e-Axle for 100% Electric Motor-Driven Hybrid and New Electric Vehicles

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Abstract

This paper describes a new e-Axle developed for 100% electric motor-driven hybrid and new electric vehicles. The e-Axle is JATCO's first unit, which was developed in collaboration with Nissan Motor Co., Ltd. It integrates a motor, inverter, and gearbox to achieve high performance with a compact size and low cost.

1. Introduction

In recent years, automobile electrification has rapidly progressed against the backdrop of global warming countermeasures and the need to reduce automobile emissions.

In battery electric vehicles (BEVs) and 100% electric motor-driven hybrid e-POWER-equipped vehicles, reducing aerodynamic drag, increasing battery space, and ensuring collision safety are important issues. To address these at a high level, the size of the drive unit must be reduced. In addition, to deliver the "motor-driven driving performance," which is unique to electric vehicles, new technologies are required to accomplish the aforementioned compactness and high-torque/high-output performance.

This paper describes the new e-Axle, which was developed jointly with Nissan Motor Co., Ltd. for new BEVs and e-POWER-equipped vehicles.

2. Objectives of the new e-Axle

To satisfy the high-performance requirements of new BEVs and e-POWER-equipped vehicles, a new e-Axle was developed with the following objectives:

- To reduce the cost by downsizing the unit and the number of parts, which contributes to improved vehicle platform performance
- To improve quietness, which is an attractive feature of electric vehicles
- To improve efficiency for increased driving range
- To share the use of the e-Axle unit in BEVs and e-POWER-equipped vehicles

In developing JATCO's first e-Axle, the unit system was designed to meet these objectives. [1]

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3. Configuration of the e-Axle unit

The configuration of the e-Axle unit is described separately for BEVs and e-POWER-equipped vehicles as follows:

3.1 e-Axle for BEVs

The e-Axle for BEVs has a 3-in-1 configuration that integrates a motor, inverter, and gearbox to reduce size and cost (Fig. 1).

Image Source: Nissan Motor Co. Ltd.

Fig. 1 e-Axle for BEV

3.2 e-Axle for e-POWER-equipped vehicles

The e-Axle for e-POWER-equipped vehicles shares as many components as possible with the 3-in-1 e-Axle for BEVs and has a 5-in-1 configuration with an additional generator and a speed increaser (Fig. 2). However, the increase in speed was designed to be smaller than that of the conventional type, and the three-axis configuration was modified into a two-axis configuration.

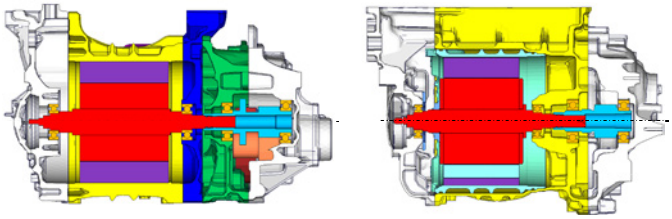
Image Source: Nissan Motor Co. Ltd.

Fig. 2 e-Axle for e-POWER

4. Design goals

4.1 Improved quietness

In the new e-Axle, we aimed to reduce high-frequency airborne noise generated by the excitation forces of the motor, inverter, generator, and gearbox. To address this, the housing structure was designed to integrate the components of the motor, inverter, generator, and gearbox. The vibratory force was suppressed by improving the joint rigidity of the housing components and by optimizing the bearing arrangement (Fig. 3).



Previous model e-Axle New e-Axle

Fig. 3 e-Axle unit section of BEV [2]

Furthermore, a six-part skew design was used for the rotor core to suppress the higher-order motor vibratory force, which resulted in a significant reduction in solid-state propagation noise. [2]

4.2 Improvement of gearbox efficiency

Improving the fuel efficiency of the vehicles equipped with an e-POWER gearbox necessitates an increase in gearbox efficiency. Therefore, losses due to the agitation resistance of the lubricating oil and friction at the gear tooth contact area were reduced.

4.2.1 Reduction of churning loss

A dual-shaft gear set was placed above the unit to reduce the agitation resistance of the lubricating oil. A three-dimensional (3D) simulation of the lubricant flow was performed to simultaneously reduce agitation resistance and gear lubrication.

4.2.2 Reduction of gear meshing loss

The gear tooth contact geometry was optimized via simulations to reduce gear loss.

Altogether, the gearbox loss was reduced by approximately 10% compared to that of the previous e-Axle (Fig. 4).

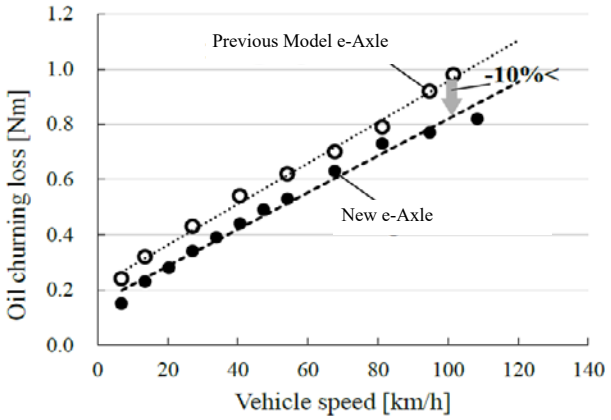


Fig. 4 Gear-box loss [1]

4.3 Initiatives for cost reduction

4.3.1 Cost reduction of magnets

The amount of heavy rare-earth metals used in rotor magnets, which account for a large proportion of motor costs, was reduced [1] (Fig. 5).

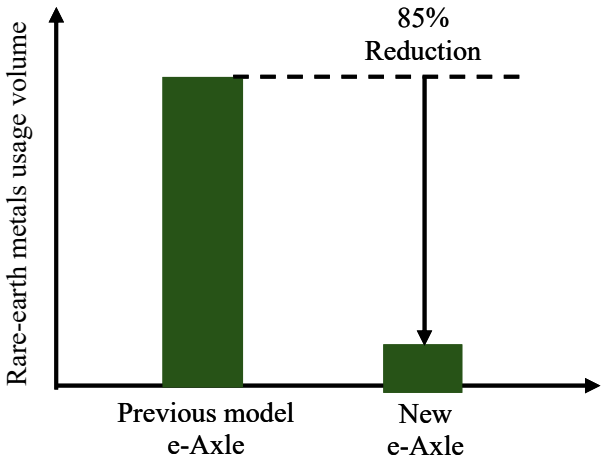


Fig. 5 Rare-earth metal usage volume

4.3.2 Shared use of parts

The e-POWER is a system that appeals to motor-driven driving performance, with a drive mechanism that can be made more compatible with BEVs. Exploiting this feature, an e-Axle that shared the same drive motor and gearbox was designed for BEVs and e-POWER-equipped vehicles, resulting in cost reduction and productivity improvement (Fig. 6).

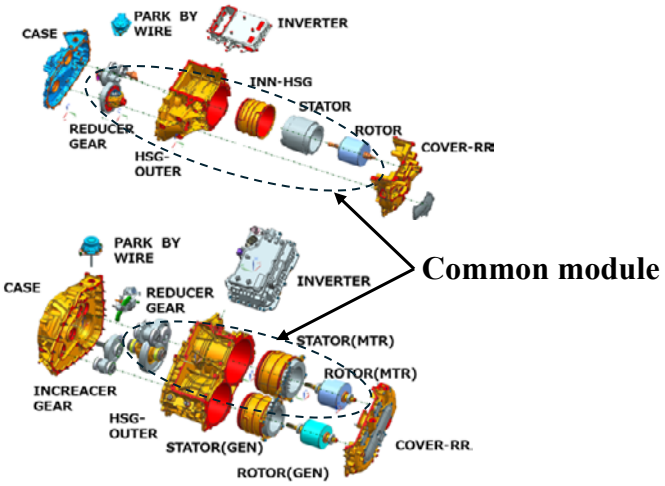


Fig. 6 Module structure concept

5. Summary

A new e-Axle was developed for new BEVs and 100% electric motor-driven hybrid vehicles.

- Quietness, an attractive feature of electric vehicles, was improved by increasing the rigidity of the housing structure and introducing a skewed rotor core.
- The design aimed to reduce lubricant agitation resistance and gear friction loss, improving driving range and fuel economy. Gearbox loss was reduced by approximately 10% compared with that of the conventional type.
- Reducing the use of heavy rare-earth metals and sharing their components led to lower cost and higher productivity while meeting the requirements of both BEVs and e-Axle for vehicles equipped with e-POWER.

6. References

(1) Sho Maruyama, et al.: Development of EV Powertrain for Third-Generation New EV, Proceedings of the 2025 JSAE Annual Congress (Autumn), 20256148

(2) Kazuhiko Arai, et al.: Development of Integrated 3-in-1 Electric Powertrain and Optimization for Dedicated EV Platform to Improve Powertrain NV, Proceedings of the 2025 JSAE Annual Congress (Autumn), 20256187

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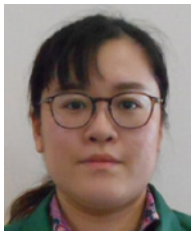
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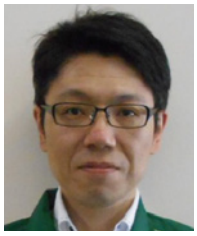
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