Improving First Pass Yield and Reducing Defect Cost of Honing Machine Using Six Sigma Approach

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Abstract

Increasing competition in the market is forcing one to adapt six sigma approaches in the industries. This paper focuses on the use of Six Sigma approach to improve the First Pass yield (FPY) of honing machine. Six Sigma is a disciplined method of using extremely rigorous data gathering and statistical analysis to pinpoint sources of errors and ways of eliminating them. The main focus of this work is to reduce potential process variations and reach the six sigma quality level. FPY is an important manufacturing metric for measuring quality and production performance, which is given by

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\text{FPY} = \frac{\text{Units of products completed from process to specification with no rework}}{\text{Total units of products entering the process}}
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Honing is an abrasive machining process that produces a precision surface on a work piece by scrubbing an abrasive stone against it along a controlled path. The problem faced by the organization is that the honing machine is producing large number of defects, thus leading to a FPY of 85%. DMAIC (Define Measure, Analyze, Improve, Control) based Six Sigma is used in the study to overcome this problem. After rigorous data collection, the Cp and Cpk
of honing machine was found to be 1 and 0.93 respectively. On analysis, the factors contributing to the problem were found to be first spindle dimension and bore rough, second spindle dimension and bore rough, pre-part bore rough and the frequency of tool change.

**Keyword:** Six Sigma, First Pass Yield, Design of Experiments, DMAIC

**Introduction**

The Six Sigma’s problem-solving methodology, DMAIC has been one of the several techniques used by industries to reduce defects and improve the quality of their products and services [1]. This work focuses to illustrate the application of Six Sigma and DMAIC to improve the first pass yield of honing machine and reduce the defect cost.

Over the last decade, the implementation of the Six Sigma approach to enhance customer satisfaction, to reduce performance variability, and to reduce significant savings to the bottom line of organizations has gained increased attention in numerous industries [2]. Six Sigma can also be applied in the fields that are not widely explored before for instance sustainability and product-service systems [3]. Six Sigma is a project-driven quality improvement approach, which addresses both process and product or service variation are strong factors affecting lead time, cost, yield, quality, and ultimately, the customer satisfaction [4].

**Literature Review**

Ploytip Jirasukprasert, et al (2014) have conducted an application of DMAIC to reduce defects in a rubber gloves manufacturing process. The important factors contributing to this seems to be oven’s temperature and conveyors speed. In another study, B. Tiahiono, et al (2010) found that seven key findings and three issues that are important in a Six Sigma project.

Chao-Ton Su, et al (2012) identified several important factors affecting the bending strength of TFT-LCD’s were determined and optimized.

**Objectives**

1. To analyze the factors responsible for process variation and defects.
2. To reduce the internal defect level from 19556/ppm to 1000/ppm.
3. To eliminate lapping operation of rework component.
4. To enhance productivity of honing machine.
**Research Methodology**

The paper follows Six Sigma based DMAIC methodology to analyze and find the factors affecting the FPY of the honing process as well as to find the cause of defects in Delivery Valve Body. In specific, primary data collection and analysis of factors are the techniques that are used to statistically determine if the key process variables (i.e. first spindle dimension and bore rough, second spindle dimension and bore rough and frequency of tool change) have any impact on the number of defects produced and also to improve the FPY of honing machine.

**Define Phase**

The manufacturer has received many complaints about the leaking of oil through Delivery Valve which is considered as a defect. These Voice of Customers (VOC’s) were converted to Voice of Engineering (VOE’s). Also the Critical to Quality (CTQ) is increasing the FPY of honing process in order to reduce the defects. Cost reduction and quality is considered to be the business case of this work.

**Measure Phase**

In order to confirm the VOC’s of the organization, data was collected to measure the process capability of honing process and FPY which is the key performance indicator (KPI) of the organization. A gage R&R study was carried out to verify the measuring effectiveness of the ring gauge (the instrument used to measure the bore diameter) of the Delivery Valve body. The results showed that the existing measuring instrument gives accurate bore diameter values.

Random sample of sub group size 125 Delivery Valve bodies were collected over four days considering all the variability such as tool change or fixture change. This was continued for next two months. This data was collected to investigate the present process capability. The next set of data was collected to find out the present system’s FPY and the average number of defects with a random sample of 200 Delivery Valve body over a period of time.

**Analysis Phase and Findings**

Descriptive statistics, capability and Pareto analysis were used in order to analyze the data collected. The data collected was analyzed using Minitab software. The first set of data was analyzed for process capability and the fig 1 shows Cp and Cpk values of honing process.

The Cp and Cpk values were found to be 1.17 and 0.94. From the second set of data the average FPY was found to be 85%. The defect found was bore rough which was coming from the honing process. Using prioritization matrix and pareto analysis factors contributing to this were listed from which the following factors dimension and bore rough, second spindle dimension and bore rough and frequency of tool change were found to have high impact on the FPY of the honing process.
Fig.1: Process capability of Honing Process.

Conclusion

The study was carried out to investigate the factors responsible for defects being produced and the process capability of the present system leading to the FPY. This study uses Six Sigma based DMAIC methodology in order to investigate the factors. The study includes:

1. First spindle dimension and bore rough
2. Second spindle dimension and bore rough and
3. Frequency of tool change

Further, work will be continued with the improve phase and control phase. It is proposed to use Design of Experiments with the above investigated factors at three levels, on optimizing will increase the process capability and the defects will be reduced to 1000/ppm. Reduction of defects enhances the FPY which ultimately reduces the use of lapping operation of rework components.

References


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