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Application of Six Sigma methodology for process design quality improvement

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Abstract: This paper deals with application of Six Sigma methodology in process design. Using an example of compressor-housing machining process design and development at the Cimos facility in Buzet the possibilities for some Six Sigma tools applications are explained. The primary tools are the process map and the cause and effect matrix. A modified process design flow with incorporate applications of the mentioned tools is shown, a comparison of the old and the modified process design flow is made and the obtained results are discussed.

Keywords: Cause-and-effect matrix; Process-Design; Process map; Six Sigma

1. INTRODUCTION

Six Sigma is a quality improvement program that aims to reduce the number of defects to as low as 3.4 parts per million [1]. Six Sigma emphasizes an intelligent blending of the wisdom of an organization with proven statistical tools to improve both the efficiency and effectiveness of the organization when it comes to meeting customer needs [2]. Six Sigma projects of continuous process improvement are led, from concept to completion, through five project-management steps or phases named DMAIC (Define, Measure, Analyze, Improve, Control).

2. PROCESS DESIGN AND DEVELOPMENT

The process design and development will be explained using the example of compressor housing. The castings are made in Cimos foundry Roč from aluminium alloy. All the machining is done in Cimos facility in Buzet, Croatia.

At the Cimos facility in Buzet there are five basic steps in process design and development [3]:

- Process feasibility study,
- Process planning,
- Process preparation,

- Trial production, and
- Process qualification.

The processes with a major influence on product quality have to be identified. Therefore, in process planning it is necessary to recognize and establish relevant quality requirements. To do so it is necessary to determine:

- A process developments plan for new and modified products, along with comprehensive documented production steps and material flow.
- The production equipment and working environment.
- Maintenance and preventive maintenance for the equipment and working environment to ensure availability of the production system.
- The procedures and methods for process quality assurance.
- That the operation is in accordance with production rules and standards, lows, defined responsibilities, quality management (QM) plans, as well as customer quality requirements.
- The monitoring and documenting of all process parameters and product characteristics, available to all competent services and departments.
- The approval for processes and equipment from all the responsible persons.

In the process planning stage Failure mode and effect analysis (FMEA) method is widely used. The process FMEA-method has great influence and significance on process preparation because outputs from the FMEA-analysis are used to determine which failures are likely to appear and what corrective actions are necessary for failure prevention.

In order to have efficient process design and development some additional tools and methods should be used in the process-planning phase. These tools can be derived from Six Sigma methodology.

3. SIX SIGMA METHODS IN PROCESS DESIGN

In the process-planning phase the FMEA-method is widely used. The problem that emerged with the application of FMEA-method is the large number of KPIV (Key Process Input Variables), which do not have a significant influence or have no influence on KPOV (Key Process Output Variables).

To have faster and more effective process design and development in the process planning stage it is necessary to apply Six Sigma tools and methods with which the number of KPIV can be reduced to minimum, or to those variables which have major influence on KPOV. For the selected example, applications of process map and cause-and-effect matrix are proposed.

3.1. Process map

A process map is a graphical representation of a process flow that identifies the steps of the process, the input and output variables of a process and the opportunities for improvements. Every process map should be result of teamwork, because it is impossible that just one person could have all the knowledge about the process.

3.2. Cause-and-Effect Matrix

A cause-and-effect matrix relates the key inputs to the key outputs using a process map and a cause-and-effect diagram as the primary sources of the input information. The key outputs are rated according to their importance, while the key inputs are scored in terms of their relationship to key outputs [4]. A factor of importance for each parameter is rank ordered and every listed input parameter is correlated to every output parameter. Finally, a total value for each parameter is obtained by multiplying the rating of importance with value given to parameters and adding across for each parameter.

To be very certain about the level of a parameter's importance an additional Pareto analysis will be applied. The Pareto diagram clearly displays information about the relative importance of the factors of a certain problem. This information helps to identify the most important factors, which will be analyzed first.

The results obtained with the cause-and-effect matrix can be used for other analysis and optimizations such as FMEA, mutli-vari analysis and design of experiments.

4. MODIFIED PROCESS DESIGN FLOW

By applying the presented method at the process planning stage the process-design flow is modified, and new process map, with all the KPIV and KPOV for compressor-housing production, is developed. Both, the KPIV and KPOV listed in the process map will be used as inputs for the analysis in the cause-and-effect matrix. The results from the cause-and-effect matrix are further analyzed with the Pareto diagram.

5. COMPARISON OF THE OLD AND THE MODIFIED PROCESS-DESIGN FLOW

To compare the old and the modified process-design flow, the number of KPIV, the number of failure causes in the FMEA-analysis, and the criticality factor, both in the old and the modified process-design flow, will be analyzed. As shown in Fig. 1, in the old process-design flow were grater numbers of KPIV. At the same time the number of failure causes analyzed in the old process-design flow was significantly lower than in the modified one. Furthermore, criticality factors are greater in the modified than in the old process-design flow.

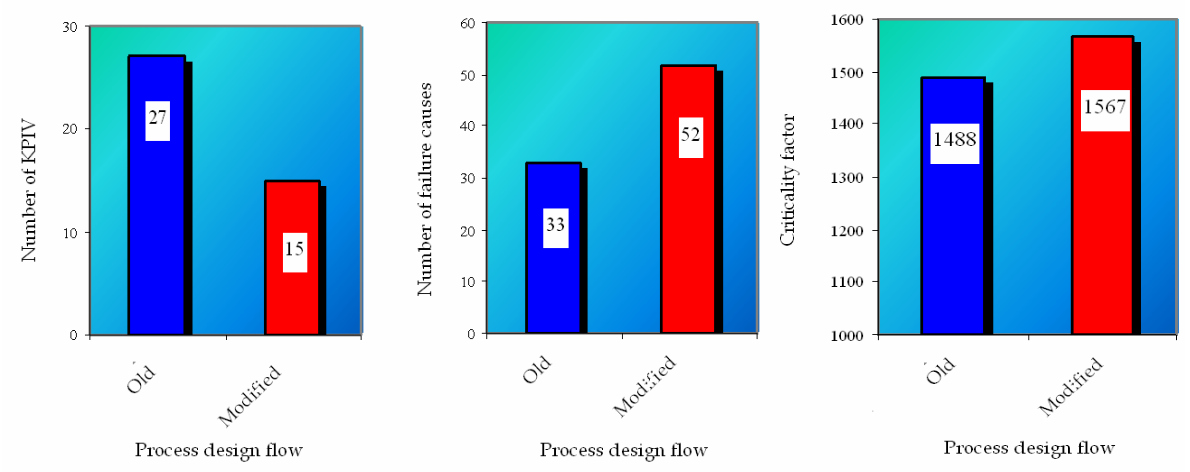

Figure 1. Comparisons of the old and the modified process design flow

A true picture can be obtained by projecting a modified process-design flow on one-month production volume. Fig. 2 shows the real poor-quality costs of one month's compressor-housing production.

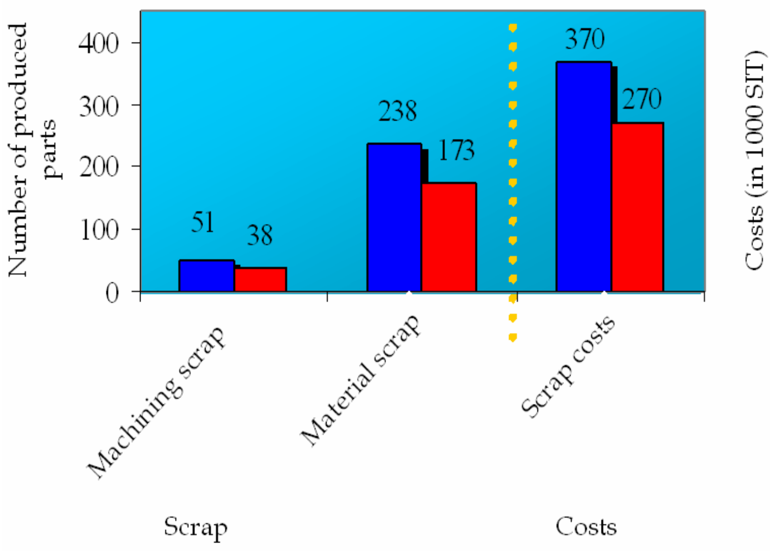

Figure 2. A poor-quality cost of one-month's compressor-housing production.

Taking into account the higher costs of the modified process-design flow and the savings in machining and materials scrap in production, a significant overall saving can be achieved by the application of the modified process-design flow.

6. CONCLUSION

Process design and development is a very important phase in the preparation of automotive-part production. Due to the very high production volume, even low scrap levels result in high costs. From this study it is evident that applied tools detect a greater number of possible failure causes, so the failures in the production process can be prevented. The new process design and development is more costly and time consuming then the old one. Hence, due to better production preparation the machining and material scrap will be decreased to such a level as to cover all the additional costs in the preparation stage and, furthermore, to produce savings that are several times greater than the initial cost increase. These results could be improved with more widespread use of Six Sigma tools and methodology.

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