Data in quality management in the restoration of automotive parts. The case of cylinder head repair.

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Abstract: *This study presents the possibility of collecting data in a specialized auto repair company with the aim of building and maintaining high quality of repaired products. The reasons for collecting data, what and how much should be collected are discussed, with examples presented in the repair of cylinder heads. The options for analyzing the obtained results using the methods of mathematical statistics are also shown.*

Keywords: *quality management, cylinder heads*

1. INTRODUCTION

In modern repair production, the range of restored parts and assemblies is extremely large, which necessitates the creation of specialized enterprises. The subject specialization of these enterprises allows for the establishment of a quality management system based on international standards from the ISO 9001 series, which allows for the maintenance of consistently high quality of the repaired products. Building a quality management system requires a lot of data to determine the quality of the product. Mass production is the repeated repetition of the same technological process. If production conditions are always repeated exactly, the products will have the same quality characteristics. In repair production, the same or similar technological processes are used, but applied to many different parts and surfaces. Unlike mass production, in which new parts, assemblies and machines are manufactured, in repair production parts, assemblies and machines with expired life are subjected to various technological impacts to restore their optimal reliability. In this sense, repair production is part of the circular economy and allows for a more economical and environmentally friendly use of resources. Repair production is inherently related to mass production, since some of the parts that are replaced during machine repair are produced in mass production conditions, and the quality of the restored product depends on the quality of their production. The variations that occur during the restoration of products, and in particular the case of the repair of cylinder heads from internal combustion engines, are associated with:

- Inconsistency of the quality characteristics of the materials, tools and consumables used in surface treatment;
- Production inaccuracies — disruption of the technological process by contractors or deviations caused by working methods;
- Variability of the characteristics of machines and tooling, e.g. change in the condition of the oil in hydraulic systems, wear of the cutting edges of tools;
- Variations in measurements caused by low qualifications, inattention of personnel or inaccuracies in processing and measurement methods.

Of great importance for the quality of the final product is the consistency of the quality indicators of the raw materials and semi-finished products used - materials for valve seats, repair valves, valve seals, valve guides, surface treatment tools.

Another source of variation is manufacturing inaccuracies. They often arise at different stages of the production process. Serious deviations from the specified quality indicators can occur due to incorrect installation of the replaced elements forming a press connection, e.g. valve seats, valve guide. These deviations depend not only on the quality of the spare parts used, but also on the skills and discipline of the production staff.

The variability of the characteristics of machines and tooling has a significant impact on the quality of the restored surfaces. For example, when the cutting edge of the tool machining the valve seats wears out, the machined conical surface becomes wavy, which consequently leads to gas leakage between the valve and its seat. This defect is unacceptable, as it reduces the power performance of the internal combustion engine.

Variations in measurements also affect the quality of rebuilt cylinder heads. For example, when measuring the wear of valve guides, if the measured values are incorrect, this will lead to increased fuel and oil consumption during engine operation.

The purpose of this study is to clarify why data is collected, what its purpose is, what quantity is needed, what data is needed, how to analyze it, and how to record it in a quality management system in the diagnosis and repair of internal combustion engine cylinder heads.

2. RESULTS

Data and why it is needed is a question that employees ask themselves when they have to collect it. Improving the quality of production comes down to reducing the variations in its basic characteristics. This is only possible to achieve when the reasons causing deviations from the predefined quality parameters are discovered.

One of the main tasks of the quality specialist is to diagnose the repair facility's work process by applying observation and research methods to identify the main possible causes of deterioration in the quality of repaired products. There are many reasons for quality deterioration in repair production, and the ones described so far are only a small part of all the possible ones. It is necessary to detect and eliminate the most important ones, which, however, is based on the experience of specialists. Often, however, it is severely limited by the place it occupies in the repair production hierarchy and the restrictions imposed are too great. Moreover, such decisions depend on the training of specialists, their personal qualities and their mentality. Therefore, it is not uncommon for the causes of the same defect to be considered by different specialists to be different. Disputes are resolved when the analysis is based on facts and strict numerical and functional dependencies, rather than on abstract ideas and hunches. The facts are expressed through numbers obtained from monitoring the production process, with the obtained numerical results revealing dependencies and trends that can be useful in improving the quality of the production process and technological culture.

Statistical methods for analyzing production quality allow information to be extracted about the state of the technological process and, based on it, decisions to improve it. Together with the measurement tools and methods, problems are diagnosed, the causes of defects are analyzed, and the quality of production is improved.

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Data collection is not an end in itself. It is needed to make decisions about influencing the process in order to improve it. The latter can be done in different ways. For example, the data needed to decide whether defective production exceeds a certain percentage is not the same as that needed to clarify the causes of a given type of defect. That is why when collecting them, the purpose for which they are collected and used must always be kept in mind. Main objectives of data collection from the production process:

1. Evaluating the state of the process — in this case, data is needed that allows conclusions to be drawn about the percentage of defective products in a given batch, the deviation of a given quality indicator from its set value, and the dispersion of values around it.

2. Analysis of the causes of defects. For this purpose, data is needed that reveals the relationship between defects and possible causes. For example, comparing the work results of two or more workers can reveal the difference in qualification or discipline, which is decisive for repair production.

3. Monitoring and management of the production process — if the quality indicators of the repaired production are tracked over time, information is obtained that shows whether the state of the process is satisfactory and whether there is a trend for quality deterioration. If it is violated or even just when such a danger is noticed, measures can be taken to prevent scrapping. They are usually prescribed in advance, and if not, they are reported to management.

4. Acceptance or rejection of repaired production — clearly defined indicators are needed to determine whether the repaired product should be accepted or rejected.

When collecting data, the question arises, "How much data is needed?" The amount of data should allow the actual state in the production system to be revealed. In the presence of randomly acting factors, of which there are many in production, this cannot be achieved with single observations alone. A systematic approach based on strict statistical laws is needed. In statistics, it is accepted that all theoretically possible observations of a given phenomenon form a general set of observations. For example, when machining the valve seats of the cylinder heads, the thermal clearance of the valves is reduced, and in engines with hydraulic adjustment it is economically unprofitable to measure for each valve when the wear and machining are within one size. In this case, the thermal clearance of only one valve in the cylinder head is checked. This method of observation is performed on only a portion of the elements of the general population, which constitutes a sample statistical control.

To obtain sufficiently accurate conclusions, it is desirable for the sample to contain as many observations as possible, which is associated with the expenditure of time and money. For this reason, the number of measurements is determined by a compromise between accuracy and the time spent obtaining the data. In the case of the thermal clearance of automatically adjusted valves, its size is checked at only one of eight possible, which is 12,5%, which is the minimum possible. The desired level of accuracy depends on the objectives of the study. Sometimes it is sufficient to have a rough initial assessment of a process to decide whether a more in-depth study is necessary. Then lower accuracy can be tolerated. However, if decisions are to be made based on the study to improve the process, it is necessary to achieve higher accuracy, and this requires more observations. In the presented example with the thermal clearances of the valves, if it is determined that the measured clearance is close to or has exceeded the limit value, then a 100% control of the thermal clearances of the valves from the cylinder head is performed. This 100% control is applied in particularly responsible cases where rejection and defects are unacceptable.

The quality of the collected data is of utmost importance for performing adequate statistical analysis, without which the system would not be able to improve. And here the question arises: "What data is needed?" The first requirement for any sample is that it be representative - that it correctly reflect the actual facts. If the analyses of the properties of a given product differ significantly when performed by different operators, there is reason to believe that their observations do not form a correct sample. The reasons may be different: negligence, difference in qualifications, use of inappropriate or inaccurate measuring devices.

The measured quantities are continuous and discrete. Continuous quantities can take values in a certain continuous interval – temperature, pressure, length. Discrete quantities take one of many countable values – number of defects.

The success of researching the quality of refurbished products depends heavily on the ability to decide what kind of data will best illustrate the facts.

When collecting data, the question arises: "How to record it?" The secret to proper research does not lie in recording all the circumstances under which the data was collected - time, place, performers of the technological process and measurements, the measurement methods and measuring instruments used, machines and equipment used in the repair and production processes. If data is collected over a longer period, it should be arranged in the order in which it was collected, noting the time of its reporting. The practice of mechanical engineering production has shown that data is most easily recorded in tabular form, which also facilitates the ultimate goal of data collection, namely their analysis.

There are a large number of statistical methods for data analysis, the most widespread due to their simplicity are the following methods:

- Checklists — checklists are tables that allow data to be collected and analyzed easily by relatively unskilled personnel. Very often, the success of the analysis is predetermined by good checklists.

- Histograms — histograms are diagrams that are constructed based on a finite number of data, giving an idea of the nature of the distribution of the dispersion of the values of a given quality indicator.

- Pareto charts — these charts allow identification of the most significant causes of deterioration in production quality.

- Scatter plots — they are simple graphical tools for discovering relationships between random variables. They can be used to study the influence of a given factor on a given quality indicator, as well as the statistical relationship between two quality indicators or two factors.

- Control charts — make it possible to monitor the current status of a given quality indicator during the production process, detect trends leading to the occurrence of scrap, and take timely organizational measures to improve production activity.

- Stratification — stratification of data allows clarification of the actual facts, as the conclusions from the analysis may be inaccurate or false if the data is collected from several objects of the same type — machines, workers, etc.

3. CONCLUSIONS

Data collection during the production and repair technological process is of utmost importance for improving the quality of the manufactured or repaired products. The quantity and adequacy of data can improve production processes, which in turn can improve the financial condition of the production system. Identifying the problems and causes of defective production is the first prerequisite for building and developing a quality management system based on international standards. The case of diagnostics and repair is indicative in that specialized repair enterprises can also build a quality management system based on the collection and analysis of data from production processes.

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