Performance of statistical control tools in identifying the defect on plunger- A review

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Abstract. In this paper, we carried out a study to upsurge the brilliance of the plungers used in the braking system. The main focus has been taken on various defects that occur in the plungers during manufacturing. In this work, we analyzed the types of defects that transpire in the plunger. The foremost issue is acknowledged using tools like Pareto graphic representation, root and effect diagram, Failure Mode and Effect Analysis, Trend Analysis and Control chart. We identified more frequently occurring defects and major causes and effects of these defects in plungers. Based on the result of the analysis, interpretation measures are taken to overcome the defects of the plungers that will help to improve the overall efficiency of the brake system in vehicles.

Keywords: Plungers, Braking system, Pareto, Failure mode, Trend Analysis.

1. Introduction

Plunger plays a vital role in the braking system and it is a very crucial part of the hydraulic braking system [1]. So, the plungers are required to have a high accuracy in its quality. Very small defects in the Plunger may also lead to a major accident so it is very important to improve the quality of the plungers [2]. In general, a brake system of a vehicle is operated to slow down or to stop the vehicle when the vehicle is in running condition. The brake pedal is associated with a plunger, as it enforces hydraulic oil through a sequence of tubes along with hoses to the braking component [3]. The piston forces the brake pads adjacent to the brake are bound to the wheel may freeze down or stop. In this research study, an attempt was made by the researchers to identify and analyze various types of defects that occur in plunger during manufacturing and the root causes for the occurrence of defects. The investigation of defects in plungers is made based on unremitting enhancement [4]. It requires coordination within the organization members and effectively using the quality tools in their improvement activities and decision-making process [5]. In the current scenario, many different tools are available in the market and each tool is used for specific purposes and differentiates among them. In further there are different types of tools format is required like statistical, analytical, and clerical [6]. The use of statistical quality control tools had increased on both the practical and theoretical levels. This analytical data is further used to measure the causes of defects using DMAIC, Cause and Effect analyses, Pareto chart [7]. In today’s scenario, the business firm is at the speed of the iterative development and this development records the feedback from the iteration for further development which implements the software-based quality tools like Pareto and six sigma and it also gathers feedback from the customer end to further rectification [8].
1.1 Plunger

It is a component inside the wheel cylinder of the braking system. The brake pedal is forced towards the plunger within the wheel cylinder [9]. This leads to the transporting of fluids to all portions of the wheel [10]. Many researchers indicated that the performance is better for a component at low pressure and heat [11]. So in turn the parameters need to be optimized [12].

2. Defects Identified in Plungers

These are the defects identified on the plunger while manufacturing is classified as Barrel diameter, damage, or wrong size, Collar diameter damage or wrong size, Damage, Drill depth over or undersize, Drill diameter oversize, Overall diameter wrong size, Seal Groove diameter oversize, Seal diameter poor finish, Seal face chatter mark, Short feed, Stem diameter oversize, Line marks, Nick marks, Wrong indexing, Runout [13], [14]. The ion implantation was advanced to avoid the deterioration in the plunger [1].

2.1 Causes of Defects

According to our research and data collected from the literature, there are some major causes of defects that will affect the quality of the plunger while manufacturing and may affect the performance of the plunger [15], [16]. These are the ways of rejection identified while the first operation and it is caused by primary faults that may occur on the machine or the operator. They are Material rejection, End bit rejection, Power cut, Process, Tryout, Operator, Setting, Tool is broken [8]. The defects due to heat are most common on engines and it affects the performance of engines too [17], [18].

3. Methodology

3.1 Research Design

In this study, the researcher has used the analytical type of research [19]. The researcher intends to collect secondary data on defect variance in plunger at brake system, such as collar diameter oversize, barrel diameter oversize, collar diameter undersize, drill depth oversize, drill depth undersize, conveyor damage, etc [20]. The root cause of the defects is analyzed and effective measures are taken to eliminate the occurrence of defects in plunger and that helps to advance the braking system used in automobiles [5], [19]. The research design needs a novel approach for improvising the performance of the wear rate on the plunger [4], [21]. The data are collected from various literature such as Quality control, Production, Manufacturing Engineering, Materials departments in industries that are taken into account for sampling the process [21], [22]. The researcher collected sample data on defects of brakes plunger. The sample data was collected for one month [23].

3.2 Limitations

On bearing in mind about time constraints for carrying out the research, only “Post- machining process defects” are considered to in this research study [24]. The defects which occur in the “Machining process” will be considered and analyzed in a future study by using statistical control tools [5], [25].

4. Results and Discussion

4.1 Fault investigation through trend chart

Trend analysis is the extensive tradition of gathering in sequence to spot a pattern [26]. Even though trend analysis is frequently used to forecast upcoming events, it also shows the path of future results
and uncertain events in the past [27]. The above trend analysis shows that the rejection rate varies continuously concerning time [28].

4.2 Pareto Analysis
A Pareto chart is an systematic technique for segregating the issues for eradicating the factors affecting the quality. The pareto chart gives a transparency of the parent defect which initiates other sub defects. It prioritize the defects using its relative consequence. From the above analysis, it is shown that vital few and trivial many defects of Plunger manufacturing.

![Pareto Chart for Frame Plant Conversion Cost](image)

**Figure 1. Pareto Analysis** [5]

4.3 Cause and Effect Analysis
The cause and effect diagram is used to discover all the impending or real cause. The causes are characterized by their effects. It is also known as the “Fishbone diagram or Ishikawa diagram”. We categorize the foremost reimbursement, and the Causes are in order according to their altitude of substance. From on top of the chart, it explains the assortment of causes of the incidence of damages in plunger the foremost causes of harm are done by the man mistakes.

![Cause and Effect Analysis for Sample High Gas Consumption Plot](image)

**Figure 2: Cause and Effect Analysis for sample high gas consumption plot** [5]
4.4 Failure Modes & Effects Analysis (FMEA)
Failure Mode and Effect Analysis is an approach for performing risk analysis, it a sequential process to categorize all possible letdown [29]. This mode of approach is an everlasting process for identical creativeness. It used to describe, recognize, and eradicate existing problems and probable prospective failures ahead of them to accomplish the customer. Every risk factor has been calculated from every process and notified from 1-Lowest risk and 10-Highest risk. From the above FMEA – Failure Mode Effective Analysis table it was originated that the probable possessions of the failures and their cause and their impending significance. By prioritizing the foremost RPN of all prospective failure to decide upon behavior to shrink risk.

4.5 Control Chart
The control chart is a graph that shows the variations in each process over time. In a control chart, the midline is called average, a high procession is for better control limit and the minor line is for subordinate control limit. By correlating the active data to these outlines, we can terminate whether the process is in control or not. Statistical process control is used to follow good quality control practices in the manufacturing process. And it is used to detect the unnatural patterns and deviations in the process.

![Figure 3. Control chart for Energy production](image)

Analysis of various defects in plungers using a statistical Quality control tool will help to identify the frequency of occurrence of defects, the causes, and its impacts. The interpretation from the statistical analysis will help to take effective measures to control and eliminate the causes of various defects in plungers during manufacturing This in turn help the companies to reduce the rejection rates of plungers and the cost of Quality. By reducing the rejection rates of defects, rework time, and rework costs can be minimized [30].

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5. Conclusion
From the above research of defects in plunger manufacturing, the researchers have identified the various defects occurring more frequently and the causes of these defects. In this Analytical type of research Pareto chart is an ideology to identify and split the imperative few from trivial many defects. Trend analysis identifies that the rejection rate continuously varies concerning time. Then the cause
and effect diagram is used to recognize the mixture of cause for the incidence of the major defect and the diagram highlights the errors produced while manufacturing of plunger. Finally, the FMEA tool is used to analyze the various effects that are caused by the defects and this tool also shows the various prevention and detection for the failure.

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