Improvement of product quality by introducing the Quality Design Sheet

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Summary

In order to deliver products of the highest quality to customers, JATCO has regularly improved its quality assurance tools and endeavored to apply the optimal processes at all times. These efforts have markedly improved both R&D and manufacturing quality. However, various problems have remained such as rework caused by poor communication between departments and not identifying all quality risks in the early stages of the development process.

This article describes the Quality Design Sheet that has been created for the purpose of promoting "active communication" and "early visualization of quality risks" in order to solve these issues. The introduction of the Quality Design Sheet is contributing to the formation of a powerful quality assurance system throughout the entire company.

1. Motivation for creating QDS

In order to put products of higher quality and performance on the market, it is essential that the intentions of product planners and development engineers are transmitted accurately to manufacturing engineers, including suppliers, and made into definite realities. One commonly used method to accomplish that is quality function deployment (QFD), and one of the tools used in this process is a quality assurance (QA) table.

Like other companies, JATCO has used QA tables to improve product quality. In handing over the responsibility for a product from the previous process to the next one, problems have sometimes occurred when intentions were not fully and accurately conveyed owing to poor communication on both sides, among other factors. In addition, communication from the R&D department to the manufacturing department has often been one-way. When manufacturing issues occurred, depending on the schedule, there was not enough time to feed them back to the R&D department. There were not a few instances when manufacturing engineers had to resign themselves to proceeding without getting issues resolved.

In order to solve such problems, it was necessary to develop some tool to facilitate sufficient communication on both sides and to enable all issues, including ones related to manufacturing, to be identified and resolved in the early stages of the development process. The Quality Design Sheet (QDS) described here was thus created as a tool that further expanded QA tables.

Figure 1 presents examples of issues that occurred due to poor communication. Gear damage is listed as an example of a potential quality risk that can occur due to exceptionally high surface pressure caused by a large

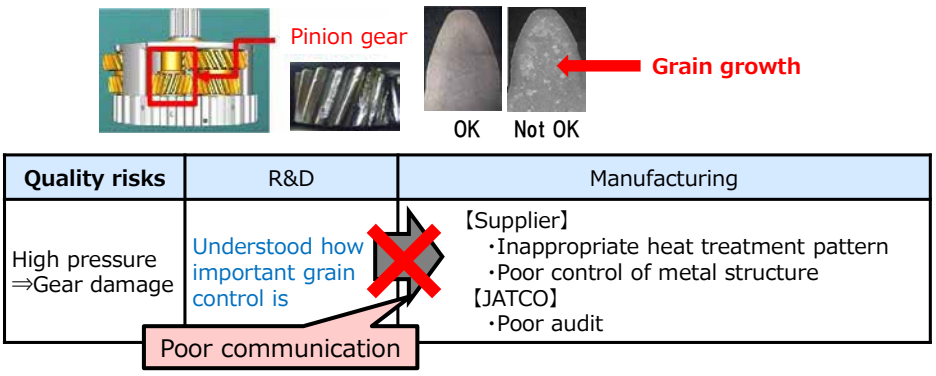

Fig. 1 Examples of issues due to poor communication

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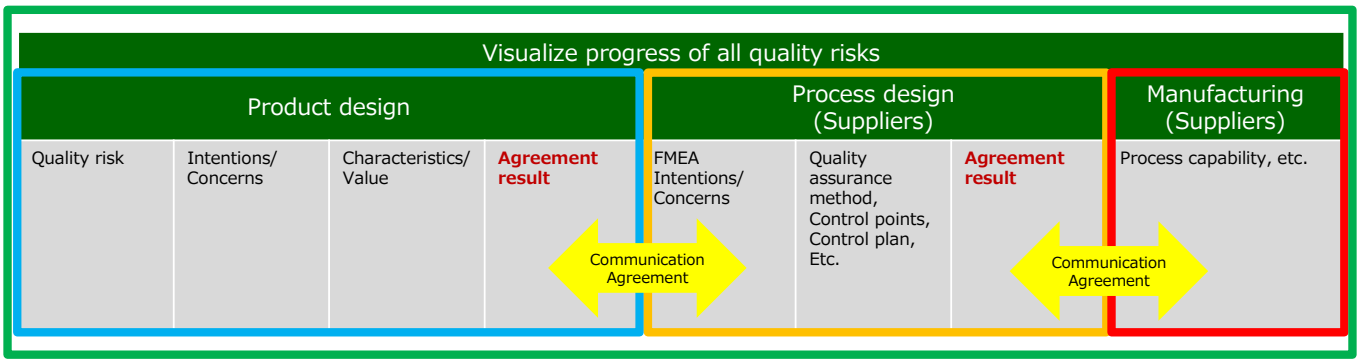


Fig. 2 Quality Design Sheet concept

torque input. R&D engineers understood the importance of crystal grain control as a crucial aspect of preventing such a risk. However, that information was not correctly conveyed to the manufacturing department so the metallographic structure was not properly controlled by applying an appropriate heat treatment pattern nor was sufficient care taken when conducting a process audit.

2. Aim of QDS and improvement

The QDS concept is outlined in Fig. 2. The QDS is divided into three stages: product design, process design and manufacturing. It is created by listing identified quality risks along the vertical axis and indicating along the horizontal axis the results of studies done by the responsible departments to solve the risks as the project progresses. The QDS has improved several processes compared with those of the traditional QA table for the purpose of solving issues originating in poor communication between departments. The following describes three major points in particular that have been improved.

1) Expanding the perspective for identifying quality risks

The QA characteristics that were identified previously were ones deemed important with regard to product functionality. They included characteristics that might possibly lead to serious risks in the field and ones concerning risks that previously occurred in the field for similar products. However, characteristics having a low possibility of becoming a risk in the field were not the target of identification, even ones that posed issues at the R&D stage and ones given close attention in design reviews of products have a high degree of novelty. Consequently, there was a problem that not all risks extending from R&D through manufacturing were included.

To solve this issue, the areas for identifying quality risks were expanded to include all aspects of concern regarding R&D and manufacturing. It was decided to call items that were newly identified as a result of this expansion of areas for identifying risks as quasi-QA characteristics.

2) System for promoting recognition of the importance of communication and agreement

In order to avoid quality risks, it is necessary for all processes to have the same awareness by accurately communicating to the production engineering department the quality risks identified by the R&D department and further to communicate them to the manufacturing department without fail. Previously, it was left to downstream processes to try to understand and avoid quality risks that occurred in upstream processes.

Signature columns (indicated as agreement result in red in Fig. 2) were provided on the QDS for indicating "who, when and what" was agreed at the time of the transition at each stage from R&D to production engineering and then to manufacturing. This was done to create a system so that a project would only proceed to downstream processes after obtaining their understanding and agreement concerning quality risks identified in upstream processes.

3) Visualizing the whole picture and progress of quality risks

Latent quality risks in a product are all listed on the QDS, making it possible to visualize the whole picture of risks and to understand at a glance how much progress is made at each stage in addressing them. This enables quality risks to be managed.

The QDS was initially applied as a tool at the stage prior to making a QA table. First, all the quality risks identified at the R&D stage were listed on the QDS and the related QA characteristics were investigated. Subsequently, they were transferred to a QA table at the time of the

transition to the manufacturing stage. The QA table alone was then used in the processes from manufacturing onward.

This made it possible for all processes to share quality risks. However, mistakes occurred in transferring information to the QA table, and both the QDS and the QA table were used together at the transition stages from R&D to manufacturing, making it difficult to manage the latest information on quality risks. These and other new issues occurred because of double management of the two forms. Therefore, an improvement was made by combining the best points of the QDS and QA table into one integrated form (Fig. 3).

This created a comprehensive QDS that incorporated the function of the QA table in a new form. Internally, the name of this form is officially registered as "QA Table (Quality Design Sheet)", but QDS will be used as the unified designation from section 3 below.

3. Composition of QDS

Monozukuri mainly consists of the stages of R&D, production engineering and manufacturing. The departments responsible for each stage bear the responsibility for delivering products of excellent quality to customers. Here, we will explain the role that each department plays in this process.

3.1 Role and responsibility of R&D department (in blue framework on left side of Fig. 2)

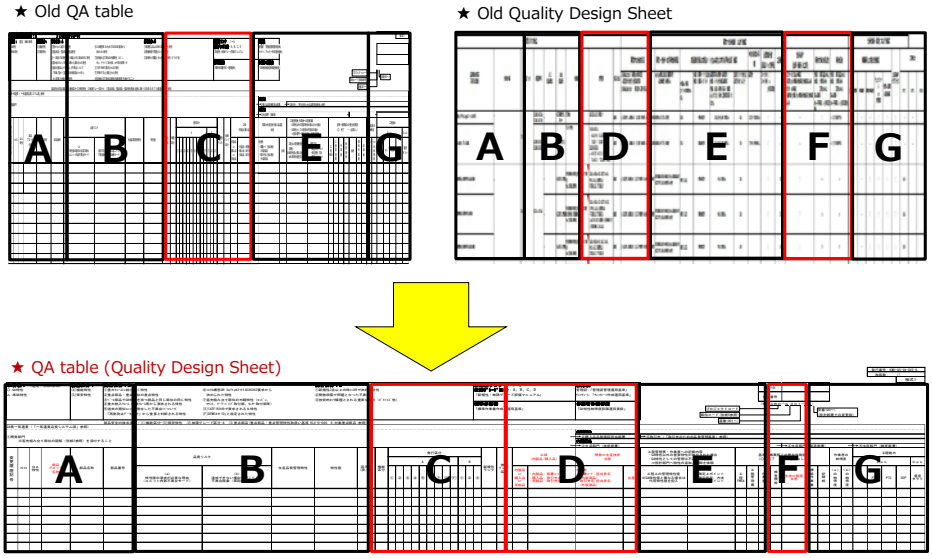
This department identifies the quality risks of all parts, assesses the degree of influence of the risks in terms of functional characteristics, and determines the categories of characteristics according to their level of importance. The categories of characteristics are classified into three levels: QA characteristics, quasi-QA characteristics and general characteristics.

How these characteristics are related to risks pertaining to the vehicle and the AT/CVT is communicated to the production engineering department along with the intentions and concerns of the R&D department.

Discussions are held until both the R&D department and the production engineering department are satisfied. At the stage where an agreement is reached, the production engineering department signs the agreement column of the QDS (Red letter in Fig. 2).

3.2 Role and responsibility of production engineering department (yellow center frame in Fig. 2)

After receiving and agreeing to the intentions



A: Risk
B: Characteristics/Value
C: Perspective for identifying characteristics
D: Agreement between R&D and production engineering
E: Document for manufacturing
F: Agreement between production engineering
G: Process capability

Fig. 3 Integration of QA table and Quality Design Sheet

and concerns of the R&D department, the production engineering department studies process designs and management methods corresponding to the QA characteristics, quasi-QA characteristics and general characteristics. Management methods are specified according to the respective categories of characteristics. The production engineering department provides feedback to the R&D department about concerns raised by the manufacturing department in cases where the methods of measuring dimensions or strength are difficult to apply or the values set for characteristics are stricter than before.

In the course of repeating these studies, the items agreed with the R&D department are incorporated in a process failure mode and effects analysis (PFMEA) and reflected in process designs. In addition, process management aspects with regard to concrete methods of measuring and assuring each characteristic are determined, and the intentions and concerns of the production engineering department are communicated to the manufacturing department.

The manufacturing department and the production engineering department hold discussions until the former understands and accepts the latter's ideas. At the stage where an agreement is reached, the manufacturing department signs the agreement column of the QDS (Red letter in Fig. 2).

3.3 Role and responsibility of manufacturing department (right red frame in Fig. 2)

After receiving and agreeing to the intentions and concerns of the production engineering department, the manufacturing department aligns the forms of the former department, including the PFMEA results, with its own forms such as process management charts, work procedure charts and others. It also evaluates the level of acceptance among manufacturing workplace employees and describes the results on the QDS.

Moreover, after all the production preparations are completed and production trials begin at the plant, the manufacturing department inspects the values of each characteristic using the assurance methods agreed with the production engineering department. Manufacturing processes and methods are continuously improved until the process capability for each characteristic satisfies the specific standard. It is confirmed that the quality risks communicated by the R&D and production engineering departments do not occur.

Process capability values are also measured in the initial production control phase following the launch of mass production, the results are recorded on the QDS and the measurements are concluded (measurement of QA characteristics continues until the end of production).

3.4 Role of corporate quality assurance department (green peripheral frame in Fig. 2)

In order to proceed with monozukuri based on the QDS, it is necessary to monitor the overall progress and to promote the smooth transfer of information and agreements between departments.

That is the role of the corporate quality assurance department. When difficult-to-solve issues occur or agreements cannot be reached between departments, the corporate quality assurance department clarifies the factors involved and works together with the person in charge of each issue to propose methods of promoting solutions; it leads this activity until the issues are closed.

This department assures the quality of products by conducting confirmation activities at various places throughout the company after issues have been closed at the R&D, production engineering and manufacturing stages, respectively. That is done to confirm that quality is being assured as agreed by the departments involved and that all the concerns have been solved, among other things.

4. Effects of QDS

This section presents specific examples of the effects obtained at each stage from the quality improvements made by using the QDS.

1) Expansion of the perspective for identifying quality risks

As explained earlier, previously, the R&D department was mainly responsible for identifying quality risks. Consequently, quality risks in production engineering and in manufacturing were not completely identified, and risks appeared after production trials were initiated.

The introduction of the QDS provides opportunities for the production engineering and manufacturing departments to confirm early on the quality risks identified by the R&D department and for both departments to provide feedback to R&D. Accordingly, quality risks in production engineering and manufacturing can now be included from the early stage of R&D activities.

Moreover, feedback is also possible from the cost planning department, after-sales service department and others, enabling risks to be identified that take into account cost attainment, field serviceability and other aspects. The expanded perspective for identifying risks has therefore been greatly effective in improving quality.

No.	Model	Part name Number	Quality characteristic	Reason	Possible defects
1	CVT	FIX PRIMARY 3--- -----	Slot contact angle ○° +○°/-○°	Belt slip, roller wear	Vehicle does not move forward and shift failure
2	CVT	FIX PRIMARY 3--- -----	Diameter of roller slot Ø○mm +○/-○	Belt slip, roller wear	Vehicle does not move forward and shift failure
3	CVT	FIX PRIMARY 3--- -----	Sheave waveness ○%, ○μm ≥ ±○%	Belt wear, sheave face wear and belt slip	Vehicle dose not move
4	CVT	FIX PRIMARY 3--- -----	Sheave roughness ○○	Belt wear, sheave face wear and belt slip	Vehicle does not move
5	CVT	FIX PRIMARY 3--- -----	Sheave roughness ○ min	Belt wear, sheave face wear and belt slip	Vehicle dose not move
6	CVT	FIX SECD 3--- -----	Slot contact angle ○○° +○°/-○°	Belt slip, roller wear	Vehicle does not move forward and shift failure
7	CVT	FIX SECD 3--- -----	Diameter of roller slot Ø○mm +○/-○	Belt slip, roller wear	Vehicle does not move forward and shift failure
8	CVT	FIX SECD 3--- -----	Sheave waveness ○%, ○μm≥±○%	Belt wear, sheave face wear and belt slip	Vehicle dose not move
9	CVT	FIX SECD 3--- -----	Sheave roughness ○○	Belt wear, sheave face wear and belt slip	Vehicle dose not move
10	CVT	FIX SECD 3--- -----	Sheave roughness ○ min	Belt wear, sheave face wear and belt slip	Vehicle dose not move

Fig. 4 Quality risk card

2) Improvement of understanding and awareness in manufacturing workplaces through communication of information and agreements

Quality risks are now communicated from the R&D department to the production engineering and manufacturing departments in the early stages of R&D for the purpose of reaching agreements on the items, categories and values of characteristics. As a result, the production engineering and manufacturing departments can now provide feedback to the R&D department approximately one year earlier than before.

In addition, the R&D department now explains the meaning and importance of the values of the various characteristics directly to the production engineering and manufacturing departments. This eliminates any discrepancies between them and has improved understanding on the part of the production engineering and manufacturing departments and raised awareness of the importance of workplace management.

An activity undertaken to improve quality at JATCO MEXICO S.A.DE C.V. is explained here as one example.

After receiving a detailed explanation of quality risks from the R&D department, the production engineering and manufacturing departments created a quality risk card (Fig. 4) based on the QDS. This card has made it possible for employees to know at a glance what types of risks might occur in the event that the processes they are responsible for do not satisfy the required characteristics. Employees always carry this quality risk card around together with their employee ID card, enabling them to confirm risks at any time. This activity has heightened all the employees' awareness of quality and has served to improve quality significantly.

It has also enabled preceding and following processes to thoroughly discuss quality risks that might occur and to reach agreements on their respective roles and measures for solving them. That has worked to heighten awareness of responsibilities in each process. For example, responsibilities are handed off to the next process like a baton in a relay race, so the locus of responsibility is clearly defined. Not only the R&D, production engineering and manufacturing departments, but also other related departments are able to become involved in resolving issues while cooperating constructively.

It has also led to more active daily communication not only about items on the QDS, but also about the production schedule, costs and other work procedures. Thus, it also has a secondary effect of enabling smooth consultations.

3) Visualization of the whole picture and progress of quality risks

Information is entered on the QDS from left to right as a project proceeds, making it easy to see the progress being made in dealing with each issue. It is now possible to understand at a glance at which stage and in what way quality has been assured against the risks identified by the R&D department.

As a result, the whole picture of which specific parts are unfinished in which processes can now be seen, enabling action to be taken immediately. This includes dealing with tiny issues that tend to be obscured by much larger ones and avoiding putting off action on risks deemed to have a low rate of occurrence, as well as matters lacking an agreement such as the values of characteristics, methods of assuring quality and process capabilities not yet attained.

5. Future efforts

We want to undertake efforts to deal with the following two points as specific issues.

1) Incorporating this process in related departments and continuous improvement

The corporate quality assurance department regularly holds meetings to explain the QDS to related internal departments and suppliers for the purpose of promoting the penetration of the QDS. Questions and opinions expressed at such meetings are gathered for promoting further improvements.

A company-wide improvement activity was launched in fiscal 2019 in which efforts were undertaken to improve the R&D process and manufacturing process in cooperation with related departments. This activity revealed certain problems in the operation of the QDS as well as many points requiring improvement, which have been consolidated into the following six issues.

(1) Reduction of variation in the extraction level of quality risks

(2) Clearly defining the methods for validating characteristics and their values

(3) Method of agreeing on how to classify the categories of characteristics

(4) Clearly defining the rules for issuing standards

(5) Method of agreeing on process management characteristics and quality assurance procedures

(6) Penetration of rules for deploying the results of identifying process capabilities

Persons responsible for these issues were determined and working groups were formed to solve them. The results of studies undertaken by the working groups were incorporated in criteria for applying the QDS and in other related standards and are already being put to practical use. They will also be reflected in new projects in the future.

2) Company-wide penetration including overseas production plants and suppliers

Regular meetings and educational activities are continuously being undertaken so that overseas production plants and suppliers also understand the importance and practical application methods of the QDS. It is also planned to include explanations of the QDS in new employee training programs so as to improve quality awareness on a company-wide basis.

6. Conclusion

As explained here, the QDS is a tool for smoothly connecting the entirety of monozukuri from the most upstream process to the final process. It contributes to improving quality by strengthening the ties between the R&D, production engineering and manufacturing departments.

The products to which the QDS has been applied in R&D and manufacturing processes have attained even better quality, confirming that this tool has produced significant results. The corporate quality assurance department naturally takes measures against issues that occur in the process of creating the QDS. It is also actively involved in dealing with any issues that occur as the various departments proceed with their studies. Not only does it create standards for the QDS, it also works vigorously to help with the revision of standards issued by each department.

Going forward, we aim to further improve quality by penetrating the QDS thoroughly throughout the company.

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