

Parameters and methods of assessing the quality of metal-cutting equipment of machine-building enterprises

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Abstract. Assessment of the quality of technological equipment is an important aspect for enterprises engaged in the repair of machines. In this article, we have reviewed the main parameters and methods of quality assessment, as well as the methodology for determining total operating costs, taking into account losses from defects. One of the key parameters affecting the quality of technological equipment is the accuracy of its operation. Accuracy is assessed using various methods, such as error measurement, statistical analysis of data and comparison of results with requirements and standards. However, when assessing quality, it is necessary to take into account not only accuracy, but also operating costs. The costs of maintenance, repairs and spare parts can significantly affect the total cost of operating the equipment. Another important aspect is the dissolution of marriage. Therefore, in the methodology for determining the total operating costs, it is necessary to take into account the losses from marriage. It is also recommended to train the personnel working with the equipment so that they can use it most efficiently and safely. As a result, assessing the quality of technological equipment and determining the total costs of its operation are important tasks for companies engaged in machine repair.

1 Introduction

Maintenance, as an activity related to the repair of aftermarket machines, entails an increase in the number of consumer complaints [1] due to the poor quality of a number of processes, especially those related to the machining of parts, where a defect occurs due to the use of worn-out equipment. These deviations also occur due to the wear and tear of the repair fund, technological equipment, personnel qualifications and the low efficiency of using the quality management system in accordance with the requirements of ISO 9000 standards [2]. Poor control organization leads to an increase in quality costs [3], especially in the form of alterations and warranty repairs, as well as control costs [4], including repeated. In the light of the above problems, the technical service should take measures to improve the quality of its activities and meet the needs of customers. One of the solutions may be the modernization

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of equipment and technological equipment in order to eliminate the causes of defects due to wear. This will increase the accuracy of machining parts and reduce the number of defects.

In addition, it is necessary to pay attention to the training and retraining of personnel. Regular trainings and professional development will help employees to master new techniques and methods of work, which will increase their professional competence and reduce the likelihood of mistakes. An internal quality control system should also be established to monitor and eliminate emerging problems at an early stage.

However, improving the quality of maintenance is necessary not only to meet customer needs, but also to reduce costs. Alterations and warranty repairs are additional costs that can be avoided if the work is done correctly from the very beginning. Quality control also plays an important role in reducing costs. Repeated checks and bug fixes require additional resources and time, which affects the efficiency of the service.

In addition to internal measures, the technical service can also improve interaction with suppliers and customers. Establishing partnerships with reliable suppliers of parts and components will help ensure constant access to high-quality materials. In addition, it is important to take into account the opinions and wishes of customers in order to meet their needs and provide a high level of service.

As a result of the implementation of these measures, the technical service will be able to improve the quality of its work, meet the needs of customers and reduce the cost of alterations and control. In addition, it will strengthen the company's reputation and attract new customers. Ultimately, the constant pursuit of quality improvement is a key factor in the success of maintenance in the secondary market.

2 Theoretical position

The worn-out equipment of repair enterprises does not provide the specified tolerances and deviations, if the processing is carried out under the repair size, because of this, internal losses grow, in the form of the number of defective parts [5]. The number of equipment failures at the consumer is also increasing, which is expressed in the form of external costs from defects at the enterprise [6, 7]. Currently, technological equipment for the repair of parts is selected and evaluated according to the following main criteria [8, 9]:

- 1) cost;
- 2) performance;
- 3) operating costs;
- 4) accuracy.

The existing problem with the worn-out equipment of repair enterprises has serious consequences for production. Insufficient compliance with the specified tolerances and deviations leads to an increase in internal losses in the form of defective parts. This not only increases production costs, but also affects the quality of the final product [10].

An increase in the number of equipment failures at the consumer also has a negative impact on the enterprise. The external costs associated with marriage become significant, which leads to an increase in costs and a decrease in the company's profit.

To solve this problem, it is necessary to reconsider the approach to the selection and evaluation of technological equipment for the repair of parts. Instead of focusing only on cost and performance, other important criteria should be taken into account.

Operating costs are one of the key factors to consider when choosing equipment. They include the costs of maintenance, repair and replacement of parts. If the equipment requires constant maintenance or has a high cost of spare parts, then its operating costs will be significantly higher.

Accuracy is also an important criterion when choosing equipment. If this does not provide the necessary accuracy when processing parts, then this may lead to additional costs for error correction and re-processing.

However, in addition to these basic criteria, other factors should be taken into account, such as the reliability of the equipment, its compatibility with other production processes, the availability of trained personnel to work with this equipment and the possibility of its modernization in the future.

The introduction of new technological equipment that meets all the necessary criteria will reduce the number of defective parts and improve the quality of the final product. This will lead to a reduction in internal losses and an increase in the company's profits. In addition, reducing the number of equipment failures at the consumer will reduce external costs and improve the reputation of the company.

As a result, the correct selection and evaluation of technological equipment for the repair of parts is crucial for the effective functioning of repair enterprises. This will reduce costs, improve product quality and increase the competitiveness of the company in the market.

The first three criteria are economic, and accuracy is technical, so their relationship is a serious problem that has not yet been solved. Our task is to show that accuracy is also an economic criterion and, in its economic essence, is no less important than cost, productivity and operating costs. It is known that violation of accuracy standards during the final processing of new or repaired parts leads to the appearance of a correctable and irremediable defect. The problem of mutual linking of economic and technical criteria of accuracy is a long-standing and relevant for many industries. It is important to understand that accuracy plays a crucial role in the efficiency and reliability of production processes, as well as in the final quality of products. Therefore, the desire for high accuracy should be recognized as a key economic factor.

One of the main reasons why accuracy is an economic criterion is the relationship between accuracy and reducing the cost of correcting defects. Violation of accuracy standards during the final processing of parts can lead to the appearance of defects, both correctable and irremediable. A correctable defect requires additional resources and time to eliminate it, which negatively affects the productivity and costs of the enterprise. An incorrigible marriage, in turn, leads to a complete loss of resources spent on the production of parts, which also negatively affects the economic performance of the enterprise.

Moreover, accuracy affects the durability and reliability of products. High precision machining of parts allows you to create more reliable and durable products, which reduces the risk of problems during operation and increases customer satisfaction. The quality of products directly affects the reputation of the company, its competitiveness and market demand. Thus, accuracy can be considered as an economic factor that affects the long-term profitability and sustainability of the enterprise.

However, in order for accuracy to be a full-fledged economic criterion, it is necessary to develop and implement appropriate control and measurement methods. The technical component of accuracy plays an important role in determining the required standards and norms, as well as in the development of methods for processing parts. Only a joint effort of economic and technical specialists will achieve an optimal balance between accuracy and cost.

Accuracy is indeed an economic criterion, no less important than economic factors such as the cost of production, cost reduction and efficiency improvement. The mutual alignment of economic and technical criteria of accuracy requires attention and further research to ensure optimal product quality and stability of the enterprise in the market.

When evaluating the effectiveness of equipment, as a rule, a complex method is used with the use of an integral quality indicator. The integral indicator is the ratio of the beneficial effect of the operation of the product in natural units to the total costs of its production and

operation or consumption. In other words, the integral indicator expresses the economic effect of the use of products received for 1 ruble of costs. And in this situation, it is necessary to remember that the losses arising from a correctable and incorrigible marriage must be taken into account. When evaluating the effectiveness of equipment using an integrated method and an integral quality indicator, it is necessary to take into account not only the beneficial effect of the operation of the product, but also the costs of its production and operation or consumption. The integral indicator is a key factor that expresses the economic effect of the use of products for each ruble spent.

However, in addition to the total costs, it is also important to take into account the losses arising from a correctable and incorrigible marriage. A fixable defect refers to defects that can be fixed by repairing or replacing components, while an incorrigible defect is a defect that cannot be fixed.

Losses from a correctable defect can be accounted for by estimating the cost of repairing or replacing components, as well as the time spent on these processes. This will determine how efficiently the equipment can be restored and used again, as well as estimate the potential repair costs.

However, an incorrigible marriage presents a greater challenge. If the equipment becomes unsuitable for further use due to incorrigible defects, it is necessary to make a decision on its replacement. This may require additional costs for the purchase of new equipment, as well as for its installation and integration into the production process.

When evaluating the effectiveness of equipment, it is necessary to take into account both the costs of its acquisition and operation, as well as losses from a correctable and incorrigible defect. This is the only way to get a more complete picture of how effectively the equipment performs its functions and brings economic benefits.

In addition, it is important to constantly monitor the condition of the equipment and carry out regular maintenance in order to minimize the occurrence of defects and maximize its service life. Such measures will help to improve the integral quality indicator and ensure more efficient use of equipment in the long term.

In order to analyze the quality indicators and economic indicators of the equipment, it is necessary to summarize the costs associated with the creation of products on this equipment, and the losses that arise during the creation of these products due to deviations of the technological process from the established standards of product quality. The analysis of quality indicators and economic indicators of equipment is an important stage in assessing the effectiveness of its use. To do this, it is necessary to take into account all the costs associated with the creation of products on this equipment, as well as losses arising from deviations in the technological process from the established standards of product quality.

One of the key aspects of the analysis is to determine the costs of equipment and its operation. This includes the cost of purchasing, installing and configuring equipment, as well as the costs of its maintenance, repair and replacement of worn parts. It is important to take into account all these factors in order to get a complete picture of equipment costs.

Various methods and tools can be used for more accurate analysis. For example, statistical quality control methods allow us to assess the level of deviations and their impact on production processes. It is also possible to apply methods of economic analysis, such as calculating the cost of marriage and its impact on the overall profitability of production.

It is important to note that the analysis of quality indicators and economic indicators of equipment should be a regular process. This will allow you to identify problems in a timely manner and take measures to eliminate them. In addition, the analysis will allow you to determine the efficiency of the use of equipment and make decisions about its modernization or replacement.

As a result, the analysis of quality indicators and economic indicators of equipment is an important tool for optimizing production processes. It allows you to identify problem areas

and take measures to improve the quality of products and the efficiency of equipment use. Such an analysis helps to prevent losses and increase the competitiveness of the enterprise in the market.

When evaluating any equipment and the process performed by it, it is most convenient to use indicators of manufacturability, such as the material intensity of equipment, energy intensity, labor intensity, material intensity of the technological process (material consumption during this technological operation), which are generally called resource intensity indicators. Any resources in the process of creating products from them or using them transfer their value to the products. Therefore, each resource has its own pricing. Processability indicators play an important role in the evaluation of equipment and processes, because they allow you to assess the efficiency of resource use. One of these indicators is the material intensity of the equipment, which determines how many materials are required for its operation. The fewer materials required, the more technologically advanced the equipment is considered.

Another important indicator is energy intensity, which determines the amount of energy required to complete the process. Modern technologies strive to reduce energy intensity, as this helps to reduce energy costs and reduce the negative impact on the environment.

Labor intensity also plays a role in the assessment of manufacturability. The less labor required to complete the process, the more effective it is considered. Automation and the use of modern technologies can significantly reduce labor intensity and increase productivity.

Another indicator of resource intensity is the material intensity of the technological process. It determines how many materials are required to perform a certain technological operation. Optimization of this indicator makes it possible to reduce material consumption and improve the economic efficiency of the process.

It is important to note that any resources used in the production process transfer their value to the products. Each resource has its own pricing, which is taken into account when calculating the cost of products. Therefore, optimization of resource intensity indicators is an important task for enterprises.

Modern technologies and methods make it possible to achieve a significant reduction in resource intensity. For example, the use of new materials with higher productivity or the development of more efficient production processes can significantly reduce the consumption of materials and energy.

In addition, it is important to take into account environmental aspects when assessing manufacturability. Many companies strive to reduce the negative impact on the environment, so the development of environmentally friendly technologies and processes is becoming an increasingly urgent task.

In general, the use of resource intensity indicators in the evaluation of equipment and processes makes it possible to optimize the use of resources, reduce costs and increase production efficiency. This is an important aspect for enterprises striving for economic efficiency and sustainable development.

Thus, unit costs, from the point of view of quality assessment, can be represented as the product of the resource intensity indicator at its own price, and all this is calculated per unit of useful effect – products.

When creating products, losses invariably appear – a correctable or incorrigible marriage. To assess these losses, we introduced such an indicator as the probability of losses from a correctable and incorrigible marriage. Unit losses, as well as unit costs, are conveniently represented in the form of the product of the probability of losses and the cost of the type of losses per unit of production. It is important to note that unit costs and losses play a key role in assessing production efficiency. They allow us to determine how efficiently resources are used and what losses occur in the production process.

Total unit costs are the sum of unit costs related to quality and unit losses as a result of correctable and incorrigible defects.

In general, the total unit costs per unit of production will look like this

$$C_k = \prod_{i=1}^x k_i \cdot \sum_{i=1}^n P_i \cdot p_i \cdot \prod_{j=1}^z k_{ij} + \prod_{i=1}^u k_i \cdot \sum_{i=1}^m c_i \cdot p_{di} \cdot \prod_{j=1}^y k_{ij}, \quad (1)$$

where C_k – is the total unit cost of quality per unit of production; P_i – is the price of the i -th resource used; p_i – is the resource intensity of the i -th resource; z – is the number of coefficients; k_{ij} – is the corrective j -th coefficient using of the i -th resource or taking into account additional costs (losses); c_i – the cost of the i -th type of losses from one defective product; p_{di} – the probability of occurrence of losses of the i -th type; k_i – the coefficient of accounting for additional costs, accruals, losses, etc. economic factors that do not directly affect costs and losses, but increase these costs or losses when considering the site, workshop, enterprise as a whole; x, u – the number of coefficients for adjusting costs and losses; n, m – the number of types of costs and losses.

Formula (1) allows us to identify the impact of each indicator of resource intensity – material intensity, labor intensity, energy intensity of work, as well as prices for these resources on the level of equipment quality. Moreover, the probability of losses multiplied by the cost of marriage is also taken into account here.

It is important to note that the marriage may have a different cost depending on the type of defect and the processing process. For example, when machining shafts, the part may deviate from the tolerance on the left side, which will lead to an incorrigible marriage. In this case, we lose the whole part, which is a significant loss for production. On the other hand, if the part deviates from the tolerance on the right side, it may be a correctable defect. In this case, the employee carries out repeated processing, and the losses will be insignificant. However, even a correctable defect affects the rhythm of production, since additional time and resources are required to correct the error.

Formula (1) takes into account both the cost of marriage and the probability of its occurrence. This allows companies to more accurately assess the impact of resource intensity on the quality of equipment and take appropriate measures to improve production processes. For example, if a certain type of processing often leads to an incorrigible marriage, the company may consider changing the technology or training employees to reduce the likelihood of errors.

3 Rresearch results

Moreover, formula (1) can be used to optimize resource costs. By analyzing the impact of each resource intensity indicator on the quality of equipment, companies can determine the optimal prices for resources. For example, if an increase in the prices of materials leads to a decrease in the probability of a defect, then the company may decide to increase the cost of materials in order to improve the quality of equipment and reduce losses from defects.

The integration of formula (1) into production processes allows companies to manage resource intensity more effectively and improve the quality of their products. By analyzing the impact of various indicators and the cost of marriage, companies can make informed decisions aimed at optimizing production processes and reducing losses. This helps to increase the competitiveness of the company in the market and meet the needs of customers for quality products.

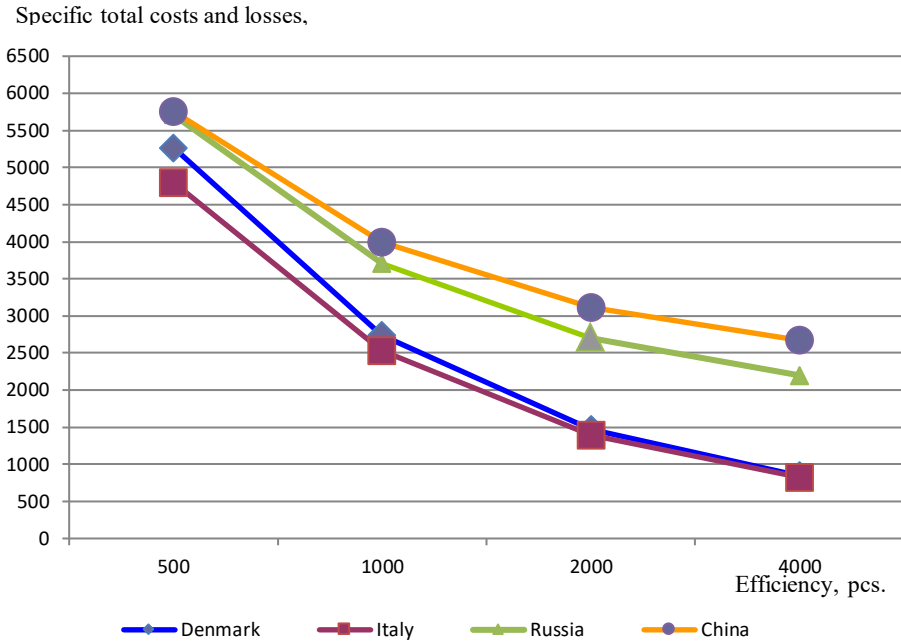


Fig. 1. The cost of processing crankshafts according to repair dimensions, taking into account losses from defects on machines of various brands.

With the increase in the production program, the total costs decrease, which is an important factor in making decisions about the purchase of equipment. However, when evaluating machines taking into account losses from defects, it becomes clear that the lowest costs arise when using more expensive and accurate machines.

The calculation results show that the purchase of cheaper technological equipment by the enterprise with low accuracy leads to a significant increase in losses from correctable and incorrigible defects. This is due to the fact that insufficient accuracy of the equipment can lead to errors in the processing of crankshafts, which, in turn, increases the number of defective parts.

On the contrary, the purchase of expensive high-precision equipment reduces the number of manufacturing defects. More precise machines provide better processing of crankshafts, which leads to a reduction in the number of defective parts. However, it should be borne in mind that the share of equipment wear in total costs is much higher when using expensive machines.

4 Conclusions

Thus, when choosing equipment for processing crankshafts according to repair dimensions, it is necessary to take into account both the cost of the equipment and its accuracy. If a company strives to reduce the number of manufacturing defects and is willing to go to great expense to purchase high-precision equipment, this may be beneficial in the long run. However, if the company is focused on minimizing costs and is willing to accept the risk of increasing the number of defects, then choosing cheaper equipment may be preferable.

The decision on the choice of equipment should be made on the basis of an analysis of the balance between cost, accuracy and losses from defects. The company must take into

account its business priorities, financial capabilities and development strategy in order to make the optimal decision that will ensure a balance between product quality and production costs.

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