Machine-building organization production using quality management methods

E V Priimak and I S Razina
Kazan National Research Technological University, Russia, Kazan

E-mail: ira-a82@mail.ru

Abstract. Mechanical engineering is the leading industry in the world, which has a significant impact on the level of development of a country. It produces various machines, machine tools, mechanisms, devices. The machine-building sector provides equipment to all other sectors of the economy, so the results of the work of related areas depend on its level of development and product quality. Among the main problems of the sector in Russia are high depreciation of fixed assets and low level of innovation. As a result, the low competitiveness of domestic machine-building products in the world market. Competitive advantages can be achieved primarily by improving the quality of manufactured products. Prompt solution of problems related to product quality is achieved by implementing various methods aimed at preventing the appearance of defects. The study presents an algorithm for the development and implementation of the 8D methodology in order to prevent the recurrence of product defects at the enterprise of AktanyshskyAggregate Plant. With the help of simple tools that underlie the 8D methodology, the causes of the defect were identified and corrective and preventive measures were proposed.

1. Introduction
Machine-building production is one of the most important industries from the point of view of the Russian economy: it accounts for about 20% of all industrial production in Russia and 1/3 of industrial employment. Machine-building plants in Russia produce a wide range of products, the range of manufactured products is counted in hundreds of positions. However, this sector of the Russian economy has a weak export potential. In the marketable structure of Russian exports, the share of «machinery, equipment» is less than 3%. At the same time, in the structure of imports, the same marketable group accounts for more than 40%. Among the main problems of the sector in the conditions of modern realities in Russia, there is a high depreciation of fixed assets and a low level of innovation. As a result, the low competitiveness of domestic machine-building products in the world market.

First of all, competitive advantages can be achieved by improving the quality of manufactured products. Prompt solution of problems related to product quality is achieved by implementing various methods aimed at preventing the appearance of defects. [1-3]. The list of such methods is quite diverse. In mechanical engineering, and in particular in the automotive industry, the 8D method is often used to solve quality problems [4,5]. The 8D technique means an eight-step approach to problem solving. Actions D1–D4 are aimed at identifying the nature of problems and determining the causes of their occurrence, and actions D5–D8 are aimed at developing and implementing corrective and preventive actions (figure 1).
The study presents an algorithm for the development and implementation of the 8D methodology in order to prevent the recurrence of product defects at the enterprise of Aktanyshsky Aggregate Plant. The main activity of Aktanyshsky Aggregate Plant, located in the Republic of Tatarstan, is the production of parts of any complexity according to samples or drawings of the customer, as well as the provision of services for metal machining (in particular, turning, milling). In 2006, the company signed an agreement with KAMAZ for the production of components. As a supplier to the automotive industry Aktanyshsky Aggregate Plant must manage the risks of producing non-conforming products. Preventive and corrective actions should be carried out in accordance with methodology 8D [6].

2. The main part
As the object of research, the balancing axis bracket for the rear suspension of the KAMAZ car was selected (figure 2a). The rear suspension of trucks has a balancing device with a single axle pressed into the bracket. The balance suspension ensures the stability of the car, that is, it prevents strong tilts. During the inspection of the finished product, the quality control department controller (QCD) revealed such a discrepancy as a gas shell in the casting of the bracket, which can cause a decrease in the quality and safety of the product (figure 2b).

Figure 1. The sequence of the 8D method.

| D0 | making a decision to start the procedure according to the 8D method |
| D1 | forming a team to solve a problem |
| D2 | defining the essence of the problem |
| D3 | elaboration of temporary / urgent deterrent actions |
| D4 | determining the cause of the problem |
| D5 | identification of long-term corrective actions and their verification |
| D6 | implementing long-term corrective actions |
| D7 | warning actions |
| D8 | summing up |

Figure 2. a) Balancer axis bracket; b) Enlarged fragment of the casting of the balancing axis bracket with a gas shell.
In steps D1–D4, detailed information about the defect is collected. The input document is the defect controller's report. For this purpose the «5W+1H» method was used, where you can find answers to such questions as «who, what, where, when, why and how». A detailed description of the method is given in the figure 3.

|Who?  | • Who discovered the problem first?  
|      | • QCD Controller  
|      | • Who is responsible for what happened?  
|      | • Quality Assurance Department  
|      | • Who does the problem concern?  
|      | • Finished product  |
|What? | • What happened?  
|      | • A defect was detected in the casting of the balancing axis bracket  
|      | • What type of problem?  
|      | • Gas shell  
|      | • What happens if the problem persists?  
|      | • Infringement of the leakproofness of the connections  |
|Where?| • Where is the problem detected?  
|      | • After manufacturing (on final inspection)  
|      | • Where did the problem occur?  
|      | • At the stages of the production process  |
|When? | • When was the problem first discovered?  
|      | • Detected by QCD controller  |
|Why?  | • Why is there a problem?  
|      | • Foundry defect (operator's mistake; equipment breakdown)  
|      | • Why wasn't the problem detected earlier?  
|      | • The control over the finished products was not strict enough  
|      | • Why didn't you try to solve the problem earlier?  
|      | • As soon as the defect was detected, the 8D process was started  |
|How?  | • How was the problem recognized?  
|      | • The presence of a defect in the form of a gas shell in the casting was confirmed by inspection through a magnifying glass  
|      | • How does it affect the work of the enterprise?  
|      | • The defective product could get to the consumer  
|      | • If this is a long-standing problem, how has it been dealt with in other cases?  
|      | • Identified for the first time  |

**Figure 3.** Description of the «5W+1H» method.
As a result, it was found that gas shells with a pore diameter of up to 16 mm were found near the surface of the casting, which can lead to a infringement of the leakproofness of the connections. Therefore, as part of the next stage, it is necessary to introduce short-term measures that immediately protect the consumer from the supply of defective products. This can be a 100% inspection of the finished part in order to detect non-compliance in a timely manner. The control consists of an external inspection and an instrumental measurement. The results are entered in the operational measurement sheet.

Deterrent actions are performed until the root cause of the problem is identified and resolved. Variables such as the human factor, equipment, materials, and process conditions were considered. After analyzing the identified causes, those that may be the main cause were identified (Table 1).

| The main reason | Root cause |
|----------------|------------|
| Methods        | Low temperature of the poured metal |
| Personnel      | Non-compliance with modes, instructions, established procedures |
| Working conditions | Non-compliant workplace |
| Technology     | Infringement of steelmaking technology |
|                 | Incorrect choice of product processing methods |
| Materials      | High gas content in the cast workpiece composition; |
|                 | No ventilation system in the molding mixture; |
|                 | Gas tightness of the molding mixture |
| Equipment      | Damaged appliances; |
|                 | Equipment wear and tear |

3. Conclusions
Based on the results of stages D1-D4, the mechanism of the defect occurrence was analyzed and consistently shows how the root cause develops into a specific defect. It was revealed that molds and rods without ventilation channels were used in the manufacture of casting molds (the root cause). Intensive gasification of the combustible components of the mold and rod begins when pouring metal. Excessive gas pressure is created in the mold and rod. It was revealed that the reduction of the gas pressure in the mold was not provided. The total pressure of the gases from the rod and the mold was greater than the pressure of the metal-static head. As a result, a gas shell was formed in the metal (defect). Also, a refrigerator with an oxidized surface was used to cool the casting. Oxides decomposing, form a gas when the melt comes into contact with such a surface. Gas shells appear in the solidifying metal of the casting.

To avoid the appearance of a defect at stages D5-D8, it is necessary to develop long-term corrective measures (for example, 100% control, revision of all relevant documents, equipment audit, additional control of the product after molding and training of production personnel) and, having determined their effectiveness, develop preventive measures.

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