Profitability increase of pre-production and autocomponents issue project

R M Khisamutdinov¹, O I Yurasova², S Yu Yurasov², E A Ryabov²

¹JSC «KAMAZ»

²Kazan Federal University, Naberezhnye Chelny Institute, 423812, Russia, Naberezhnye Chelny, Prospekt Syuyumbike 10A

sunnywind@list.ru, yurasova-olya@yandex.ru, docfile@yandex.ru, Evgeniy.ryabov@inbox.ru

Abstract. In modern conditions auto components domestic manufacturers should not only improve the quality of products to the world level, but also provide the greatest possible profit. As a result, a technique for developing modern technological documentation was proposed. In the framework of this methodology, requirements to modern technological documentation have been developed, factors of profitability decrease in the APQP project cycle have been identified, work grouping providing the best results for the APQP process stages have been grouped, technological information as the basis of enterprise management has been worked out, technological design and technical documentation processes have been developed, scheme of the process of technological design. In the paper, the key control characteristics of technological transitions are systematized, the principles of management of the preparation of production (technological design) based on technical documentation are formulated. The developed measures allow at the stage of technological design not only to obtain information for managing the auto component quality, but also to prevent potential losses, that is, to increase the profitability of the project.

Russia’s accession to the WTO has led to the fact that auto components domestic manufacturers should not only improve the products quality to the world level, but also provide the greatest possible profit. One of the main conditions is to provide specialists and managers with the necessary set of technological information.

The introduction of quality management systems in the Russian automotive industry in accordance with GOST R ISO 16949-09 implies the transfer of as many works as possible to create information support for the early stages pre-production. It details the main provisions of the planning process, development, pre-production and production of the component (APQP-process). The purpose of the APQP-process is to ensure the output of the planned quality of mass-produced automotive components meeting the requirements and expectations of consumers.

The main principle is the execution of works by a multifunctional APQP-team of specialists. As the internal goal of the APQP process, the clear interaction of all its participants and ensuring timely implementation of the required stages of work at acceptable costs is indicated. The results of the APQP process, designed in an appropriate form, are included in the set of documents on the harmonization of automotive components.

The stages of the APQP process are shown in Fig.1
Activity on the production processes development is carried out at the third stage pre-production. This is not only a technological design with the formulation of standardized technological maps, but also the development of the life cycle processes of the projected commodity product, the processes of providing jobs with resources, the technology of collecting and storing associated products (waste, emissions, etc.), control technology (obtaining, analyzing, information processing, planning, reporting).

To organize management, each process should receive a full range of quantitative characteristics. These are the indicators of the quality of the product being created, the duration of implementation, the norms for the expenditure of all types of resources, and labor standards. These characteristics can be determined by the developer-technologist with the availability of appropriate software tools and electronic databases. Complex presentation of information about each operation provides undeniable advantages: not only are contradictions and omissions in information chains eliminated, but for the first time there is the opportunity to manage the system of production processes, which is the basis for long-term competitiveness.

At present almost all Russian suppliers of automotive components must certify their quality management systems according to the requirements of ISO / TS 16949-09. Establish a world-class output does not make sense unless it is possible to obtain as much profit as possible in each APQP project.

In the pre-production, miscalculations and omissions that can lead to serious consequences in the production process are unacceptable. Losses must be prevented at the production planning stage. It is necessary not only to eliminate, but also prevent further occurrence and development of losses.

The increase in the profitability of the project for the pre-production and production of auto components is an extremely difficult task for Russian machine builders. Let's analyze the possible economic results of the APQP project, the scheme is presented in Fig.

In the course of determining the market requirements for the product (Stage 1), in general, a detailed analysis of the legislation, the requirements of the prospective consumers, the capabilities of the
competitors, as well as the supplier's ability to meet these requirements should be performed. At stage 2 (design), along with the development of documentation, it is required to manufacture and test prototypes to confirm the achievement of the planned quality requirements. If the designer does not provide them, loss of income is unavoidable, and if unreasonably overestimates - the cost increases. Process development activities are carried out at the 3rd stage of pre-production. It is a mistake to think that this is only a technological design with the formulation of standardized technological maps. When developing processes in the course of technological design at stage 3, it becomes extremely important to lay the least expensive options for technological solutions. At the same time, it is not enough to develop them in the shortest possible time. It is equally important not to allow miscalculations and omissions in the content of operations, the selection of tooling and tools, the assignment of technological parameters, the choice of measuring instruments. Trying to save will lead to the fact that in serial production there will be a lot of problems - both at workplaces and when the products are delivered to the consumer.

The APQP project is aimed at ensuring that in the final pre-production (Stage 4) all works are performed with due quality, especially the installation of equipment, training of personnel, manufacturing or ordering of equipment. Many technologists and production managers are trying to "slip through" this procedure, not wanting to waste time confirming the correctness of the decisions taken. As a result, after the release of the auto component, problems may arise returning to the early stages pre-production.

In Figure 2, in the business project, the preparation of production was planned to receive a stable profit (dotted line), but the problem that arises requires time and financial resources to eliminate its causes [3]. Steps APQP can overlap, go parallel, refine. For example, suppliers, prices, equipment composition can change.

For effective management, you need the most complete information about the requirements for the process and its actual state. It can be concluded that the requirements of the standards are inconsistent in terms of optimizing the cost of the processes in the preparation of production, the complexity of determining planned losses, as well as the need to systematize and regularize the causes of potential losses at each stage of production planning.
Fig. 2. Corollary of errors and omissions in the pre-production

To avoid losses in the early stages of the project is easier and cheaper than eliminating them after detection. For the manager, the profit planned from the project for the release of the new car component can be presented in simplified form as follows:

\[
\text{Profit}_{cc} = \sum_{i=1}^{n} I - (Z_{pp} + PPP) - Z_{z} - (S_{v} + P_{v}) - (Z_{c} + P_{e} + P_{s}), \quad (1.1)
\]

where:
- \( n \) - the number of positions of the supplied auto parts;
- \( I \) - income from the sale of auto components;
- \( Z_{pp} \) - the cost of preparing their production;
- \( PPP \) - losses in this training;
- \( Z_{z} \) - expenses for third-party purchases;
- \( S_{v} \) - the cost of production of auto components;
- \( P_{v} \) - losses in the process of their release;
- \( Z_{s} \) - expenses for their service;
- \( P_{e} \) - losses in the course of their operation;
- \( P_{s} \) - losses from sanctions by the consumer and supervisors [5].

The first condition of profitability is getting the maximum income from selling the car component to consumers. It is ensured by the unmistakable preparation of production in the shortest possible time, by maintaining the world-class quality of the product, by strictly observing the planned schedule of deliveries, by the impeccable organization of the service.

The second condition of profitability is the minimum cost of the product life cycle processes, as each of these processes will be repeated many times.

The third condition of profitability is the minimum of all losses, internal and external, with no sanctions at all. Losses must be prevented at the production planning stage.

Factors affecting the amount of income are mainly concentrated in the first three stages of the APQP process. The omission of any requirement or error in its importance can lead to a decrease in sales, which it is meaningless to search years after the launch of production. It is necessary to exclude the possibility of such errors occurring during the design work.

It is also important to prevent all the factors of profit reduction, classified in Table 1.

Tab. 1. Factors of decrease in profitability in the cycle of APQP-project

| Stage | Decrease in income | Increase in the planned cost of processes | Losses at the stage of manufacturing and delivery |
|-------|--------------------|-------------------------------------------|--------------------------------------------------|
| 1     | omission of the legislative requirement for the auto component; Option of the customer's requirement for the auto component. | - Overestimation of the customer's requirements assessment; - Overstating the evaluation of the capabilities of competitors | - The omission of the legislative requirement for the safety of production; -Improving the legislative requirement for environmental friendliness. |
| 2     | Underestimation of technical requirements for the quality of the auto component | Overestimation of the technical requirements for the quality of the auto component | Errors in the contents of the requirements of the design documentation |
| 3     | - Errors in technical documentation; | -Expanding the requirements for | Errors in: -Technological |
|   | The designation of inadequate measuring instruments | equipment, the qualification of production personnel; |
|---|--------------------------------------------------|----------------------------------------------------|
|   | - Neoptimality of planning;                      | - Non-optimal organizational structure.            |
|   | - Requirements to the quality of equipment;      | - Distribution of duties, authorities, responsibilities. |
| 4 | Poor installation of equipment                   | -                                                 |
| 5 | Undervaluation of current price                   | -                                                 |
|   | -Non performance of requirements to the quality of equipment, personnel qualification; | - Errors in working instructions |

The omission of legislative requirements for the safety and environmental friendliness of production will create the risk of obtaining sanctions from the supervisory authorities. Errors in the contents of design documentation requirements increase the probability of marriage. Errors in the technological documentation, the requirements for the quality of the tooling also lead to the marriage of products, cause a loss of time for correcting the indicated errors. Errors in the distribution of duties, authority, responsibility can cause any of the 7 losses, as well as the loss of time for correcting errors and omissions.

Failure to meet the requirements for tooling quality, staff qualifications, errors in working instructions can lead to losses for repairing defects, alteration. Negligence in the preparation of working instructions will lead to violations of technological discipline, a decrease in quality, and perhaps even injuries to workers.

To increase the efficiency of the enterprise, it is necessary to increase the effectiveness of management and minimize the cost of the process. To ensure minimum cost of the process, it is necessary to minimize labor costs and streamline labor intensity standards, to plan resource consumption, to apply the standard method of cost accounting and to calculate the cost of production. Thus, the cost of the process and the planned costs can be expressed by the following formulas:

\[
\text{Cost}_{\text{process}} = \sum \text{the costs of the plan} + \sum \text{Losses} , \quad (1.2)
\]

where \(\sum\) the costs of the plan - the total costs of the process, rubles;
\(\sum\) Losses - total losses on the process, rubles.

\[
\sum \text{the costs of the plan} = \text{Zupr} + \text{ZZAK} + \text{Zizg} + \text{Zbyt} + \text{Service} + \text{Zutil} , \quad (1.3)
\]

where \(\text{Zupr}\) - management costs, rubles;
\(\text{ZZAK}\) - the cost of obtaining and processing the order, rubles;
\(\text{Zizg}\) - the cost of manufacturing the order, rubles;
\(\text{Zbyt}\) - sales costs, rubles;
\(\text{Service}\) - the cost of maintenance, rubles;
\(\text{Zutil}\) - the cost of recycling, rubles.

For really effective management, which ensures a continuous improvement in the quality of products, the fullest information about both the requirements for the process and its actual state is needed. As a result, a set of requirements for interaction with consumers, the quality of the auto component and its components, and the characteristics of all processes of its life cycle should be developed. Each individual process should receive quantitative indicators of effectiveness and efficiency.
Thus, the complete technological documentation is the basis of enterprise management. For this purpose, a structural diagram of technological information is proposed as the basis of enterprise management (Fig. 3).

Fig. 3 Technological information as the enterprise management basis

In the process of technological design, it is necessary to develop a full range of technologies for the activity of the enterprise associated with the new product and to issue the relevant documents. The volume of work on technological pre-production is increasing many times today. This increases the risk of errors and omissions in the content of different groups of documents. But for this it is necessary to clearly define which documents are created at this or that stage of the APQP project, when exactly the requirements for their creation should be defined. The process of technological design must be strictly regulated.

Traditionally, the main content of technological design seems to be a two-level process: the development of routes and the development of separate operations as part of the routes. When obtaining a standardized set of technical documentation, this was quite enough. However, for the preparation of modern production, which requires additional information, it is necessary to identify additional procedures in the design process related to the preparation of such information. This is the first condition.

The second mandatory condition is that it is necessary to embed technological design in the structure of the APQP process in order to ensure the formation and analysis of each document exactly when it is needed.

As a result, the following scheme of technological design is proposed and schematically shown in Fig. 4:

1) At stage 2 (design of the auto component), reconcile the content of its life cycle and create a documented flow route scheme so as not to leave any process uncontrolled. This scheme is becoming an important tool for coordinating the work of diverse specialists in the APQP team.
2) In the 3rd stage of the APQP process "Process Development" in the cycle of the actual technological design during the procedure for analyzing the causes and consequences of potential defects (FMEA) [1], it is necessary to distinguish not 2, but 3 parts:

a) Routing design. It must be performed with additions to the routing technological map:
- Mandatory line layout (it provides planning of all transport operations);
- Methods for measuring the most important indicators of equipment accuracy.
In addition, the routing technological map also suggests the addition of those operations in which key quality indicators of the auto component are formed in order to automate the preparation of the process flow map as part of the PPAP set [1].
b) The design of technological operations, as usual, involves the definition of a sequence of transitions, but with a mandatory designation of those in which the key quality indicators are directly formed.
The following documents should be attached to the operational technological map:
- Methods for measuring each key quality indicator;
- Techniques for measuring the accuracy of the tooling;
- Technological setup card;
- Operator's manual;
Operational instruction of the operator.
c) The process of designing it has been separately carried out, since the management of quality indicators is carried out precisely in the transition. The modern technologist is obliged not to list the treatment modes, but to determine and rank those control characteristics that affect the values of the key quality indicators. This is a new condition for modern Russian technologists. For each key control characteristic, it is also necessary to indicate a response plan (the way it is regulated to maintain key quality indicators within specified limits). So, the process of technological design should become more transparent.
In the paper, key control characteristics are systematized for regulating the value of a key quality indicator and stabilizing production processes.
To do this, all factors that influence the result of processing in the transition are proposed, divided into 3 groups, as illustrated in Fig. 5.

![Fig.5. Systematization of key control characteristics of technological transitions](image)

**Methods of Definition**

1 group - characteristics that act in long cycles of functioning of the workplace. This is the limiting accuracy of equipment and accessories. Their current values can be identified by diagnosis, and then used to predict the accuracy of processing.
2 group - setup characteristics, for example:
- adjusting size;
- the actual accuracy of the forming tool;
- geometric characteristics of the tool;
- Coolant characteristics.
Some of these characteristics can be determined during the setup process, and some - set by verification of adjustment (after processing and measuring the trial part).
3 group - the factors acting directly in the process of processing (these are cutting forces, temperatures, the intensity of tool's dimensional wear, the coolant supply regime, etc.). Their contribution to the total deviation of the key indicator can be calculated.
Knowing this set of factors, it becomes much easier to plan and regulate the value of the key quality indicator of the auto component by known theoretical dependencies.
The developed documentation must be approved, its content verified. Verification is an affirmation that a document can be used as a criterion that is impossible without the implementation of production. For this purpose, a special document is created - the management plan for the installation part of the auto component.
After analyzing the results of processing the batch, it is possible to identify in the documentation various kinds of errors, or necessary improvements. Only after correction it is permissible to begin official coordination and subsequent approval of the set of documentation.
Procedures for approbation and application of documents are additionally ordered. For this purpose, a separate statistical management plan is developed (Fig. 6).
Technological documents become an effective management tool. Thus, the set of technical documentation becomes more alive, close to the real processes. One of the advantages of the proposed information support is the ability to visually trace the causes of a potential error in the pre-production. As a result, a technique for developing modern technological documentation was proposed. In the framework of this methodology, requirements for modern technological documentation have been developed, factors of profitability decrease in the APQP project cycle have been identified, work has been grouped to provide the best results for the APQP process stages (3, 4, 5 stages), technological information as the basis for enterprise management, developed processes of technological design and application of technical documentation, the scheme of the technological design process is presented. In the paper, the key control characteristics of technological transitions are systematized, the principles of management of the pre-production (technological design) based on technical documentation are formulated.

References

[1] 2005 GOST R 51814.6 - 2005. Quality management systems. Quality management in the planning, development and automotive components pre-production. - 70 p

[2] 2008 GOST R ISO 16949-09 Quality management systems. Special requirements for the application of ISO 9001: 2008 in the automotive industry and organizations that produce the relevant spare parts. - 51 p

[3] Grechishnikov VA, Kasyanov SV, Yurasova OI, Romanov V.B. 2016 Increase of competitiveness of the enterprise at a stage of manufacture auto components pre-production the Bulletin of MGTU "STANKIN" 2 (37)

[4] Kasyanov SV, Yurasova OI 2015 Differential planning of a complex of quantitative indices of production processes of auto components at the stage of technological design Socio-economic and technical systems: research, design, optimization. Publisher: " Kazan (Volga region) Federal University " vol 2 (65) pp 27-32

[5] Yurasova OI, Pautov G.A. 2015 Increase the efficiency of the machine-building enterprise by optimizing the cost of the process Theory and practice of social development 9 pp 53-55