedure has been created for the conventional test stand consisting of a transmission and a dynamometer. In addition, a bench test method has recently been developed for testing an actual vehicle on a test stand. Virtual testing is possible with either approach by creating CAE models of the vehicle and the engine. At the present time, it is preferable to test an actual vehicle on a test stand because it eliminates stand-by time.

The overall configuration of the test system is outlined in Fig. 6.



Source: Ono Sokki Co., Ltd., Real Car Simulator Manual (in Japanese)[1]

Fig. 6 Configuration of bench test and virtual testing system

4.4. Targeted configuration for control system testing

In approximately the next three years, we plan to substitute virtual testing for vehicle driving tests by promoting on-line calibration, automatic calibration and migration from vehicle tests to bench tests. The resultant virtual testing environment will be combined with HILS-based control system validation to reduce the number of man-hours substantially.

In this case, actual vehicle testing and control software validation using HILS will involve roughly the same amount of man-hours. It is expected that overall efficiency will be improved significantly.

5. Conclusion

This article has explained the application of virtual testing to conventional component, performance and control system tests. All of these elements are very complex and exist in manifold varieties. Accordingly, in order to carry out virtual testing procedures efficiently, it will be increasingly necessary to make

のと期待している.

5. あとがき

以上，部品・性能・制御実験のバーチャルテストについて説明してきたが，これらは複雑で，種類も多くなる．したがって，これらの業務を，効率的に使うには，業務 NAVI としてだれでも使えるようにすることが，今後益々重要となるであろう.

今後も業務 NAVI の中に，バーチャルテストコーナーを設けて技術蓄積を進めていきたい.

6. 参考文献

(1) 小野測器（株）カタログ

them readily usable by everyone in the form of an operations wizard.

We intend to establish a virtual testing program as one part of the operations wizard and continue to accumulate the related technologies in the coming years.

6. References

(1) Ono Sokki Co., Ltd., Real Car Simulator Manual (in Japanese)

■ Authors ■


Yoshiaki YOKOYAMA


Hideo ASANO


Kouji KOIZUMI


Kazuo KATAYAMA


Haruo KUMADA

バーチャルファクトリーの取り組み

Virtual Factory

北川　裕樹*
Hiroki KITAGAWA

抄　録　生産領域では，V-3P を軸に生産準備～工場での業務のデジタル化を推進してきた．これまでは新規プロジェクトのみを中心に展開をしてきており，その効果の拡大と浸透のスピードアップが課題となってきている．その課題に対応する為，生産戦略部では【設計との更なるコラボレーション】【工場でのデジタル技術の活用】を現在推進している．その活動を，実例を挙げながら紹介する．

Summary　Efforts have been promoted under the V-3P program to implement digital tools in production processes, ranging from production preparations to manufacturing operations at the plants. To date, these efforts have mainly been carried out only in new product development projects. The next task is to accelerate the extension and penetration of the benefits resulting from these efforts. In order to address this issue, the Manufacturing Strategy Planning Department is promoting "greater collaboration with product development" and "application of digital technologies at the plants." This article describes examples of these activities.

1. はじめに

The Jatco Way を実現する為の一方策として，モノづくりプロセスの改革の為の活動「V-3P」を全社にて取り組んでいる．生産技術ではこのV-3P を達成する為，デジタルツールの活用を中心としたバーチャルファクトリーの取り組みを2004 年度より進めてきた．主に型・設備準備期間短縮を狙い，新規プロジェクトを中心にデジタルツールの適用をおこなっており，業務の前倒し・手戻り削減・工数削減等の効果をあげてきた．

しかし，その効果を得られているのは生産準備の極一部の領域であり，昨今の環境変化に追従する為に，更なる効果の拡大が求められている．効果を“効果の質×効果の面積”とすると，その拡大の為には，

・他の領域との連携による，効果の質の向上
・適用領域の拡大による効果の面積の拡大

が必要である．

本稿では，上記の効果拡大を狙った取り組み

1. Introduction

A company-wide program of V-3P activities is under way to reform our monozukuri processes as one approach to accomplishing our corporate philosophy set out in The Jatco Way. For the purpose of achieving the V-3P program in production engineering, we have been proceeding with efforts to create a virtual factory centered on the use of digital tools since fiscal 2004. Digital tools are mainly used in new transmission development projects with the primary aim of shortening the time needed to prepare dies, molds and production facilities. Significant benefits have been achieved in the front-loading of operations, eliminating rework and reducing necessary man-hours, among other improvements.

However, these benefits have been achieved only in certain limited areas of production preparations. It is necessary to extend these benefits to other areas in order to keep up with recent changes in the operating environment. In terms of "the quality of the benefits x the area of the benefits," further extension will

* 生産戦略部
Manufacturing Strategy Planning Department

として，
①開発との更なるコラボレーション
②工場でのデジタル技術の活用
の事例を紹介する．

2. 開発との更なるコラボレーション

モノづくりにおけるデジタル業務は 3D 製品設計からスタートし，生産では製品 3D モデルを基に，その生産性の評価を目的に各種シミュレーションを実施している．領域としては，鋳造・鍛造・熱処理・加工・組立等の各領域で取り組んでおり，その結果は製品設計・工程設計に生産要件としてフィードバックしている．それぞれの取り組み内容の一例としては，

・鋳 造 領 域：アルミダイキャストの湯流れや凝固の解析
・熱処理領域：プーリーの熱処理時における曲がりの解析
・加 工 領 域：加工時の工具の干渉や成立性，加工時間のシミュレーション
・組 立 領 域：部品の組み付け性や作業性を事前に 3D で検証

等である．Fig. 1 は組立領域で取り組んでいる作業性事前予測の一例である．

Fig.1 Example of Assembly Simulation

これら生産でのシミュレーションの結果は，出来る限り製品設計の早期の段階で製品開発にフィードバックをおこなうことが，業務のフロントローディングの観点から望ましい．このフィードバックの事例を Fig. 2 に示す．この事例では既存の加工ラインに，新たに別の車型の

require:

- Improvement of the quality of the benefits through cooperation with other work areas
- Expansion of the area of the benefits by expanding the application of digital tools to broader areas

This article describes examples of the following efforts aimed at expanding the benefits noted above:

(1) Greater collaboration with product development
(2) Application of digital technologies at the plants

2. Greater Collaboration with Product Development

The work of implementing digital tools in monozukuri processes began with 3D product design. Various types of simulations using 3D product models are conducted in production processes for the purpose of evaluating productivity. The areas where these simulations are performed include casting, forging, heat treatment, machining and assembly, among others. The results obtained are then fed back to product design and process design as production requirements. The following are examples of the activities being undertaken in each area:

- Casting: Analysis of aluminum melt flow and hardening in casting dies
- Heat treatment: Analysis of pulley shaft bending during heat treatment
- Machining: Simulations for analyzing tool interference, process feasibility and required machining time
- Assembly: Prior validation of ease of assembly for parts and workability using 3D models

Figure 1 shows an example of an assembly simulation that is conducted in advance to predict workability in assembly operations.

From the standpoint of the front-loading of work operations, it is desirable to feed back the results of these production process simulations to product design at the earliest possible stage in the product development process. An example of this type of feedback is shown in Fig. 2. In this example, a study of mixed production was conducted at an early stage under the assumption that the transmission case for a different car model was newly added to the existing machining line. Specifically,

(1) The feasibility of mixed production was examined by superimposing the 3D data of the

ミッションケースを混流して生産することを前提に早期の段階で検討をおこなった. 具体的には,

①既存ラインの製品を固定する加工治具の 3D データに，新たに流す製品の 3D データを載せその成立性を検討

②混流が可能な製品形状を検討し，その結果を製品形状として製品設計に提案

③設備投資などの観点で他の案と比較

以上を実施した．早期の段階で，このような詳細な生産要件の検討を開発と同席にて実施することにより，最適な製品形状や設備投資を実現することが出来る．

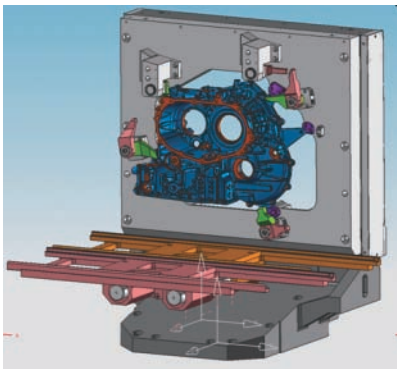


Fig. 2 Example of Machining Simulation

一方これらの検討は，鋳造や組立等各領域で実施しているが，現状は個別にシミュレーションを実施・製品開発へのフィードバックをおこなっており，生産全体の要件として最適化されているとは言えない．業務プロセスの問題だけでは無く，領域間のデジタルツールや 3D データのフォーマットが異なっている問題も非常に大きい．今後は業務プロセスの見直しに合わせ，領域間での 3D データの共有化，流通のスピードアップ・効率化が今後の課題である．

3. 工場でのデジタル技術の活用

これまで，製品開発～生産準備の領域を中心にデジタル化を進めてきたが，検討に用いた 3D データ等のデジタルデータを更に活用して効果を拡大するにあたり，工場への拡大に着目した．そこに着目したポイントは,

・ ライン出来高シミュレーション等，工場での改善

new transmission case on the 3D data of the jigs used for fixturing workpieces on the existing machining line.

(2) A study was made of a case shape that would allow mixed production, and the result was proposed to product design as the product shape.

(3) A comparison was made with other proposals from the standpoint of the required capital investment in production facilities.

This detailed study of the production requirements was conducted together with product development personnel at the early stage of the project, making it possible to determine the optimum case shape and amount of required capital investment in facilities.

Similar studies are also done in casting, assembly and other processes, but at the present time the simulations are done independently and the results are fed back to product development separately. Consequently, the overall production requirements are not optimized in an integrated manner. In addition to the problems found in the various production processes, there are also large issues concerning the use of different digital tools and 3D data formats between different work areas. In conjunction with a review of work processes, other issues that should also be tackled include the sharing of 3D data between workplaces, speeding up the circulation of data and enhancing efficiency.

3. Application of Digital Technologies at the Plants

Digital tools have so far been created mainly in the areas of product development and production preparations. Attention is now being focused on expanding the use of the 3D digital data used in simulations to include the plants in order to obtain broader benefits. The main points of this focus include:

- There are already many digital tools that can be used in improvement activities at the plants, including a line output simulation program.
- The 3D models of products and production facilities used in product design and production preparations can be applied to the various forms used at the plants.
- The digital data used at the plants can be utilized in the next development project as the latest information.

活動への活用が可能な既存のデジタルツールが多くある．

・製品設計や生産準備で使用した，製品や生産設備の 3D モデルが工場で使用する帳票に活用が可能．

・工場で活用したデジタルデータを，最新の情報として次プロジェクトで活用出来る．

等である．

工場への拡大にあたり，最初に実施したのは“人づくり”である．工場で既に実施されていた保全技能や組立技能等，各種技能を教育する技能塾と連携し，その講座体系の一部でデジタルに関する教育が出来ないかを検討した．検討に際しては，技能塾を主催している人事部，全社的に CAD を推進している解析センター，情報システム部と協力・分担をしながら進めてきた．部門を越えてクロスファンクショナルに進めることが出来た結果，構想～インフラ整備～資料準備～開講までを約半年でおこなうことが出来た．

Fig. 3 に講座の全体像を示す．赤枠が現在開講している初級編である．

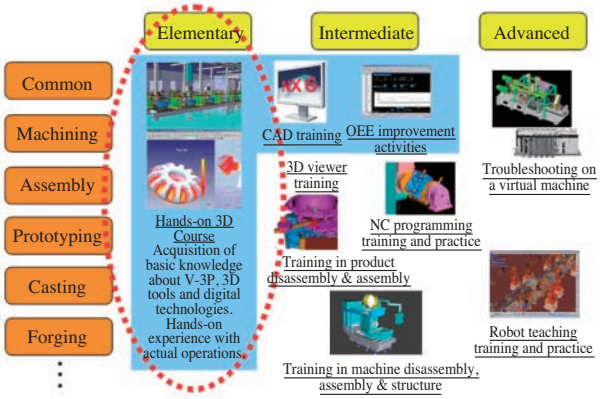


Fig. 3 Overview of Digital Skills Curriculum

初級編では主にマインドの醸成を狙い実施している（Fig. 4）．講座の中では 3D ビューアの教育も実施しているが，まずは“面白い，楽しい”と感じることを大切と捉えてカリキュラムを組んでいる．

講座の中で実施している演習においてもゲーム性を重視し，3D で表現された生産ラインの中に隠れている作業者を探すという課題を設定している．また，講座の最後には“デジタルツールを自分の業務に生かすには？”という題目に対してディスカッションをおこない，自らどう活用していくのかを考える場も設定している（Fig. 5）．

The first case of expanding the use of digital tools at the plants has been for human resources development. JATCO's Technical Skills School has already been conducting educational programs for training workers in various skills such as those for maintenance and assembly. A study was made of the possibility of initiating training in digital skills as one part of the overall curriculum. This study was carried out under a cooperative division of labor with the Human Resources Development Department, which sponsors the Technical Skills School, the Engineering Analysis Technology Development Center and the Management Information Systems Department that are promoting the company-wide use of CAD. As a result of taking this cross-functional approach cutting across departmental lines, all the preparations for starting an elementary training course were completed in approximately six months, including course conceptualization, implementation of the necessary infrastructure and creation of the training materials.

Fig. 4 Digital Skills Course

Figure 3 shows an overview of the digital skills curriculum. The elementary course is enclosed in the red frame. This elementary course is mainly designed to foster a basic understanding of digital tools (Fig. 4). The participants are also taught how to use a 3D viewer, and the curriculum has been designed to make them feel that learning about digital tools is interesting and enjoyable. The exercises that they practice in this course emphasize game-like learning. For example, one task they are given is to find operators hidden in an assembly line depicted in a 3D representation. In the final session of the course, the

Fig. 5 Discussion during Final Session

参加した技能員からは，

“3D を画像データ化して現場の帳票へ流用してみたい”

“作業習熟で活用が出来るのでは？”

といった意見が交わされており，工場での今後の活用が期待出来る．

今後は，実際の活用に向けた中級講座の開講と，工場でより気軽に使えるデジタルツールの導入と継続的なサポートが課題であると考えている．

4. 今後の課題

以上，生産準備領域でのバーチャルファクトリーの取り組みを簡単に紹介した．今後は個別に活用しているデジタルツールやデータの相互連携，更なる製品設計や生産現場との連携をおこない，いかに全体最適化していくかが課題だと捉えている．今後も他部署との連携をおこないながら，ベンチマークや最新技術情報の収集をおこなってデジタルツールの充実を図り，環境の変化に追従して良いモノづくりに繋げていきたい．

participants discuss the subject, "What should be done to use digital tools in your own job?" This provides an opportunity for them to think about how to use digital tools in their own work (Fig. 5).

Technicians who have taken part in the course expressed the following opinions:

- "I'd like to turn 3D product data into images and try to apply them to the forms used in my workplace."
- Couldn't 3D product data be converted to images and used in work skills training?"

It is expected that digital tools will be used more commonly at the plants in the future.

One task for the future is to initiate an intermediate course that focuses more on actual applications of digital tools. Other tasks include the introduction of digital tools that can be used readily at the plants and the provision of continuous support.

4. Future Challenges

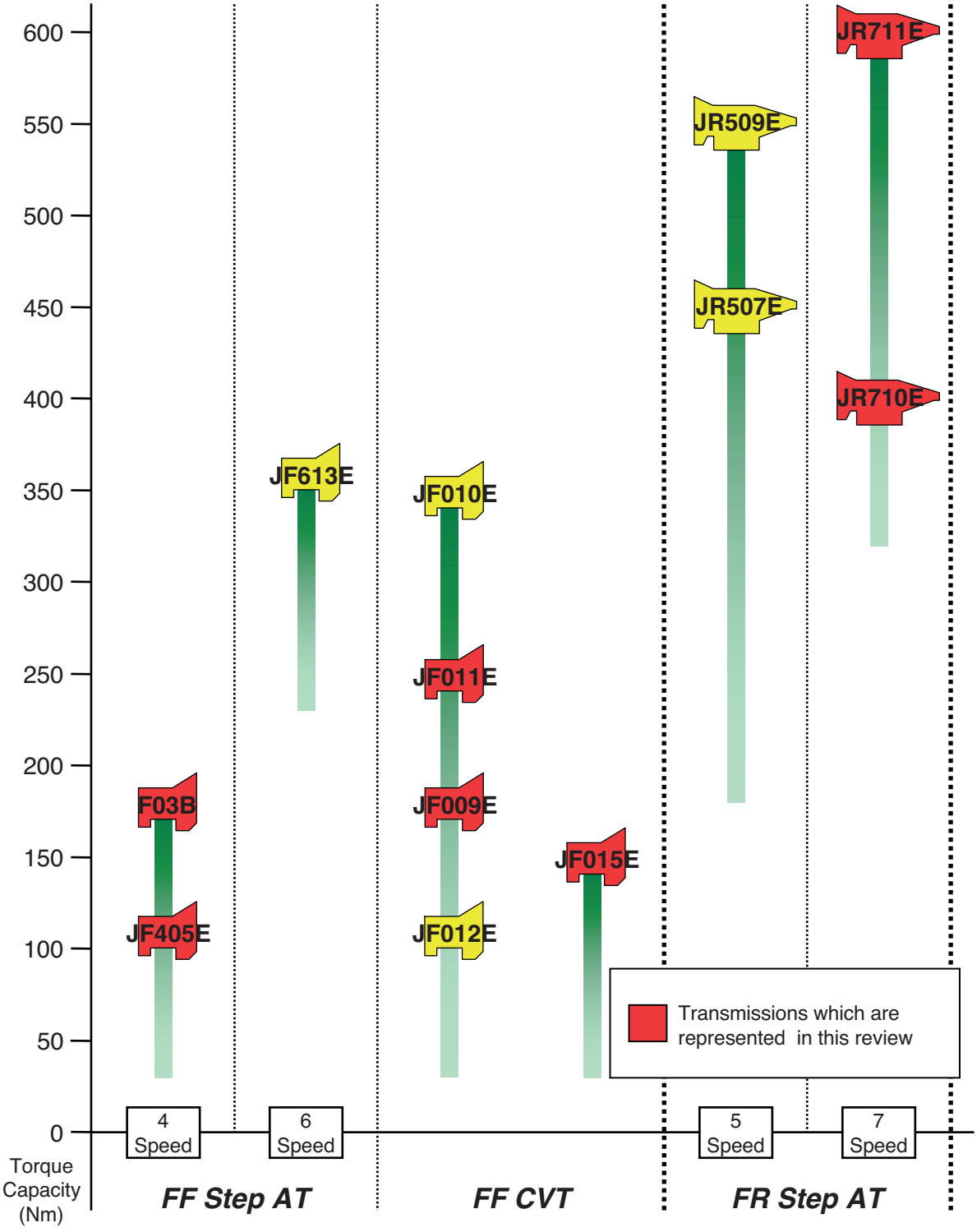
This article has briefly explained the efforts being made to create a virtual factory in the area of production preparations. In the future, we want to interconnect the digital tools and data that are now being used separately. We also want to further strengthen collaboration with product development and the production plants. One challenge will be the question of how to optimize the digital technologies overall. While strengthening cooperation with other departments, we also want to practice benchmarking and collect the latest data in order to improve the digital tools further. We hope these efforts will lead to better monozukuri processes capable of following changes in the operating environment.

■ Authors ■

Hiroki KITAGAWA

Product Line-up

Jatco



ルノー自動車向け　FF車用CVT　JF011E の紹介

Introducing the JF011E Steel-belt CVT for Front-drive Cars

JF011E はルノー・日産のアライアンスプロジェクトとして開発して '08 年 12 月から販売を始めたルノー自動車（株）の新型メガーヌ，セニックに搭載されております.

ヨーロッパの厳しい CO_2 規制を満足する優れた燃費性能と ASC（Adaptive Shift Control）の採用によって運転状況に合わせる適切な変速指令で，ドライバーが意図した走りやリニアな変速感で運転性能も向上させ，お客様の好評を得ております.

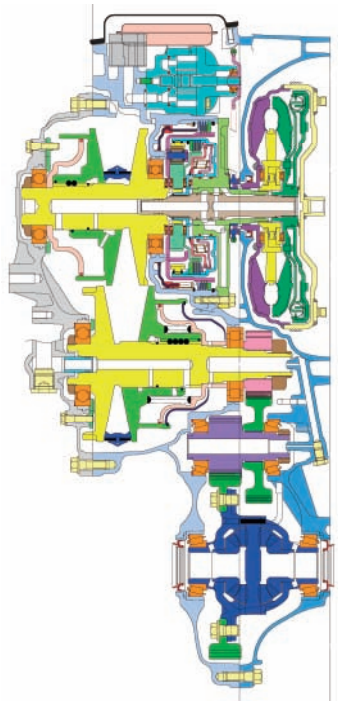


Fig. 1 Main cross-sectional view

Developed under the Renault-Nissan Alliance project, the JF011E CVT is mounted on the new Renault Megane and Scenic models released in December 2008. This CVT provides outstanding fuel economy to meet Europe's stringent regulations on CO_2 emissions. It also adopts Adaptive Shift Control (ASC) that issues suitable shift commands according to the driving conditions. This achieves driving performance matching the driver's intentions and the linear shift feel works to improve driveability as well. As a result, the JF011E has been highly popular among customers.

Table 1 Specifications of JF011E CVT

Max. input torque		210 Nm
Control system		Electronic
Torque converter size		UUF 236 mm dia.
Gear ratios	Pulley ratio	2.349～0.394
	Rev.	0.745
Final drive gear ratio		6.466
No. of selector positions		6
Overall length		354.7 mm
Center distance between engine and differential		197 mm
Wet weight		90.7 kg

■ Typical models fitted with the JF011E CVT ■

New MEGANE

スズキ向け　FF車用 CVT　JF011E の紹介

Introducing the JF011E Steel-belt CVT for Front-drive Cars

JF011E 型 CVT は，2009 年 9 月にスズキ株式会社の SX4 に初めて搭載され，軽量・コンパクトな設計，優れた燃費性能，変速レスポンスの早さで好評を得ています.

2009 年 10 月にはフラッグシップモデルの Kizashi でさらにグローバルに拡大採用をされています.

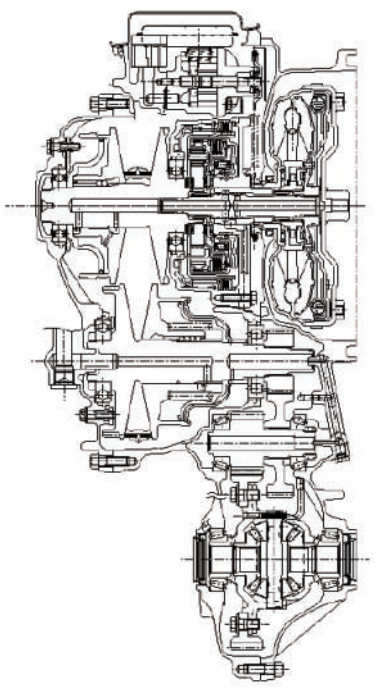


Fig. 1 Main cross-sectional view

The JF011E CVT was first adopted on the SX4 that Suzuki Motor Corporation rolled out in September 2009. It has been highly acclaimed for its lightweight, compact design, outstanding fuel economy and fast shift response.

In October 2009, application was further expanded globally when this CVT was adopted on the Kizashi, Suzuki's flagship model.

Table 1 Specifications of JF011E

Torque capacity	250 Nm
Control system	Electronic
Torque converter	236 mm dia.
Pulley ratios	Low : 2.349
	High : 0.394
Ratio coverage	6.0
Final gear ratio	5.798
No. of selector positions	4 (P, R, N, D)
Overall length	354.4 mm
Weight (wet)	93 kg

■ Typical models fitted with the JF011E CVT ■

SX 4

Kizashi

ルノー三星自動車向け FF車用CVT JF009Eの紹介

Introducing the JF009E Steel-belt CVT for Front-drive Cars

'09年7月から発売のルノー三星自動車（株）のニュー SM3に搭載されたJF009Eは，ルノー・日産のアライアンスプロジェクトとして韓国市場に紹介され，柔らかな変速感，優れた燃費性能，マニュアルモードによるスポーティー な運転性能でお客様の好評を得ております．

車両燃費及び運転性能を共に満足させる最適の手段としてCVTを韓国市場に定着させる契機になっております．

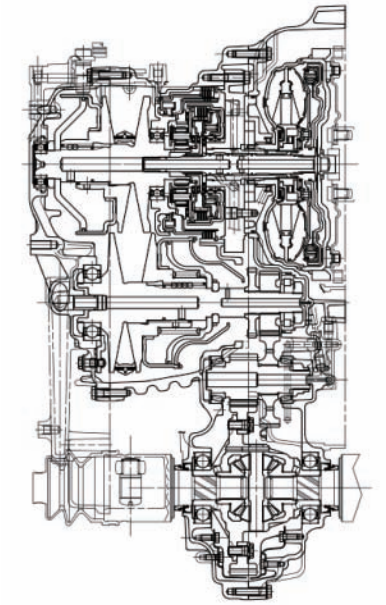


Fig. 1 Main cross-sectional view

The JF009E CVT is fitted on the new SM3 model launched by Renault Samsung Motors in July 2009. It was developed under the Renault-Nissan Alliance project and introduced in the South Korean market on the SM3. It has been highly praised by customers for its velvety shift feel, excellent fuel economy and sporty driveability provided by the manual shift mode.

The JF009E has created an opportunity to firmly establish CVTs in the South Korean market as the optimum transmission for satisfying demands for both vehicle fuel economy and driving performance.

Table 1 Specifications of JF009E CVT

Max. input torque		150 Nm
Max. input speed		6000 rpm
Control system		Electronic
Torque converter		215 mm dia.
Gear ratios	Pulley ratio	2.561～0.427
	Rev.	1.02
Final drive gear ratio		5.473
No. of selector positions		6
Overall length		361.4 mm
Center distance between engine and differential		186 mm
Wet weight		78 kg

■ Typical models fitted with the JF009E CVT ■

New SM3

スズキ向け　FF車用CVT　JF015Eの紹介

Introducing the JF015E Steel-belt CVT for Front-drive Cars

2009年9月に発売のスズキ株式会社のパレットに搭載されたJF015Eは，従来のベルト式無段変速機＋遊星歯車を用いた副変速機構を備えた独自の機構を採用することで世界一の変速比幅を実現し，レスポンスの良い発進，加速性能を確保しつつ，高速走行時の静粛性向上及び低燃費を実現して，お客様に好評を得ております.

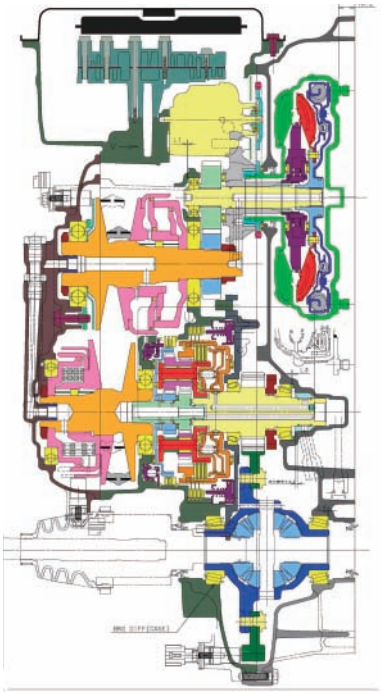


Fig. 1 Main cross-sectional view

The JF015E CVT achieves the world's widest ratio coverage, thanks to its unique structure that combines a planetary gear auxiliary transmission with a conventional belt-type stepless gearbox. It has been highly popular among customers for its quick start-off response, acceleration performance, improved quietness in high-speed driving and excellent fuel economy. The JF015E is fitted on the Suzuki Palette that was released in September 2009.

Table 1 Specifications of JF015E

Max. input torque			160 Nm
Max. input speed			6000 rpm
Max. vehicle weight (GVW)			1280 kg
Control system			Electronic
Torque converter			185 mm dia.
Gear ratios	Pulley ratios	Forward (Low-High)	2.200～0.550
		Reverse	Fixed at 2.200
	Planetary gear ratios Auxiliary transmission	Forward (1st gear)	1.821
		Forward (2nd gear)	1.000
		Reverse	1.714
Counter gear ratios			1.346 / 1.178 / 0.967
Final drive gear ratio			3.882
No. of selector positions			5
Overall length			343 mm
Center distance between engine and differential			172 mm
Dry weight			57.3 kg

■ Typical models fitted with the JF015E CVT ■

Palette SW

GM大宇 Auto & Technology 社向け FF車用4速AT JF405Eの紹介

Introducing the JF405E 4-speed AT for Front-drive Cars

FF4速自動変速機 JF405E は，'02年7月に GM 大宇オート&テクノロジ社の Matiz に初めて搭載されました.

今年8月にモデルチェンジを行った 1000CC 軽自動車 Matiz creative に適用された JF405E はコーストスリップロックアップ採用による燃費性能の向上とトルク制御による変速性能の向上及び K-OBD（Korea-On Board Diagnostics）に対応した AT として韓国市場だけではなくて，全世界に輸出されています.

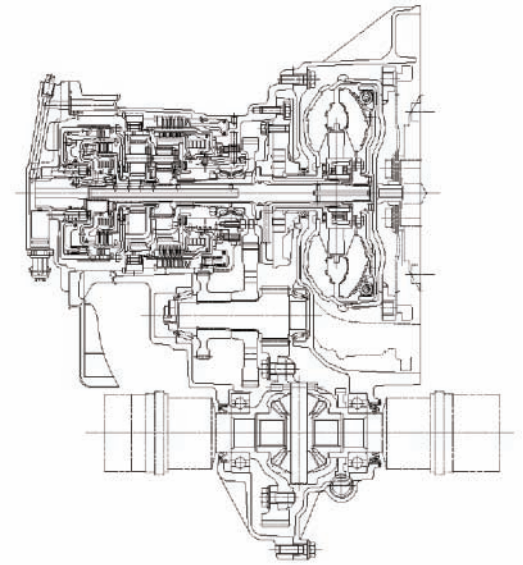


Fig. 1 Main cross-sectional view

The JF405E 4-speed AT for front-drive cars was first adopted on the Matiz, produced by GM Daewoo Autos & Technology, in July 2002. In August 2009, the Matiz underwent a full model change and was newly released as the 1.0-liter Matiz Creative minicar fitted with the JF405E. This AT now features coasting slip lock-up control for a further improvement in fuel economy as well as improved shift performance achieved with cooperative engine torque control. It also complies with the requirements for Korea On-board Diagnostics (KOBD). The Matiz Creative is being exported worldwide, in addition to being sold in the South Korean market.

Table 1 Specifications of JF405E

Max. input torque		92.3 Nm
Max. input speed		6,500 rpm
Max. vehicle weight (GVW)		1235 Kg
Control system		Electronic
Torque converter		200 PCD
Gear ratios	1st	2.914
	2nd	1.525
	3rd	1.000
	4th	0.725
	Rev.	2.642
Final drive gear ratio		4.709
No. of selector positions		6 (P, R, N, D, 2, L)
Overall length		359.9 mm
Center distance between engine and differential		172 mm
Dry weight		50.4 kg

■ Typical models fitted with the JF405E AT ■

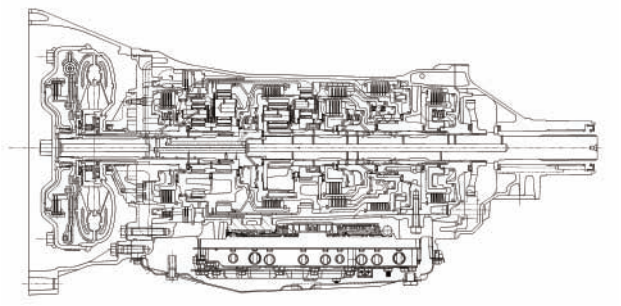
Matiz

日産自動車向け　FR車用7速AT　JR710E（JR711E）の紹介

Introducing the JR710E (JR711E) AT for Rear-drive Cars

JR710E／711Eは，最大トルク600Nm（JR711E）までの幅広い車両への適用が可能な当社初のFR7速自動変速機です．08年6月に日産自動車（株）の北米向けInfiniti FX35／50に初めて採用され，その後もグローバルにInfiniti EX37，M35，G37，Fairlady Z，スカイライン，フーガ等へ順次搭載されております．

ワイドなレシオカバレッジに加え同変速機の特徴である低フリクション，スリップロックアップ領域の拡大，最新制御技術の採用により，燃費の向上と運転性の向上を両立させ，いずれの車両においても好評を博しております．また搭載車両の拡大にあたり，アイドルニュートラル制御や更なるロックアップ制御の改良等の進化をつづけております．



As JATCO's first 7-speed AT for rear-drive cars, the JR710E/711E has wide applicability to a broad range of vehicles, with a maximum torque capacity of 600 Nm for the JR711E version. In June 2008, it was first adopted on the Infiniti FX35/50 models marketed in North America by Nissan Motor Co., Ltd. Since then, it has been steadily expanded to other models that are marketed globally, including the Infiniti EX37, M35 and G37 and the Nissan Fairlady Z, Skyline and Fuga.

Besides its wide ratio coverage, this AT also features low friction, an expanded slip lock-up operation range and the latest control technologies. It has received high acclaim in every vehicle model application. As its application has been expanded to more car models, it has continued to evolve, including the addition of neutral idle control, improved lock-up control and other advanced features.

Table 1 Specifications of JR710E

Max. input torque	400 Nm
Control system	Electronic
Torque converter	250 mm dia.
Gear ratios	1st 4.923
	2nd 3.293
	3rd 2.042
	4th 1.411
	5th 1.000
	6th 0.862
	7th 0.771
	Rev. 3.972
R/C	6.38
No. of selector positions	4(P,R,N,D)+Manual mode shift
Overall Length	769 mm
Wet weight	89 kg

■ Typical models fitted with the JR710/711E AT ■

Fairlady Z

SKYLINE CROSSOVER

SKYLINE

Infiniti G37

Infiniti FX50

FUGA

日産自動車向け　FF車用4速 AT　F03Bの紹介

Introducing the F03B 4-speed AT for Front-drive Cars

F03B は，軽量，コンパクトな設計で好評を得ている，FF 車用 4 速 AT です.

既に，日産自動車（株）の海外向けティーダ，ノート，シルフィー，マイクラ等には搭載されていますが，日産自動車（株）の NV200 へ搭載されるにあたり，初の重量級（全備重量 2t 以上）となる車両に合わせて

1. ハードの適用見直し
2. 変速タイミング・油圧性能の最適化
3. ロックアップ領域の拡大

を行ったことで，お客様要求を満足する性能を達成しました.

The F03B has won high praise for its lightweight and compact design as a 4-speed AT for front-drive cars. Previously, the F03B has been fitted on various models exported by Nissan Motor Co., Ltd., including the Tiida, Note, Sylphy and Micra. The following improvements were made in connection with its adoption on the Nissan NV200, its first application to a heavier weight class in which a fully equipped vehicle weighs more than 2 tons.

1. Review of the hardware specifications
2. Optimization of the shift timing and hydraulic performance
3. Expansion of the lock-up operation range

These refinements have achieved levels of performance that fully satisfy the customer's requirements.

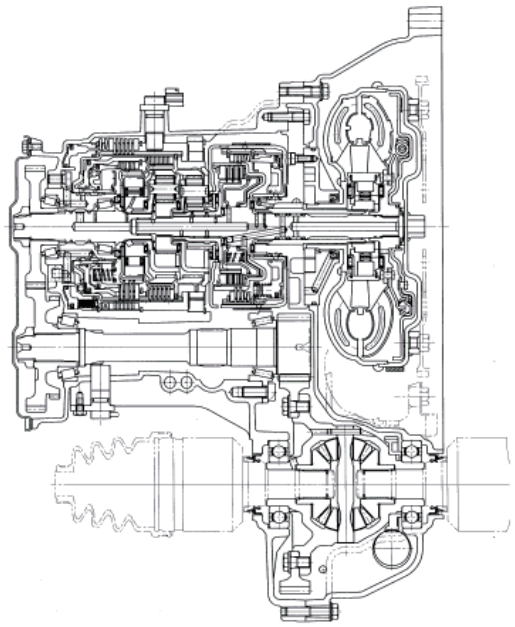


Fig.1 Main cross-sectional view

Table 1 Specifications of F03B

Max. input torque	160 Nm
Control system	Electronic
Torque converter	236 mm dia.
Gear ratios	1st 2.861
	2nd 1.562
	3rd 1.000
	4th 0.697
	5th -
	6th -
	Rev. 2.310
R/C	4.1
Final drive gear ratio	4.072
No. of selector positions	6 (P,R,N,D,2,1)
Overall Length	387.5 mm
Center distance	186 mm
Wet weight	68 kg

■ Typical models fitted with the F03B AT ■

NV200

Jatco 一年間のトピックス

Topics Highlights of the Past Year

1.【茅ヶ崎美化キャンペーン】&【厚木市鮎まつり早朝清掃】

7月27日（日）朝6：30から，茅ヶ崎市菱沼海岸周辺で茅ヶ崎市主催の美化キャンペーン「クリーン茅ヶ崎」に，社員・ご家族，総勢31名が参加．早朝にもかかわらず地元自治会を中心として，子ども会，サーフィン関係者，一般市民等，総勢1,427名が参加し，2.86トンのゴミ回収が行われた．

また，8月3日（日）朝5：45から，厚木市相模川合流地点にて，厚木市主催の「あつぎ鮎まつり」早朝清掃活動に，社員･ご家族，計27名が参加した．

前日に行われた「あつぎ鮎まつり」大花火大会の会場で，58万人が楽しんだ花火の後片付けに，近隣企業等72団体，総計1,724名が参加によって総量約6トン（会場周辺）のゴミを回収することができた．

1. Participation in Chigasaki beautification campaign and early morning cleanup after Atsugi Ayu Festival

Thirty-one JATCO employees and family members participated in the "Clean Chigasaki" beautification campaign sponsored by the city of Chigasaki on Sunday, July 27, 2008 beginning from 6:30 a.m. Despite the early hour, a total of 1,427 people took part and collected 2.86 tons of trash along the city's Hishinuma shoreline. Participants were mainly from local community associations and included children's groups, the surfing community and local residents in general.

Twenty-seven JATCO employees and family members also took part in an early morning cleanup activity after the Atsugi Ayu Festival sponsored by the city of Atsugi. This involved cleaning up the area in the city where the Sagami and Mikawa rivers converge, beginning from 5:45 a.m. on Sunday, August 3, 2008. The previous day that area had been the site of a large fireworks display enjoyed by 580,000 people at the Atsugi Ayu Festival. A total of 1,724 participants from 72 organizations, including nearby companies, collected approximately six tons of trash in the area around the site.

2. ジヤトコ メキシコ社で CVT 生産累計 100 万台を達成

自動車用変速機の専門メーカー，ジヤトコのメキシコ現地法人ジヤトコ メキシコ社（略称:JMEX，本社:メキシコ合衆国アグアスカリエンテス州アグアスカリエンテス市）は，8 月 7 日（日本時間 8 月 8 日），現地での CVT 生産累計 100 万台達成の記念式典を実施した.

ジヤトコは環境対応技術のひとつである CVT のグローバルな需要拡大に対応するため，新世代 CVT の生産能力拡充を図り，同社初の海外生産拠点として 2003 年 4 月にメキシコに JMEX を設立．JMEX は 2005 年 11 月に月産能力 3 万 5,000 台の第 1 生産ライン（グローバル No.3 ライン）が稼動開始，さらに今年 4 月に第 2 生産ライン（グローバル No.5 ライン）も稼働を開始し，現在月産能力は 5 万 8,000 台．製品の納入先は米クライスラー LLC，北米日産会社及びメキシコ日産自動車会社などとなっている.

3. 輝け！未来のエンジニア！

8 月 8 日（金）と 9 日（土），パシフィコ横浜にて 55,000 人を越える来場者を迎え，自動車技術会主催のキッズエンジニア 2008 が行われた.

この催しは未来を担う小学生を対象に，科学技術やモノづくりに興味を持ってもらうことを狙いとして，体験的な学習の機会を提供する人材育成イベント.

ジヤトコも遊星ギア模型を組み立てて仕組みを理解する体験型教室を開催し，100 人の子供たちがトランスミッションに込められた，技術の魅力を体感した.

2. JATCO Mexico's cumulative CVT production reaches one million units

JATCO Mexico, S.A. de C.V. (JMEX) held a ceremony on August 7, 2008 (August 8 Japan time) to celebrate production of its one millionth CVT. JMEX is JATCO's local subsidiary in Mexico, specializing in the manufacture of automotive automatic transmissions and CVTs. The company is located in the city of Aguascalientes in Aguascalientes state.

JATCO established JMEX in April 2003 as the company's first overseas manufacturing facility in a move to expand production capacity for next-generation CVTs. That was done to meet the expanding global demand for CVTs, which are regarded as a key environmentally friendly technology. JMEX launched its first production line (JATCO's third CVT line globally) in November 2005 with a monthly production capacity of 35,000 units. A second production line (JATCO's fifth CVT line globally) was launched in April 2008, raising JMEX's monthly production capacity to the current level of 58,000 units. JMEX's products are delivered to America's Chrysler LLC, Nissan North America, Inc. and Nissan Mexicana, S.A. de C.V., among other customers.

3. Budding future engineers

The Society of Automotive Engineers of Japan held Kids Engineers 2008 at Pacifico Yokohama on Friday-Saturday, August 8-9, 2008, which attracted over 5,000 attendees. This event was aimed at inspiring an interest in science, technology and manufacturing among elementary school pupils. Designed to foster the development of the next-generation of human resources, the event provided various opportunities for hands-on learning.

JATCO conducted a hands-on classroom to give kids an understanding of how planetary gears work by having them assemble scale models. One hundred kids personally experienced the fascinating technologies incorporated in automotive transmissions.

4.「ENE － WAY2008」開催

8 月 27 日（水）～ 29 日（金）の 3 日間, ポートメッセなごや（愛知県名古屋市）にて,「ENE-WAY2008」が開催された.

この展示会は，環境負荷低減対策をはじめ，省エネルギー，コスト削減，作業環境改善など，企業が抱えるさまざまな課題解決を目的としたもの.

他企業とのコラボレーション事例を紹介する「ソリューションステージ」の中で，ジヤトコ蒲原地区のアルミ鋳造溶解炉で導入した「熱監視システム」の事例が紹介され，来場者の注目を集めた.

5. 富士宮地区が危険物安全協会連合会会長表彰受賞

9 月 3 日(水), 静岡市のグランシップ静岡において,（社）静岡県危険物安全協会連合会の創立記念大会が開催され，富士宮地区がジヤトコとして初めて連合会会長表彰を受賞した.

これは危険物の保安推進を図る上で，危険物による事故，災害の防止に不断の努力，及び著しい成果を収めた個人，事業所に対して贈られる.

4. JATCO technology at ENE-WAY 2008

ENE-WAY 2008 was held at Port Messe Nagoya in Nagoya, Aichi over a three-day period from Wednesday-Friday, August 27-29, 2008. This exhibition was focused on solutions to various issues currently confronting companies, including measures for reducing environmental impacts, energy conservation, cost reduction and workplace improvement, among others. The heat monitoring system JATCO installed for the aluminum casting furnace at the Kambara plant was featured on the Solutions Stage as an example of collaboration with other companies and attracted much interest among the attendees.

5. Fujinomiya plant receives Chairman's Award given by Shizuoka Association for Safety of Hazardous Materials

The Shizuoka Association for Safety of Hazardous Materials held a convention at the Shizuoka Convention and Arts Center in the city of Shizuoka on Wednesday, September 3, 2008 to commemorate its establishment. Fujinomiya plant received the Chairman's Award given by the Association, the first time a JATCO facility has been so honored.

This award is given to individuals or to business places for ceaseless efforts to prevent accidents and disasters due to hazardous materials and for outstanding achievements in promoting the security of hazardous materials.

6. ジヤトコ自衛消防隊各地訓練大会で活躍

10 月 19 日（日），富士市防火協会主催による「第 36 回自衛消防隊ポンプ操法大会」にジヤトコ自衛消防隊（NICS 警備）は見事優勝を飾り，32 回大会より通算 5 連覇を達成した.

大会は消防ポンプ車とエンジン式小型ポンプで行われ，ジヤトコは消防ポンプ車部門にエントリーし 5 人編成による統率性，規律性，タイム，個人別技能等の審査において総合優勝となった.

なお，10 月 21 日（火）には八木地区でも 「 第 7 回　南丹・船井，自衛消防訓練大会 」に参加し最優秀賞（優勝）を獲得した.

7. 韓国油空圧 System 学会で論文発表

10 月 22 日（水），韓国（仁川市の松島コンベンシア）において「韓国油空圧 System 学会」が行われ，JKE から「自動変速機用ソレノイドバルブの圧力制御特性に関する研究」について，論文発表が行なわれた.

【韓国油空圧 System 学会とは】

油圧及び空気圧システム，水圧システムのような機能性流体システムを利用した動力伝達及び制御システムに関する学問と技術の発展を図って，この分野関連産業に寄与する学術団体である.

当日発表会場には大学教授が 30 名ほど出席し，JKE の PR ／リクルート／産学活動の向上などにつなげることが出来た.

6. JATCO's independent fire-fighting squads victorious in local training tournaments

JATCO's independent fire-fighting squad (NICS Security) handily won the championship at the 36th Independent Fire-Fighting Pump Operating Tournament sponsored by the Fuji City Fire Protection Association on Sunday, October 19, 2008. The JATCO squad garnered its fifth consecutive championship since the 32nd tournament.

The tournament has categories for fire-fighting pump trucks and small engine-driven pumps. JATCO's five-man squad entered the category for fire-fighting pump trucks and was awarded the overall championship by the judges for their leadership, discipline, time and individual skills.

JATCO's fire-fighting squad at the Yagi plant also took part in the 7th Namba-Funai Independent Fire-Fighting Training Tournament on Tuesday, October 21, 2008 and won the championship.

7. Paper presented at KFPS Symposium

The Korea Fluid Power Systems Society (KFPS) held an international symposium at the Matsushima Convention Hall in Incheon, South Korea on Wednesday, October 22, 2008. An employee of JATCO Korea Engineering Corporation (JKE) presented a paper titled "Study on Pressure Control Characteristics of Solenoid Valves in Automatic Transmissions."

KFPS is a scientific organization that promotes scholarship and technological development for power transmission systems and associated control technologies involving the use of functional fluids such as hydraulic pressure, air pressure and water pressure and contributes to the advancement of industries related to these fields.

Since approximately 30 university professors attended the symposium that day, the presentation provided a good opportunity to publicize JKE, promote recruitment and strengthen industrial-academic activities.

8.『静岡県科学技術振興知事褒章(研究開発功労者)』受賞!

11 月 5 日（水）,「テクノサロン静岡 2008」が静岡グランドホテルで開催され平成 20 年度静岡県科学技術振興表彰が行われた．ジヤトコからはジヤトコグループ初となる「静岡県科学技術振興知事褒章（研究開発功労者）」を受賞した.

【研究開発功労者とは】

長年にわたり研究開発に従事し，その研究活動を通じて社会・経済に貢献のあった，静岡県における研究者の範となる人物のことである.

9. 第6回中国国際汽車展覧会（広州モーターショー）開催

11 月 19 日（水）～ 25 日（火）, 広東省広州市で「第 6 回中国国際汽車展覧会（広州モーターショー）」が行われ，東風日産／インフィニティをはじめ多くの自動車メーカーが出展し，大勢の来場者を魅了した.

東風日産乗用車公司ブースでは，中国内で環境への取り組みをアピールし CVT の普及を図るために，CVT 説明パネルとジヤトコの CVT 映像及びベルト CVT 作動原理モデルを展示し来場者の注目を集めた.

8. Shizuoka Prefecture Governor's Award for promotion of science and technology (distinguished contributions to R&D)

The Shizuoka prefecture awards for the promotion of science and technology in fiscal 2008 were presented at the Techno Salon Shizuoka 2008 exhibition, held at the Shizuoka Grand Hotel on Wednesday, November 5, 2008. JATCO employees received the Shizuoka Prefecture Governor's award for promotion of science and technology in recognition of their distinguished contributions to research and development. This marked the first time JATCO Group employees have won this award.

The award for distinguished contributions to R&D is given to persons who have been engaged in research and development for many years and whose research activities have contributed significantly to society and the economy. The recipients are regarded as being models for other researchers in Shizuoka prefecture.

9. JATCO CVTs at 6th China (Guangzhou) International Automobile Exhibition

The 6th China (Guangzhou) International Automobile Exhibition was held in Guangzhou, Guangdong from Wednesday-Tuesday, November 19-25, 2008. Many vehicle manufacturers, including Dongfeng Nissan and Infiniti, exhibited car models that fascinated the large crowds of visitors.

The booth of Dongfeng Nissan Passenger Vehicle Co. displayed CVT panel explanations, showed a video of a JATCO CVT and presented a model that illustrated the working principle of a JATCO steel-belt CVT. These exhibits were intended to popularize CVTs by emphasizing their environmental benefits in China and attracted a great deal of visitor interest.

10. 静岡県優秀技能者功労表彰

11 月 20 日（木），静岡市東部勤労福祉センター「清水テルサ」にて静岡県優秀技能者功労表彰（県知事功労表彰）の表彰式が行われ，当社から 1 名が受賞した.

11.「モノづくり連携大賞 新技術開発賞」

11 月 26 日（水），東京有明東京ベイワシントンホテルで産学官連携の優れた取組みを表彰する「第 3 回モノづくり連携大賞」の贈賞式が行われた.

本大賞の新技術開発賞に，ジヤトコと熊本大学の共同研究，「産学官連携による次世代耐熱マグネシウム合金基盤技術開発：くまもとテクノ財団，熊本大学」が選出された.

これは次世代耐熱マグネシウム合金の実用化に向け，ネック技術である大型ビレットの製造技術を共同で研究しているもの．ジヤトコは企業としても同表彰を受賞した.

10. Shizuoka Governor's Award of Distinction given to an outstanding JATCO technician

A ceremony was held at Shizuoka Prefecture's East District Labor and Welfare Center (Shimizu Terrsa) on Thursday, November 20, 2008 to present the Governor's Award of Distinction to outstanding technicians in the prefecture. One JATCO employee was honored with this award.

11. Monozukuri Grand Awards: New Technology Development Prize

An award ceremony was held at the Tokyo Bay Ariake Washington Hotel in Tokyo on Wednesday, November 26, 2008 to present the 3rd Monozukuri Grand Awards in recognition of outstanding efforts to promote industry-academia-government collaboration. A collaborative research project initiated by JATCO, Kumamoto University and Kumamoto Techno Industrial Foundation was selected for the New Technology Development Prize. The aim of this project is to develop the basic technology for next-generation, heat-resistant magnesium alloys through industry-academia-government collaboration.

Joint research is under way on the technology for manufacturing large billets, which is currently a technical bottleneck hindering the practical application of next-generation heat-resistant magnesium alloys. JATCO also received the same award as a company.

12. 2008 欧州 CTI（7th International CTI-Symposium）で講演

12 月 1 日（月）～ 5 日（金）ドイツ ベルリンにて 2008 欧州 CTI（7th International CTI Symposium Innovative Automotive Transmissions）が開催され，今年も主要自動車メーカーや変速機メーカーをはじめとする業界関係者約 1,000 人が参加した．

当社からは基調講演を含め，以下 3 件の講演がおこなわれた．

『Fuel Economy in the Real World』

『Development of new 7-speed Automatic Transmission for medium and large RWD vehicles』

『Strategic development target of transmission』

13. 環境講演を実施

12 月 8 日（月），静岡市産学交流センターにおいて，日刊工業新聞社の主催する読者セミナーが行われた．

ジヤトコの「環境にやさしいモノづくりをいかにして実現するか」と題した講演には静岡県内外から 70 名余りの企業関係者が参加し，熱心に聞き入っていた．

当講演は，環境への取組みに成果をあげている企業として，第一回の本田技研工業（株），第二回目のスズキ（株）に続いて講演依頼されたものであり，生産技術革新やリサイクル・リビルドなど「モノづくりを通じた CO_2 削減」だけでなく，「製品を通じた CO_2 削減＝ CVT の燃費効率の良さ」についても，アピールする良い機会となった．

12. Presentations at 7th International CTI Symposium 2008 in Europe

The 7th International CTI Symposium Innovative Automotive Transmissions was held in Berlin, Germany from Monday-Friday, December 1-5, 2008. This year's meeting attracted about 1,000 attendees from major automakers, transmission manufacturers and other companies involved in the industry. Three JATCO employees gave presentations, including a keynote address, on the following topics: Fuel Economy in the Real World; Development of a New 7-speed Automatic Transmission for Midsize and Large RWD Vehicles; and Strategic Development Target for Transmissions.

13. Lecture on environmental activities

Nikkan Kogyo Shimbun, Ltd. sponsored a seminar for its readers at the Shizuoka Industry and Academia Exchange Center on Monday, December 8, 2009. More than 70 business people from within and outside Shizuoka prefecture listened intently to a lecture given by a JATCO employee on the subject of "How Environmentally Friendly Monozukuri Operations are Achieved."

This invited lecture was the third in a series given by companies that have achieved significant results in their environmental efforts. The first lecture was by Honda Motor Co., Ltd. and the second one was by Suzuki Motor Corporation. It provided an excellent opportunity to publicize JATCO's efforts to reduce CO_2 emissions in monozukuri operations through production engineering innovations, recycling and rebuilding, among other activities. Moreover, it was a good chance to emphasize that the excellent fuel efficiency of CVTs translates into a reduction of CO_2 emissions at the product level.

14. 快挙　省エネルギー月間表彰式でジヤトコ初のダブル受賞

2月10日（火），東京ビッグサイトで平成20年度省エネルギー月間表彰式がおこなわれた．省エネルギー推進の各分野において，全国レベルで顕著な功績のあった工場，グループ，個人，などが表彰されるこの授賞式で，ジヤトコは

エネルギー管理優良工場等表彰：「資源エネルギー庁長官賞」

エネルギー管理功績者表彰：「経済産業大臣賞」を受賞した．

会社始まって以来の堂々のダブル受賞で，省エネや地球環境に対するジヤトコの取り組みを広くアピールする機会となった．

15. ジヤトコ，若手社員を対象とした環境野外研修を実施

2月13日（金），ジヤトコは，若手社員を対象に実施している「モノづくり学校」の一環として，富士市内の清掃活動や，富士市のゴミ処理場の見学などの，環境に焦点をあてた環境野外研修を実施した．

「モノづくり学校」は，若手社員が，素材成形・加工・組立・保全・検査など，トランスミッションの各製造過程全体を体験することにより，モノづくりへの理解を深めるとともに，チームワークの醸成や，社会人としてのマナー・モラル・礼儀を身につけることなどを目的に，昨年12月から開校したもの．

ジヤトコでは，毎月1回独自に設けている「環境の日」に事業所周辺の清掃活動を実施し，また，富士山クリーン活動へ参加するなど，地域環境の美化に努めているが，今後も社員の環境意識の向上や地域社会と一体となった地球環境保護への努力を継続する．

14. JATCO's first-ever double awards at Energy Conservation Month Award Ceremony

The Energy Conservation Month Award Ceremony for fiscal 2008 was held at Tokyo Big Sight on Tuesday, February 10, 2009. Awards were presented to plants, groups, individuals and others for outstanding achievements on a national level in promoting energy conservation in various fields.

JATCO received two awards: the Agency for Natural Resources and Energy Director-General's Award under the Commendation Program for Excellent Energy Management Factories and the METI Minister's Award under the Commendation Program for Excellent Energy Managers.

This marked the first time in the company's history that JATCO has received these impressive double awards. It provided an excellent opportunity to publicize widely JATCO's vigorous efforts to conserve energy and to safeguard the global environment.

15. JATCO holds outdoor environmental training for young employees

Outdoor training focused on the environment was conducted on Friday, February 13, 2009 as part of the Monozukuri School that JATCO has started for young employees. This training involved cleanup activities in the city of Fujinomiya and a tour of the city's garbage treatment center, among other things.

JATCO opened the Monozukuri School in December last year for the purpose of deepening young employees' understanding of monozukuri through personally experiencing all transmission manufacturing processes, including casting, forging, molding, machining, assembly, maintenance and inspection. Another aim is to foster teamwork and to acquire the manners, morals, and etiquette expected of working members of society.

JATCO directs concerted efforts toward beautification of the local environment, including conducting cleanup activities around the facilities once a month on the company's independently designated Environment Day and participation in cleanup activities on Mt. Fuji. These efforts to strengthen employees' awareness of the environment and to protect the global environment through close cooperation with local communities will be continued in the future.

16. 平成 20 年度高度熟練技能者認定

3 月 19 日（木），ジヤトコから 2 名の高度熟練技能者が認定され，認定証及び技能者章の交付及び伝達式が行われた．高度熟練技能者とは，機械では代替できない高度な技能を駆使して，高精度・高品質の製品・試作品等を作り出すことが出来る技能者，または機械が作り出す製品と同等以上の高精度・高品質の製品の製造や整備が出来る技能者で，国が認定する制度．

この制度は平成 10 年度に始まり，自動車部品製造関係ではこれまでに全国で 996 名，ジヤトコでは今回を含め 21 名の方が認定されている．また，一般・精密・電気機械器具整備関係では静岡県内初の認定者となった．

17. 日本塑性加工学会 東海支部賞 技術賞受賞

ジヤトコは「平成 21 年度日本塑性加工学会 東海支部賞 技術賞」を受賞し，4 月 21 日（火），愛知県刈谷市にあるアイシンコムセンターにて，表彰された．

件名：歯型鍛造における
　　成形シュミレーションの有効活用評価内容

シミュレーション結果の判断をカンコツから定量的に行うようにし，解析精度を向上させた．

この取り組みにより，試作一発良品化に結びつけたことが評価された．

16. Two JATCO employees certified as high-proficiency skilled workers in fiscal 2008

A ceremony was held on Thursday, March 19, 2009 to present a certificate of certification and a badge to two JATCO employees who were certified as high-proficiency skilled workers in fiscal 2008. A high-proficiency skilled worker is one who can create high-precision, high-quality products, prototypes and other items using advanced skills for which there is no machine substitute, or one who can manufacture or maintain products of high precision and high quality equal to or better than the products produced by machines.

This certification is given under a national system established in 1998. To date, 996 technicians involved in auto parts manufacturing have been certified throughout Japan. Including the latest two, 21 JATCO technicians have received such certification. These two technicians were the first in Shizuoka prefecture to be certified in the category for maintenance of general, precision and electrical machinery and equipment.

17. Recipient of Technology Award given by JSTP's Tokai Chapter

JATCO employees received the Technology Award among the honors given by the Tokai Chapter of the Japan Society for Technology of Plasticity (JSTP) for fiscal 2009. An award ceremony was held at the Aisin COM Center in Kariya, Aichi on Tuesday, April 21, 2009. The award was presented for "effective use of a forming simulation in forging gear teeth." The citation indicated that this technology enables qualitative judgment of simulation results instead of using intuition or hunches, thereby improving simulation accuracy. The fact that it leads to the attainment of good quality in a single production trial was evaluated highly.

18. 中国トランスミッションシンポジウムに参加

4月21日～22日に中国自動車技術会初のトランスミッションシンポジウム（2009 International Symposium on Transmission Innovation and China Market Development）が上海にて産学官約300名が参加し開催された.

日本企業で唯一，スポンサー挨拶，基調講演，Desktop Displayを行い，今後，最もAT車（2ペダル車）の市場が拡大すると予測される中国にて，最もアピールをした日本企業となった.

19. SAE 2009 World Congressで講演

4月21日（火）～23日（木），北米デトロイトのCobo Centerにて「SAE 2009 World Congress」が開催され，ジヤトコは，FR車用7速AT（JR710E，JR711E）に関する講演をおこなった.

内容は“自動車の燃費向上”に貢献した「ロックアップ領域の拡大」と，“自動車の運転性向上”に貢献した「アダプティブシフト制御」に特化していたが，特に“自動車の燃費向上”に対する関心度が高く，講演終了後，聴講者との積極的な質疑応答が取り交わされた.

18. Participation in a transmission symposium in China

The Society of Automotive Engineers of China held the 2009 International Symposium on Transmission Innovation and China Market Development in Shanghai on April 21-22, 2009. This was its first-ever transmission symposium and it attracted some 300 attendees from industry, academia and government.

JATCO was the only Japanese company to give a sponsor's greeting, a keynote address and a desktop display, thus making the biggest appeal among Japanese enterprises in the Chinese market where AT-equipped vehicles are projected to see their largest growth in the near future.

19. Paper presented at 2009 SAE World Congress

JATCO employees presented a paper at the 2009 SAE World Congress held at the Cobo Center in Detroit in the U.S. from Tuesday-Thursday, April 21-23, 2009. The presentation dealt with the JR701E and JR711E 7-speed ATs for rear-drive cars. It focused specifically on expansion of the lockup operating range for improving vehicle fuel economy and on adaptive shift control for improving driveability. There was especially strong interest among the audience concerning the improvement of vehicle fuel economy. After the presentation, there was a lively exchange of questions and answers between the audience and the presenter.

20. "MPT2009 Sendai" で講演

5月13日（水）～15日（金）の3日間に渡り，宮城県仙台市で（社）日本機械学会が主催する国際会議 MPT（Motion and Power Transmissions）2009 が開催され，ジヤトコからは基調講演と技術講演が行われた.

21. 人とくるまのテクノロジー展 2009" に出展

5月20日（水）から22日（金）にかけて, パシフィコ横浜・展示ホールにおいて「人とくるまのテクノロジー展 2009」が開催された.

『CVT の普及で CO_2 削減に貢献するジヤトコ』をテーマに当社の主力商品であり，環境対応技術の一つとして注目されている CVT に焦点をあて，フルラインナップのカットモデルを展示するほか，CVT 技術の進化や何故 CO_2 削減に効果があるかなどについてのパネルや，操作式の CVT 作動原理モデルの展示をおこなった.

20. Presentations at MPT 2009 Sendai

JATCO employees gave a keynote address and a technical presentation at the International Conference on Motion and Power Transmissions (MPT 2009 Sendai) sponsored by the Japan Society of Mechanical Engineers in Sendai, Miyagi over a three-day period from Wednesday-Friday, May 13-15, 2009.

21. JATCO Exhibits at Automotive Engineering Exposition 2009

The Automotive Engineering Exposition 2009, sponsored by the Society of Automotive Engineers of Japan, was held at the Pacifico Yokohama Exhibition Hall from Wednesday-Friday, May 20-22, 2009. JATCO's booth centered on CVTs, which are among the company's mainstay products and are the focus of much attention as an effective environmental technology. The theme was "JATCO contributes to reducing CO_2 emissions by popularizing CVTs." Exhibits included cut-away models of JATCO's full lineup of CVTs, panel explanations showing the evolution of CVT technology and why CVTs are effective in reducing CO_2 emissions, and a working model of a CVT that could be operated by visitors.

22. 自技会 2009 春季大会で論文賞受賞

5 月 21 日（木），パシフィコ横浜会議センターで行われた自動車技術会 2009 春季大会において，論文賞を受賞した．

【受賞理由】

近年，環境問題に対する自動車の燃費改善と，走りの性能の両者を両立し得る技術として，金属ベルト式無段変速機（CVT）への関心が高まってきている．その伝達効率を向上するためには，動力を伝達するプーリとエレメントの間の摩擦係数（μ）を，耐摩耗性を損なわずに増加させることが重要な課題である．受賞者らは，緻密な実験により，高いμの発現に関係が深いプーリ表面の粗さの状態を調べ，高いμが現れるメカニズムを明らかにした．さらに，プーリ・エレメント間で境界潤滑膜を形成する CVT 油については，低粘度で高μな潤滑油に改良した．この両成果を組み合わせることにより，プーリ・エレメント間μを現行比で 20%向上できることを実機サイズ試験機で検証しており，CVT の伝達効率向上に大きく寄与する有用な研究成果といえる．

23. 自動車技術会フェロー称号を授与

6 月 10 日（水），自動車技術会中部支部通常総会において，自動車技術会フェロー称号の授与が行われ，ジヤトコからは今回 1 名の授受者があった．自動車技術会フェロー制度は，自動車技術会の目的達成及び自動車に係る科学技術に関し，多大の貢献をなしている会員にフェローの称号が授与されるもの．今回の受賞で当社の授受者はのべ 8 名となった．

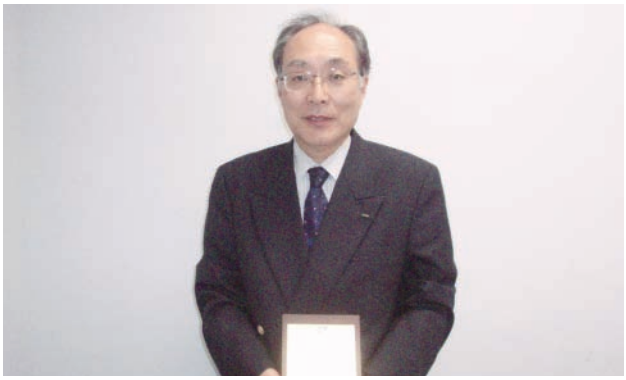
22. Best Paper Award at the 2009 JSAE Annual Spring Congress

A paper presented by JATCO employees at the 2009 Annual Spring Congress of the Society of Automotive Engineers of Japan (JSAE) received the Best Paper Award. The congress was held at the Pacifico Yokohama Convention Center on Thursday, May 21, 2009. The award citation read as follows:

"Interest in steel-belt continuously variable transmissions (CVTs) has been growing in recent years as a technology that can both improve vehicle fuel economy for addressing environmental issues and also provide excellent driving performance. An important issue for improving the transmission efficiency of CVTs is to increase the friction coefficient (μ) between the belt elements and pulleys that transmit power without sacrificing their wear resistance. The authors have made clear the mechanism producing a high μ value through their meticulous experiments to investigate the pulley surface roughness condition, which is closely related to the appearance of high μ. Moreover, they have improved the CVT fluid that forms a boundary lubrication film at the pulley-element interface by developing a low-viscosity, high-μ lubricating fluid. Tests conducted with a full-size experimental CVT verified that the combination of the two resultant effects improves the pulley-element μ value by 20% compared with the current level. Their research results are expected to be effective in helping to improve the transmission efficiency of CVTs substantially."

23. JATCO employee granted JSAE Fellow Member status

A JATCO employee was granted JSAE Fellow Member status at the ordinary general meeting of the JSAE Chubu Branch on Wednesday, June 10, 2009. The JSAE Fellow Member system confers this membership grade designation on regular members who have made significant contributions to the accomplishment of JSAE's objectives and to automotive science and technology. This latest honor brings the total number of JATCO Fellow Member recipients to eight at present.



24. くるみんマーク " 取得
（働きやすい職場づくりへの取組み

＜くるみんマーク取得＞

ジヤトコは '09 年 6 月，厚生労働大臣より次世代を担う子どもたちが，健やかに生まれ育つ環境づくりを推進する企業として認定され，「くるみん」マークを取得した.

このマークを取得するには，雇用環境の整備について，適切な行動計画を策定し，目標を達成する必要があります.

例えば

◆子供をもつ社員が勤務を継続できる制度を整えていること.

◆計画期間内に男性の育児休業等取得者がいること.

◆計画期間内の女性の育児休業等取得率が 70% 以上であること　　等々,

法律で定める一定の基準をクリアする必要がある.

現在認定企業は '09 年 3 月時点で日本全国でも 652 社にとどまり，日産関係会社の中では最初の取得となった.

ジヤトコはこのマークを取得したことに満足せず，誰もが働きやすい職場環境づくりを推進・継続していく.

24. JATCO receives Kurumin Mark for efforts to create employee-friendly workplaces

In June 2009, JATCO obtained the Kurumin Mark and was certified by the Minister of Health, Labor and Welfare as a company that promotes efforts to create a workplace environment conducive to the healthy birth and rearing of children as the next generation. In order to secure this mark, a company must formulate a suitable action plan for its employment environment and achieve the objectives set out in the plan. It is necessary to clear certain standards as prescribed by law such as those illustrated by the examples below.

◆ There must be a system that enables employees with children to continue working.

◆ There must be male employees who take childcare leave during the period of the plan.

◆ The percentage of women taking childcare leave during the period of the plan must be at least 70% of such women concerned.

As of March 2009, there were only 652 certified companies in Japan. JATCO was the first company in the Nissan Group to obtain the Kurumin Mark. Without becoming complacent about the acquisition of this mark, JATCO intends to continue to promote efforts to create workplaces friendly to all employees.

ジヤトコ（広州）自動変速機有限公司の紹介

Introducing JATCO (Guangzhou) Automatic Transmission Ltd.

上拾石　孝*
Takashi KAMIJUKKOKU

1. 概要

社　名	ジヤトコ（広州）自動変速機有限公司
所　地	広州先進技術産業開発区科学城荔紅二路 8 号
創　立	2007 年 4 月 13 日
資 本 金	約 46 億円
事業内容	自動車自動変速機及びその部品の製造、販売及び関連アフターサービス
生産機種	FF 車用ベルト式 CVT
生産能力	約 14 万台／年

1. Overview

Company name:	JATCO (Guangzhou) Automatic Transmission Ltd.
Location:	No. 8, Lihong 2 Road, Science City, Guangzhou Hi-Tech Industrial Development Zone, Guangzhou, Guangdong, China
Establishment:	April 13, 2007
Capitalization:	Approx. 4.6 billion yen
Business activities:	Manufacture and sale of automatic transmissions and parts and provision of related after-sales services
Production mixs:	Steel-belt CVTs for front-wheel-drive vehicles
Production capacity:	Approx. 140,000 units/year

Fig. 1 JATCO(Guangzhou) Automatic Transmission Ltd.

ジヤトコ（広州）自動変速機有限公司（以下，ジヤトコ広州）は，ジヤトコの主力商品である CVT のグローバル展開の一翼を担う中国の生産拠点として，2007 年 4 月に設立され，2009 年 4 月に先行生産を開始，9 月には 2 直体制での本格生産を開始した．

ジヤトコ広州は，メキシコに続くジヤトコの 2 番目の海外生産工場であり，中型 FF 車用（2.0 リッター

JATCO (Guangzhou) Automatic Transmission Ltd. (JATCO Guangzhou) was established in April 2007 as the company's production center in China and is expected to play a key role in the global expansion of CVTs, representing JATCO's mainstay product lines. Preliminary production was launched in April 2009 and full-fledged production under a two-shift system was started in September.

JATCO Guangzhou is JATCO's second overseas production facility after JATCO Mexico and produces steel-belt CVTs for use on 2.0-liter class midsize front-wheel-drive cars. The plant was built at an investment of 4 billion yen and has an annual production capacity of 140,000 units. The manufacturing operations performed in-house are transmission case machining and CVT assembly. Component parts are obtained from Japan under knocked-down (KD) supply and also procured from suppliers in China, Korea, Thailand and India. The workforce as of September 2009 numbered approximately 250 employees and will be expanded

* 董事　総経理
President & Board Member

クラス車用）のベルト式 CVT を生産する．投資額は 40 億円で，生産能力は年間 14 万台である．内製工順としては CVT 組立と CASE 加工を行い，その他の構成部品は，日本からの KD 供給の他，中国・韓国・タイ・インドから調達する．09 年 9 月時点での従業員数は約 250 名で，フル生産能力体制確立へ向け，今後増員していく．

この新工場で生産される CVT は，東風日産乗用車公司で生産されるシルフィ，ティアナ，キャシュカイ，エクストレイルに搭載される注目の環境先進技術ユニットである．

Fig. 2 Growing financial district

2. 環境

北京，上海に次ぐ中国 3 番目の大都市広州（人口 1,018 万人：2008 年）は，自動車産業の集積地として知られ，世界で唯一，日本の 3 大自動車メーカーが生産拠点として進出している都市である．

中国の自動車産業は，2008 年下期の世界同時不況の中でも堅調な伸びを示し，2009 年 3 月からの月間自動車販売台数は 6 ヶ月連続で 100 万台を超えた．広州の乗用車の生産高は全国第 2 位と，自動車産業発展の中核を担っている．

そして，2010 年の広州アジア大会開催に向け，各種インフラ整備が急ピッチで進められている．ジヤトコ広州のある先進技術産業開発区にも地下鉄が整備され，完成すると広州市の中心街からの通勤が可能となる．

ジヤトコ広州は，この成長著しい中国市場と広州市の発展を絶好のチャンスと捉え，更なる事業発展を目指していく．

further as the plant moves to establish a system for producing CVTs at full capacity.

The CVT2 built at this new plant is a unit noted for its advanced environmental technologies and is fitted on the Silvia, Teana, Qashqai and X-Trail models built by Dongfeng Nissan Passenger Vehicle Company.

2. Local Environment

Guangzhou is China's third largest city after Beijing and Shanghai, with a population of 10.18 million people in 2008. It is known as an automotive industry center and is the only city in the world where Japan's Big Three automakers have all established production facilities.

Despite the global economic downturn in the second half of 2008, China's automotive industry continued to show robust growth. Since March 2009, monthly new car sales have exceeded one million units for six consecutive months. Guangzhou's vehicle production volume is the second highest nationwide, and the city plays a core role in promoting the development of China's automotive industry.

Various types of infrastructure are now being constructed at a rapid pace in preparation for the 2010 Asian Games that will be held in Guangzhou. A subway line is also being built through the Guangzhou Hi-Tech Industrial Development Zone where JATCO Guangzhou is located. When completed, it will be possible to commute to the plant from the center of the city.

At JATCO Guangzhou, we aim to expand our operations further by taking advantage of this golden opportunity offered by the dramatic growth of the Chinese market and the rapid development of Guangzhou.

Fig. 3 Shamien's vestiges of the past

3. Introducing Guangzhou

Guangzhou has flourished since ancient times as a gateway for external trade. Legend has it that five gods

3. 地域の紹介

対外貿易の窓口として古くから栄える広州は，羊に乗った 5 人の仙人が空から舞い降り，黄金の穂を広州の地にもたらし飢餓を救った伝説から，「五羊城」「穂城」と，また 1 年中花が咲いていることから「花城」という愛称で呼ばれている．

2200 年以上の歴史がある広州の下町である上下九路には古き良き広州が残り，また，1840 年のアヘン戦争以降欧州列強によって占領され租界地となった沙面は，当時の面影が残り，歴史を肌で感じることができる．

さて，現代の広州に目を向けると，「GDP 成長率が中国 10 大都市中トップ 3」が示す通り，建築ラッシュが今も続き，その発展と景観の変わり様は目を見張るものがある．

文化の面では，まずは周知の「食在広州（食は広州にあり）」という言葉の如く，朝の飲茶から深夜の夜食まで，外食文化が根付いており，食で困ることはない．

また別の一面として，中国では 80 年代に生まれた「80 後（バーリンホウ）」が注目されているが，広州のこの世代が特に関心があるのが，日本アニメやマンガである．日本のアニメには日本同様に「宅男（ザイナン）」「宅女（ザイニュー）」といわれる「オタク」のような熱狂的なファンもいるほどである．

このように，旧新の歴史・文化が交差するこの広州で，「モノづくりの原点」を探究しながら，会社と社員の心身の成長を目指すジヤトコ広州に，今後注目して欲しい．

descended from the sky on rams, bringing golden ears of rice with them to the area and saving the people from famine. That gave rise to Guangzhou's nicknames of the City of Five Rams and the City of Rice Ears. Because flowers bloom beautifully the year around, Guangzhou has still another nickname as the City of Flowers.

Shangxiajiu Street in the downtown area retains the feel of the good old days in Guangzhou, the history of which dates back more than 2,200 years. Shamian Island became the foreign quarters occupied by the European powers following the Opium War. It retains vestiges of that era which give a firsthand feeling of the city's history.

Looking at the modern Guangzhou, remarkable growth and changes in the city's appearance are taking place amid the ongoing flurry of construction activity. This is indicative of Guangzhou's ranking among the top three of China's ten largest cities in terms of the GDP growth rate.

As for cultural aspects, there is first of all the popular saying "eating in Guangzhou." One never has any trouble finding good food, as there is a firmly established custom of eating out, from breakfast in the morning to a late-night snack.

Another notable aspect concerns the younger generation born since the 1980s in China. In Guangzhou, this generation is especially interested in Japanese animation (anime) and comics (manga). Japanese animation is so popular that there are male and female fans who are as obsessed with anime as their "otaku" counterparts in Japan.

As described here, Guangzhou has a history and culture that intermix the old and the new. At JATCO Guangzhou, we intend to foster the all-around growth of both the company and the employees in seeking the origin of monozukuri. The company bears close watching in the coming years.

■ Authors ■

Takashi KAMIJUKKOKU

京都工場の紹介

Introducing the Kyoto Manufacturing Department

荒井　和則 *
Kazunori ARAI

1. 概要

ジヤトコ株式会社第三事業所京都工場を紹介する.

所 在 地　京都市右京区太秦荒木町 1
従 業 員　377 名

1. Overview

This article introduces JATCO's Kyoto Manufacturing Department in Manufacturing Division No. 3.

Location: 1, Araki-cho, Uzumasa, Ukyo-ku, Kyoto, Japan
No. of employees: 377

京都工場は，1975 年の三菱自動車工業㈱時代にオートマチックトランスミッション（以下 AT）の生産を開始したのを皮切りに，1977 年にはミラージュに搭載された FF 専用トランスミッション（以下 TM）を生産し，その後，エンジンを含むパワートレインの主力生産工場としての地位を確固たるものとしてきた.

その後，2002 年 4 月に三菱自動車工業㈱から，トランスミッション関連部門が分社して設立されたダイヤモンドマチック㈱を経て，2003 年 4 月にジヤトコ社と合併し現在に至っている．現在は，三菱自動車パワートレイン製作所京都工場内に居を構え，国内，海外向け普通車両用の前輪（FF）・後輪（FR）駆動用トランスミッションの生産を行っている.

Fig. 1 AT assembly line

The Kyoto Manufacturing Department began producing automatic transmissions (ATs) in 1975, when the plant was still operated by Mitsubishi Motors Corporation (MMC). In 1977, it started manufacturing front-wheel-drive (FWD) transmissions that were fitted on the Mitsubishi Mirage. The plant later established a solid position as a principal production center of powertrain systems, including engines.

Subsequently, MMC spun off its transmission division and established Diamondmatic Co., Ltd. in April 2002 as an independent company, which merged with JATCO in April 2003. Currently, the Kyoto Manufacturing Department makes its home on the premises of MMC's Powertrain Plant in Kyoto and is engaged in producing transmissions for use on ordinary FWD and rear-wheel-drive (RWD) vehicles sold in Japan and in overseas markets.

The Kyoto Manufacturing Department builds three types of transmissions: stepped ATs and CVTs for FWD cars and ATs for RWD cars. For the Japanese market, these transmissions are mainly mounted on the Mitsubishi Colt, Lancer, Pajero and other models. They are also are fitted on various car models that are shipped to many markets around the world, including North America, Asia and Southeast Asia (China, Taiwan, Malaysia, Thailand, etc.) and Europe

* 第三事業所 京都工場
Kyoto Manufacturing Department, Manufacturing Division No. 3

京都工場で生産されるTMには，FF車用のステップATとCVT，FR車用のATの3機種がある．主に搭載される車両として国内向けでは，コルト，ランサー，パジェロなどがあり，海外向けとしては，北米，東南アジア（中国，台湾，マレーシア，タイ等），欧州（ドイツ，オランダ等）など世界各国に出荷され，さまざまな車両に搭載されている．

2. 特徴

京都工場の特徴のひとつとしては，世界初のFF用ステップAT（FA4）とFF用CVT（FC1）の組立での混流生産を実現したことが上げられる．この混流生産を実現できた背景には，FA4・FC1が同一車両に搭載されることで，動力伝達軸位置やエンジンとのドッキング面の共通性，及びTM内に充填されるオイルの共通性が挙げられる．また，生産設備面から見て，混流生産のベースとなったFA4組立ラインは，元々混流生産をコンセプトに開発された設備であり，多様な機種にも対応可能な組立パレットを有すると共に，ロボットを多用して様々なボルト締付位置にも容易に対応可能としたり，種々の機種が流れることで，生産効率が悪化しないようにするための可変ピッチコンベアーが備え付けられていたことなどが挙げられる．

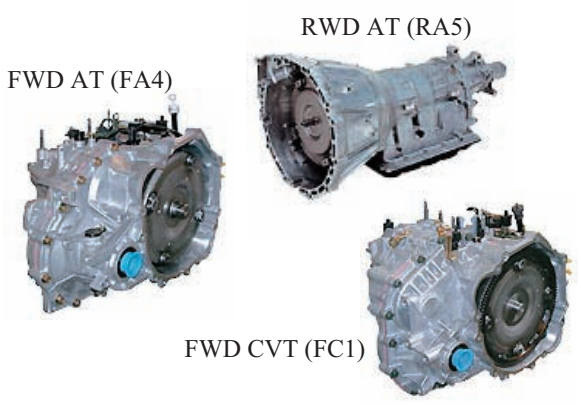


Fig. 2 ATs produced at Kyoto

もうひとつの特徴として挙げられるのは，部品共用率の高さにある．混流生産前のFA4組立ラインでは，既に大きく構造の異なる4速と5速のATを組立てているが，これを実現できた背景のひとつには，使用している種々部品の共通率が高いことで，組立ラ

(Germany, the Netherlands, etc.).

2. Main Features

One of the distinguishing features of the Kyoto Manufacturing Department is that it has the world's first mixed production system for the assembly of stepped ATs (FA4) and CVTs (FC1) for FWD vehicles. This mixed production system was achieved because both the FA4 and FC1 units share certain common aspects since they are used on the same vehicles. These include the same position of the power-transmitting shaft, engine interface and type of transmission fluid used.

The production facilities also incorporate various features that support mixed production. The FA4 assembly line that served as the basis of the mixed production system has facilities that were originally developed around a mixed production concept. The assembly pallets used can accommodate diverse transmission models. Numerous robots are installed that can easily be adjusted to handle various bolt-tightening positions. Variable pitch conveyors are also used to avoid any deterioration of production efficiency when different transmission models are sent along the same assembly line.

Another distinguishing feature that can be cited is the high rate of parts commonality. Prior to the start of mixed production, the FA4 assembly line was already assembling 4- and 5-speed ATs which have large structural differences. One factor making that possible was the high rate of commonality among the various parts used. That made it possible to secure sufficient space alongside the line for storing parts and to ensure ease of assembly, among other things. In addition, the RA5 transmission that was subsequently developed for RWD vehicles shares many parts with the FA4 unit for FWD vehicles. That commonality contributes to easier parts procurement and helps to stabilize quality.

3. Introducing the Local Area

Kyoto is located in a basin surrounded by mountains on three sides. With a history dating back 1,200 years, the city has nurtured a rich and diverse culture. Streets in the center of Kyoto are laid out in a grid pattern, and there are over 2,000 Shinto shrines

インサイドの部品置場の確保や組立の容易性確保などが可能となっている．また，後発で開発された，FR の RA5 においても，FF の FA4 用部品を多用しており，調達の容易性，品質の安定性などに寄与している．

3. 地域の紹介

京都は，三方を山に囲まれた盆地の中にあり，1200 年の歴史の中で，様々な文化を育んできた．市の中心は，碁盤の目のように道路が配置されており，その中には室町時代の北山文化を代表する金閣寺をはじめ，二条城，桂離宮などの世界文化遺産と 2000 以上の神社仏閣が点在している．

この様な歴史の都市であると共に日本国内はもとより，世界各国からの観光客が訪れる観光都市であり更には 37 の大学，短期大学が集結する学術研究都市でもある．

Fig. 3 Kinkakuji Temple

また，年中行事としての祭りには，豪華絢爛な山鉾が都大路を練り歩く祇園祭や葵祭，時代祭などの京都三大祭をはじめとして，五山の送り火・鞍馬の火祭など，季節を彩る数多くの祭り行なわれ，訪れる人に感銘を与え続けている．また，人々は暮らしの中に，夏の「打ち水」や川面にせり出す「納涼床」での食事や，風通しのよい「京町家」など，様々なかたちで四季を取り入れてくるなど，日常生活の中に，新旧がみごとに調和した町となっている．

and Buddhist temples scattered throughout the city. Notable examples include the Kinkakuji Temple (Golden Pavilion Temple) that typifies the Kitayama culture of the Muromachi Period in the early 15th century, the Nijojo Castle and the Katsura Rikyu Imperial Villa. All three have been designated as UNESCO World Heritage Sites, as have many other Kyoto attractions.

Kyoto is a city of history and of tourism, attracting many tourists from throughout Japan as well as from countries around the world. Furthermore, it is a city of scientific research home to 37 universities and junior colleges.

Many festivals are held as annual events that showcase the seasons in Kyoto and deeply impress visitors. These include Kyoto's three big festivals: the Gion Matsuri (Gion Festival) when gorgeously decorated Yamaboko floats are paraded along the city's broad avenues, the Aoi Matsuri (Hollyhock Festival) and the Jidai Matsuri (Festival of the Ages). Other festivals like the Gozan no Okuribi (Five Mountain Bonfires) and Kurama no Hi Matsuri (Kurama Fire Festival) are also well-known.

The elements of the four seasons are also incorporated into people's lives in a variety of ways. Summer is noted for "uchimizu" (sprinkling water on the streets) and eating on "noryo yuka" (a wooden terrace for enjoying a cool evening breeze) extending out over the Kamo River. Kyoto's traditional wooden houses called "kyomachiya" were also built to be well-ventilated by natural breezes. Thus, Kyoto is a city where both the old and the new are beautifully harmonized in everyday life.

Fig. 4 Katsura Rikyu Imperial Villa

4. 京都工場の今後

京都工場では，代表生産機種であるＦＦのＦＡ４ユニットとその加工部品について，中国のハルピンにあるDAE（中国ハルピン東西汽車発動機製造公司）において，自力生産ができるようにすることを目的に，現地からの研修生指導を手始めに，全面的な技術支援を開始している．

4. Future of the Kyoto Manufacturing Department

The Kyoto Manufacturing Department has begun providing comprehensive technical support to Harbin Dongan Automotive Engine Manufacturing Co., Ltd. (DAE), including accepting trainees from DAE, located in Harbin, China. This assistance pertains to the FA4 transmission, one of our mainstay products, and its machined components. The aim is to enable DAE to produce ATs with its own capabilities.

■ Authors ■

Kazunori ARAI

特　許　紹　介

Patents

1. ベルト式無段変速機の制御装置

（Fig. 1）

出　願：出願日　2002.9.30　特願 2002-285503
登　録：登録日　2008.1.25　特許第 4072200 号
名　称：ベルト式無段変速機の制御装置
発明者：プロジェクト推進室　脇　博宣
　　（退職）　澤田　真

1. Control for belt-type continuously-variable transmission

(Fig. 1)

Application Number: 2002-285503
Application Date: 9.30,2002
Patent Number: 4072200
Registration Date: 1.25,2008
Title: Control for belt-type continuously-variable transmission
Inventor: Hironobu Waki (Project Promotion Office)
Makoto Sawada (Resigned from Jatco)

【目的】

ライン圧の変動によるベルト滑りの発生を抑制する．

【発明の構成】

速度比とトルク比とに基づき入力トルクを推定する入力トルク推定手段と，推定された入力トルクに基づき変速制御弁及びセカンダリプーリに供給するライン圧を制御するライン圧制御手段と，を備えたベルト式無段変速機の制御装置において，入力トルク推定手段は，トルク比の減少率が制限値より大きいときは，トルク比の減少率が制限値以上変化しないようにトルク比を補正する．

【作用・効果】

運転者がアクセルペダルの踏み込みと足離しを連続して行ったときのライン圧の変動幅を抑制することができ，ベルト滑りの発生を抑制することができる．

【SUMMARY OF THE INVENTION】

In a belt drive continuously-variable transmission control apparatus, a line pressure control section controls a line pressure to be supplied to a shift control valve for controlling a fluid pressure to a primary pulley, and a secondary pulley, in accordance with an estimated input torque to the continuously-variable transmission, and an input torque estimating section to determine the estimated input torque in accordance with a speed ratio and a torque ratio of the torque converter. The input torque estimating section checks if the decreasing rate of the torque ratio is greater than a predetermined limit value. If the decreasing rate is greater than the limit value, the input torque estimating section imposes a limitation on change of the torque ratio in the decreasing direction.

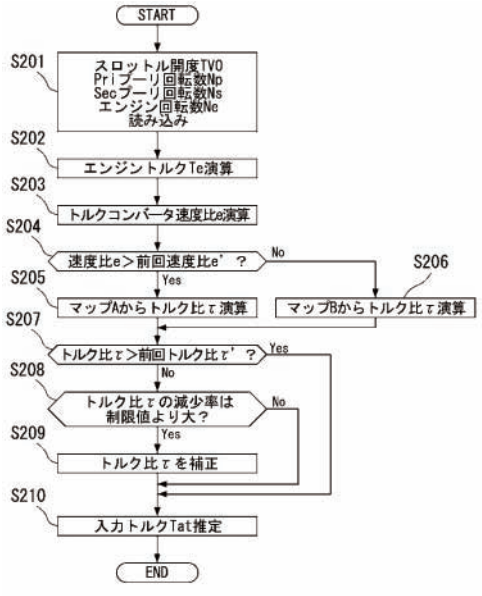


Fig. 1

2. スプロケット取付確認に用いるセンサ治具

（Fig. 1）

出　願：出願日　2004.9.2　　特願 2004-256005
登　録：登録日　2008.3.14　特許第 4095596 号
名　称：スプロケット取付確認に用いるセンサ治具
発明者：部品システム開発部　　高橋　祐二，
　　蒔田　健一
　　Jatco Mexico　　佐藤　学

2. Method of checking sprocket attachment and sensor jig used for same

(Fig. 1)

Application Number: 2004-256005
Application Date: 9.2,2004
Patent Number: 4095596
Registration Date: 3.14,2008
Title: Method of checking sprocket attachment and sensor jig used for same
Inventor: Yuji Takahashi (Hardware System Development Department)
Kenichi Makita (Hardware System Development Department)
Manabu Sato (Jatco Mexico)

【目的】

スプロケットが正規位置に取り付けられたことを確実に確認する．

【発明の構成】

ボールベアリング 50 を圧入したドリブンスプロケット 40 をオイルポンプカバーの円筒部 34 に押し込んだ後，センサ治具 10 の基板 12 から延びる脚 1，14 を円筒部 34 の端面 38 に当接させ，脚 13 と平行に移動可能であるとともに透光孔 18 が形成されたセンサプレート 17 の先端をボールベアリング 50 の端面 53 に当接させる．なお，基板 12 上には，対向して配置された発光器 22 と受光器 23 とを備える．

【作用・効果】

ドリブンスプロケット 40 がオイルポンプに対して正規位置にないときは，発光器 22 と受光器 23 間の光路 L をセンサプレート 17 が遮り，正規位置であれば透光孔 18 が光路 L 上にくる．これにより，受光器 22 からの受光信号の有無を確認することで，自動的に取り付け状態の適否がわかる．

【SUMMARY OF THE INVENTION】

After a driven sprocket 40 into which a ball bearingv50 is press-fitted is pushed into a cylindrical portion 34 of a pump cover, a sensor jig 10 is set so as to have its legs extending from a base plate 12 in contact with an end face 38 of the cylindrical portion, and a front end of a sensor plate 17 movable in parallel with the leg 13 in contact with an end face 53 of the ball bearing. When the driven sprocket 40 is not in a normal position in relation to the oil pump, the sensor plate 17 intersects a light path between a light-emitting device 22 and a light-receiving device 23 placed as opposed to each other on the base plate, and on the other hand, when the driven sprocket is in a normal position, a light-passing hole 18 formed in the sensor plate comes on the light path between the light-emitting device and the light-receiving device.; Thereby it can be automatically determined based upon absence or presence of an optical signal from the light-receiving device whether or not an attachment state is appropriate.

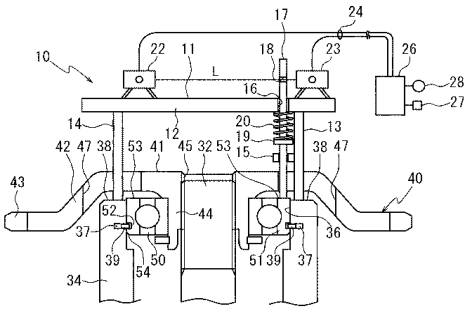


Fig. 1

社外技術発表一覧（2009 年 1 月1日～ 2009 年 12 月 31 日）

発表月日	発表先	表題	発表者	
2009/03/03	自動車技術会 関東支部 学術研究講演会	AMESim を活用した無断変速機の 油圧系シミュレーション	先行技術開発室	三宅　昌夫
2009/03/03	自動車技術会 関東支部 学術研究講演会	自動車 CVT 用油圧制御回路 圧力に発生する圧力脈動に 関する研究	先行技術開発室 先行技術開発室 神奈川大学	勝城　勝 石森　義則 小嶋　英一
2009/4/20 ～ 23	2009 SAE World Congress	FR 車用 7 速オートマティック トランスミッション向けの 新しい制御システム開発	制御システム開発部 プロジェクト推進室 部品システム開発部 日産自動車（株）	高取　和宏 尋木　真一 高橋　直己 内田 正明 EL
2009/4/21 ～ 23	2009 International Symposium on Transmission Innovation and China Market Development	中国市場における CVT	ジヤトコ株式会社	石井　彰
2009/5/7 ～ 8	30th INTERNATIONAL VIENNA MOTOR SYMPOSIUM	新型 7 速オートマチック トランスミッションと その HEV への発展	制御システム開発部 プロジェクト推進室 日産自動車（株）	臼杵　克俊 加藤　義邦 （執筆協力） 内田 正明 EL
2009/5/13 ～ 15	The JSME International Conference MPT 2009 Sendai	自動変速機における遊星 ギヤノイズの予測技術	プロジェクト推進室 プロジェクト推進室 プロジェクト推進室 プロジェクト推進室 部品システム開発部 テクニカル原価低減推進室 日産自動車（株）	那倉　祐介 陣場　規人 上田　泉 関口　和広 下坂　俊郎 室井　明 森川　邦彦
2009/5/13 ～ 15	MPT 2009 Sendai	Outlookfor the Future of Automotive Transmissionand Transmission Technology Trends	ジヤトコ株式会社	土井　利政
2009/5/20 ～ 5/22	人とくるまの テクノロジー展 2009	エレメント・プーリ間 μ 向上に よるベルト CVT の伝達効率向上	先行技術開発室	山﨑　正典
2009/05/21	（社）自動車技術会 2009 年春季大会学術講演会	7AT の新スリップロック アップ制御開発	制御システム開発部 部品システム開発部	山脇　盛正 山本　毅
2009/05/29 ～ 31	09 年度塑性加工学会 春季講演会	パークギア歯型成形への 成形シミュレーション適用	成形技術課 成形技術課 成形技術課 成形技術部 日産自動車（株）	田澤　純 斎藤　巌 小野山　浩一 上野　完治 藤川　真一郎
2009/06/02	JCS 2009	トランスミッション組立 ラインでの DELMIA 活用	業務革新課	北川　裕樹
2009/06/19	KFPS- 韓国油空圧 System 学会	自動車変速機用ソレノイド バルブの C コア形状によ I-PCurve 特性解析	JKE JKE JKE	崔　潤龍 李　尚炫 ヤン　幸植
2009/07/12	トランスミッション フォーラム 2009	AT ／ CVT の小型軽量化と 燃費向上技術	ジヤトコ株式会社 ジヤトコ株式会社 経営企画部	土井　利政 柴山　尚士 青山　明宏

発表月日	発表先	表題	発表者	
2009/7/13 ～ 14	第 39 回　信頼性・保全性 シンポジウム	FTA 支援ツール開発 −物理量次元インデクシングに基づく 知識マネジメントの応用−	品質企画管理部 品質企画管理部 東京大学	平岡　洋二 山本　克成 村上　存
2009/09/04	熱処理応用講座	浸炭焼入れシミュレーション と実際	基盤開発課	谷口　光一
2009/09/10	2009 年度　精密工学会 秋季講演会	複合加工機を用いた摩擦攪拌形 バニシングによるシャフト材表面層の 高硬度化・圧縮残留応力付与	先行開発課 東京農工大学	瀬川　俊明 笹原　准
2009/09/15	日本鉄鋼協会秋季講演大会 シンポジウム	穴加工による穴内面組織の微細化と 疲労強度向上の要因に関する解析	先行開発課	瀬川　俊明
2009/9/15 ～ 17	鉄鋼協会 第 158 回秋季講演大会	真空浸炭におけるプロパン ガス噴射パターンの最適化	先行開発課 加工技術課 基盤開発課 加工技術課	岡本　宗幸 井上　信彦 太田　利一 伊藤　隆彦
2009/9/6 ～ 11	World Tribology Congress 2009	ベルト CVT の伝達効率向上と トライボロジーの役割	制御システム開発部 先行技術開発室	道岡　浩文 加藤　芳章
2009/12/1 ～ 2	8th International CTI-Symposium in Berlin	粒子法を使った自動変速機 内部の流体流れ シミュレーションの開発	解析技術センター 要素信頼性グループ 箱物設計課	矢部　康志 千葉　康雄 鈴木　利和
2009/11/13	自動車技術会中部支部 第 1 回技術講習会	自動変速機の現状と今後の 技術進化の方向性	商品開発室	服部　昇
2009/12/02	2009 International CTI-Symposium in Berlin	成就するであろう革新的 シナリオにおける CVT の 性能とそれを支える技術	ジヤトコ株式会社	土井　利政
2009/12/17	熱処理応用講座	浸炭焼入れシミュレーション と実際	基盤開発課	谷口　光一
2009/12/14	第 3 回「ダイカストの品質及び生産 性向上技術」研究部会	トランスミッションケースの 軽量化への取組み	基盤開発課 基盤開発課 部品システム開発部	森　秀伸 安納　義治 平野　聡

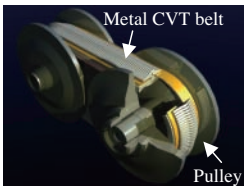
第59回自動車技術会賞『論文賞』受賞論文

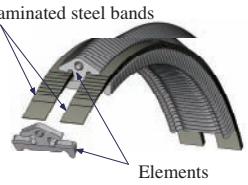
エレメント・プーリ間μ向上による ベルトCVTの伝達効率向上

Yoshiaki KATO
Advanced Technology Development Division

NEDO地球温暖化防止新技術プログラム
ベルト・プーリ間摩擦係数向上技術

プーリ表面の粗さや，微細溝パターンなどの表面テクスチャーを制御することと，CVT油の添加剤の配合を改善して，ベルトCVTのベルト・プーリ間摩擦係数を現行比20%UPさせて，燃費を2%向上することを目的として取り組んだ．

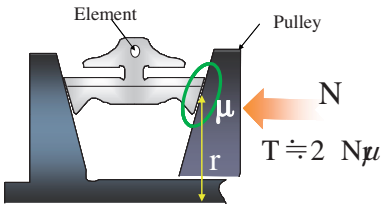




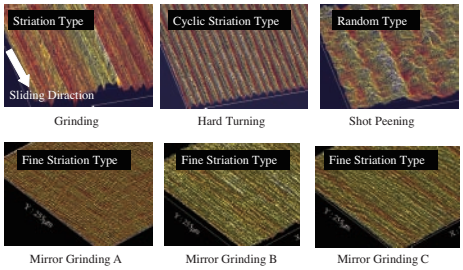
金属ベルト

プーリ表面性状の制御による高μ化

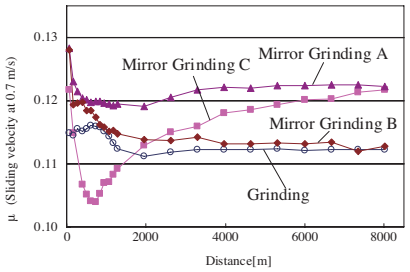
表面性状の異なる試験片を，様々な加工手法により作成し，摩擦係数（μ）を評価した結果，鏡面ﾌﾟｰﾘAは，従来の研削加工品よりもμが約14%高くなることがわかった．
また，μは表面粗さの突起密度（Dsum）と相関が高く，高いμを発生するメカニズムは，突起密度が高いことにより接触部の押し込み深さが減少し，基材の有効硬さの影響を緩和するためであることがわかった



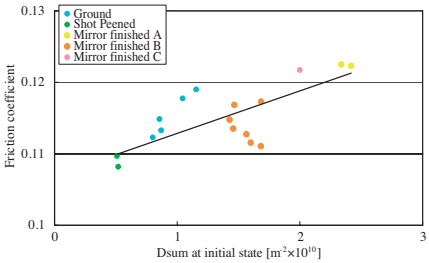
トルク伝達メカニズム



各種試験片の表面性状



表面性状の異なる試験片のしゅう動距離とμの関係

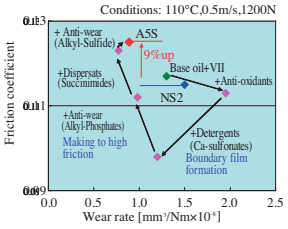


Dsumとμの関係

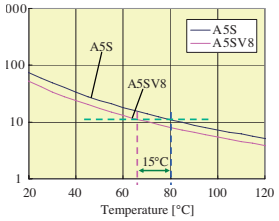
CVT油の高μ化と低粘度化

添加剤の配合を改善し，耐摩耗性と高μを両立した高μ油A5Sを開発した．A5Sは市販油（NS2）に比べて反応性が高く，広い範囲に境界潤滑膜を生成し，高いμを発揮する．更に基油と粘度指数向上剤の選定により，粘度を約15℃相当低くしたA5SV8を開発した．

エレメント接触面の様子

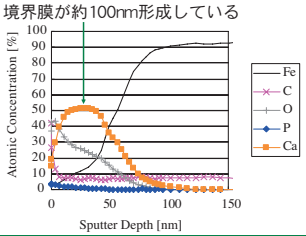


高μ油開発コンセプト



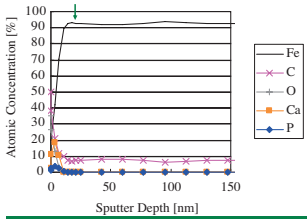
高μ油の低粘度化

白色部分はCaやPを多く含む
境界膜が約100nm形成している



エレメント接触面白色部のAES分析結果

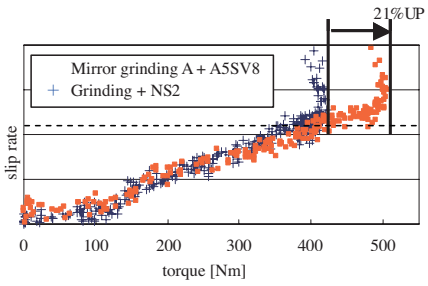
黒色部分は添加剤による境界膜が少なく
表面から20nmで基材に到達する



エレメント接触面黒色部のAES分析結果

実機での効果検証

実機ベルトBOX試験機にて，鏡面プーリAとA5SV8の組み合わせで従来の研削加工プーリ+NS2と比べて，トルク容量が21%高くなることを確認した．
これは，約21%μが高いことと等価である．
また，従来の研削加工プーリ+NS2と同等のトルク容量となるよう，プーリ油圧を調節した結果，ベルト・プーリの伝達効率が約2%改善した．



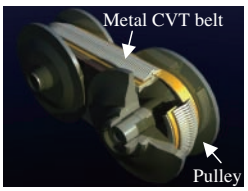
実機ベルトBOX試験機により測定したトルク容量比較

JATCO Paper Receives Outstanding Technical Paper Award at 59th JSAE Awards Program

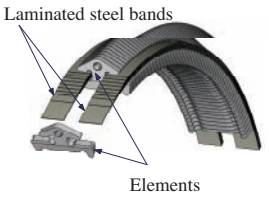
Improvement of Steel-belt CVT Transmission Efficiency by Improving Element-pulley Friction Coefficient

NEDO's New Technology Program for Prevention of Global Warming
Technology for improving belt-pulley friction coefficient

The aim of this work was to enhance vehicle fuel economy by 2% as a result of improving the friction coefficient (μ) between the belt and pulleys of a steel-belt CVT by 20% over the current level. The μ value was improved by controlling the pulley surface roughness and texture, including applying a micro-groove surface pattern, and by improving the additive package of the CVT fluid.



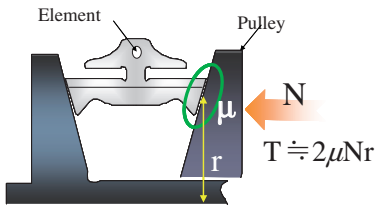
Steel-belt CVT



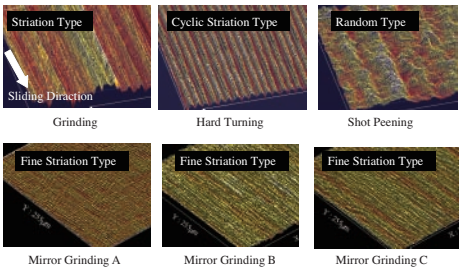
Steel belt

Higher μ attained by controlling pulley surface texture

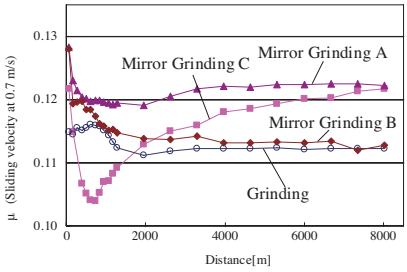
Test pieces having different surface textures were prepared by using various machining methods and their μ value was evaluated. The results showed that mirror-finished pulley test piece A displayed approximately a 14% higher μ value than the conventionally ground test piece. The mechanism producing a high μ value, which is strongly related to the density of roughness asperity summits (Dsum), was also revealed. A high asperity density reduces the amount of asperity compression in the area of contact, thereby mitigating the influence of the effective hardness of the base material and resulting in a higher μ value.



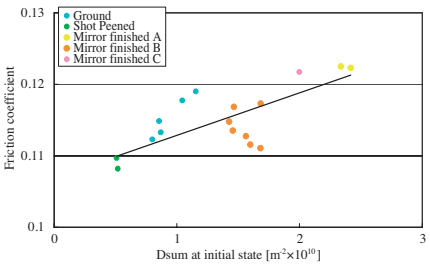
Torque transmission mechanism



Test piece surface textures



Relationship between sliding distance and μ for test pieces with different surface textures

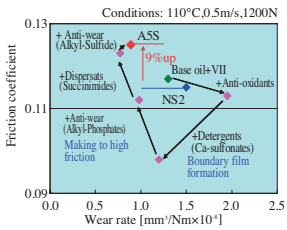


Friction coefficient vs. Dsum

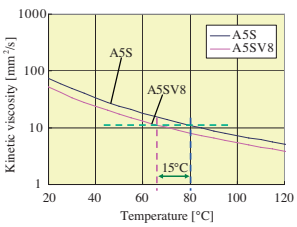
High-μ CVT fluid with lower viscosity

A high-μ CVT fluid (A5S) that provides both strong wear resistance and a high μ value was developed by improving the additive package. The A5S fluid has higher reactivity than the commercial NS-2 fluid and forms a boundary lubrication film over a wider area, enabling it to display a higher μ value. In addition, by carefully selecting the base oil and viscosity index improver, we also developed the A5SV8 fluid that has lower viscosity, corresponding to a temperature difference of approximately 15°C.

Condition of sliding contact surface of element

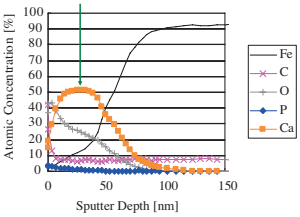


Development concept of high-μ fluid



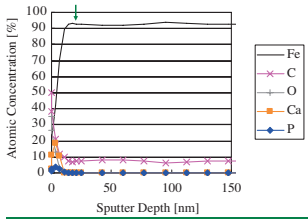
Lower viscosity of high-μ fluid

White areas contain a lot of Ca and P and form a boundary lubrication film of about 100 nm in thickness.



AES analysis results for white areas of sliding contact surface of elements

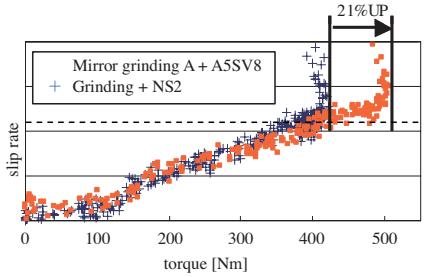
Boundary lubrication film formed by additives is thinner in the black areas. Depth to the base metal is 20 nm from the surface.



AES analysis results for black areas of sliding contact surface of elements

Validation of effects using actual CVT belt and pulleys

The combination of mirror-finished pulley test piece A and the A5SV8 fluid was compared with the conventionally ground pulley test piece and the NS-2 fluid using a belt box test rig. The torque capacity of the former combination was found to be 21% higher, which is equivalent to approximately a 21% improvement in the μ value. When the pulley pressure was adjusted so that the torque capacity would be equal to that of the conventionally ground pulley test piece and the NS-2 fluid, it was found that the belt-pulley transmission efficiency was improved by approximately 2%.



Comparison of torque capacities measured with the belt

編集委員会（Editorial Committee）

ジヤトコ・テクニカル・レビュー　No.9

Ⓒ禁無断転載
発　　行　2010 年 2 月
発行・編集人　ジヤトコ・テクニカル・レビュー
　　編集委員会
発　行　所　ジヤトコ株式会社
　　エンジニアリング管理部
　　静岡県富士市今泉 700-1
　　〒 417-8585 0545(52)2661
印　刷　所　株式会社 カネヤマ
　　静岡県富士市大野 128-1

Jatco Technical Review No.9

February, 2010
Publisher　Jatco Technical Review
(Editor)　Editorial Committee
Distributor　Engineering Administration Department
　　Jatco Ltd
　　700-1, Imaizumi, Fuji City
　　Shizuoka, 417-8585, Japan