Journal of Material Science and Mechanical Engineering (JMSME)
p-ISSN: 2393-9095; e-ISSN: 2393-9109; Volume 10, Issue 1; January-March, 2023, pp. 22-25

http://www.krishisanskriti.org/Publication.html

Improving quality using statistical quality control tools in the bearing cage manufacturing: A case study

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Abstract—*The present paper investigated use of seven quality control tools (7QC) in identification and defect reduction of bearing cages. The flowcharts, check sheets, pareto charts, histograms, cause-and-effect diagrams, control charts have been used to improve product quality and reduce defects. Three month data was used to assess and eliminate defects in bearing cages manufacturing. The pareto chart identified inner diameter (ID) oversize as major defect. By focusing on this defect, the root cause of the problem was identified using ishikawa diagram. After implementing corrective measures the defect level was significantly reduced. The present paper is a complete guide for implementing these technologies and emphasizes the significance of continuous improvement in the manufacturing business.*

Keywords: *7QC, bearing cages, productivity, cost, histogram.*

Introduction

Utilizing the Seven Quality Control (7QC) tools can greatly improve productivity and address quality-related problems in operational processes and delivery [1, 2].

The tools can be applied to boost the efficiency of manufacturing processes and identify and solve issues at any point in the process [3, 4]. Implementing 7QC tools can reduce costs, and there are no other complicated decision-making support systems that can replace these tools [5]. The quality of a product is directly related to the process conditions. If the process is operating within the control limits, the product will be considered acceptable, but if the process goes beyond these limits, the product may be rejected, require rework or end up as scrap [6].The utilization of problem-solving tools can have a direct positive impact on customers, as it leads to a decrease in product defects and lower costs for the company. A company's ability to improve the quality of their product is crucial for its longevity in the market. By implementing the 7QC tools in the production process, defects can be reduced and opportunities for improvement can be identified [7]. There have been reports indicating the existence of over two Statistical Process Control (SPC) methods, namely the Ishikawa diagram (also known as the Fishbone diagram) and SPC control charts. These techniques have been implemented in the bearing industry as well [8].

In today's tough business environment, it's crucial for companies to use effective tools to improve their productivity. This article presents how a Bearing cages manufacturing company can use 7QC tools to improve their operations. The writers aimed to utilize the complete set of 7QC tools and learn how to apply them properly to reduce defects in the brass department.

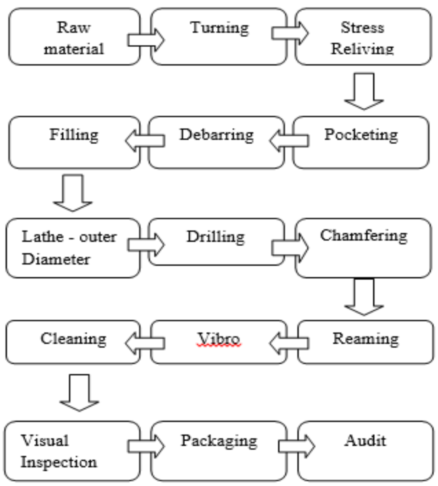
Experimental details

The present study was conducted at bearing cage manufacturing industry located in Gujarat, India. The defect analyses was carried out by collecting defect data for past three months. The defects were categorized in four types: Bend, Dent, ID (Internal Diameter) oversize and Height undersize. Then, the defects having direct contact was identified and focused. To pinpoint the root cause of cages defects, a check sheet was developed using the cause and effect diagram technique can help decrease the number of defects in the product. Using the check sheet over a three-month period, data was collected using the check sheet and the same process was repeated. The collected data was reported and could be simulated for better analysis [9].

Methodology

Flow Chart (QC Tool 1):

Flow charts are a basic tool used to study a whole process and identify problems. They show the process step by step, from raw material to end product. The flow chart can be prepared for particular section of the plant. Flow diagrams are a graphical way to depict a process sequence, providing better understanding and analysis. Flow diagrams give information about process and material handling, making the problem solving easier. For the present study, the flow chart was created to gather information from the brass department and is shown in Figure 1. All other tools were exclusively utilized within the manufacturing area.



Figurer 1: Flow chart of the bearing case manufacturing

Check sheet (QC Tool 2):

Check sheets are a vital tool for collecting and categorizing data, providing insight into how frequently a defect occurs. The data collected through check sheets is highly valuable, as it can be used in other quality tools such as Pareto charts and histograms. Check sheets are ideal for real-time data collection and analysis at the source of the data. They serve as an essential starting point for organizations looking to use process improvement and problem-solving tools. Once the defects have been identified, the next stage involves gathering data. To facilitate this, check sheets were created to collect defect data, with a specific focus on attributed data. The sheets were designed to be user-friendly, featuring simple checkmarks that inspectors could use to indicate the occurrence of defects. These check sheets listed the various types of defects present in the brass department. The data collection process took place between December 2022 and February 2023. The check sheet for the present study is shown in Table 1.

Table 1: Check sheet (monthly defect)

Month and defect	Bend	Dent	Height undersize	ID oversize	Grand total
Dec-22	28	74	38	79	219
Jan-23	21	22	41	48	132
Feb-23	18	33	25	75	151
Grand Total	**67**	**129**	**104**	**202**	**502**

Histogram (QC Tool 3):

Histograms are a popular graph used in quality tools and can be created using Excel. They are developed based on data collected through check sheets to display process variation and capability. A Histogram is a graphical representation of numeric data, showcasing the frequency of each value in a data set. Histograms are primarily used to examine the shape of a data set. In the case of defect data, a monthly histogram from December 2022 to February 2023 was created to display the occurrence frequency of each defect. This histogram is illustrated in Figure 2[10]. From the Figure 2, it is clear that ID oversize is the major defect in the production of bearing cages.

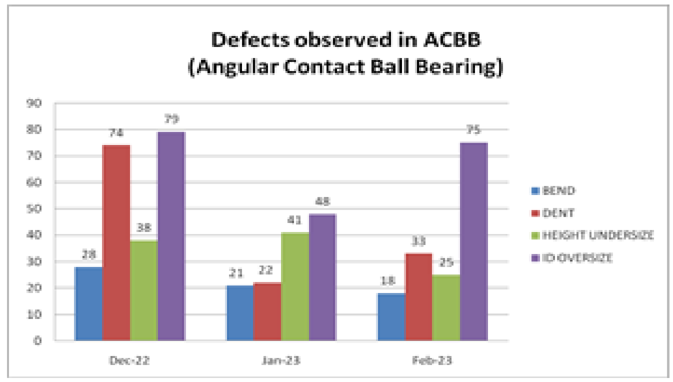
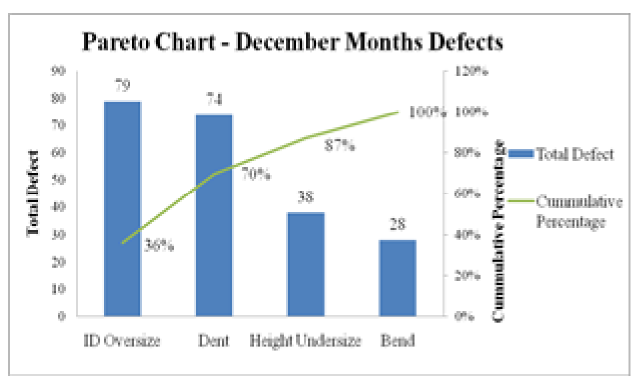


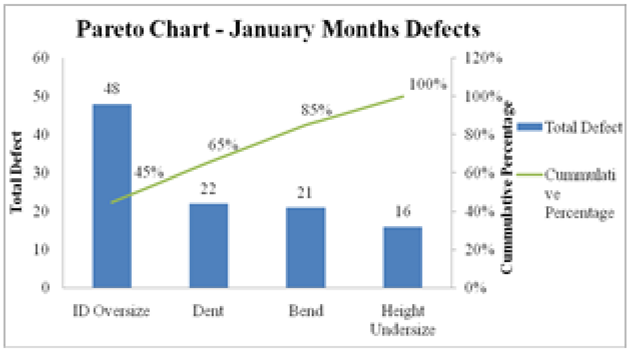
Figure 2: Histogram for Brass Department defects

Pareto diagrams (QC tool 4):

The Pareto chart, developed by Vilfredo Pareto, is a valuable tool that uses a series of bars to illustrate the impact of defects or problems. According to the 20-80 rule, 20% of errors cause 80% of defects. The chart displays defects in descending order of their frequency, with the cumulative frequency shown on the secondary axis and the trend line indicating the cumulative percentage of defects. The Pareto diagrams for the defect analysis in brass department are displayed in Figure 3. The Parato diagram are drawn for defect data collected for December 2022, January 2023, and February 2023.

By analyzing the chart, it is possible to identify the primary areas of focus for process improvement. For instance, in this case, eliminating the ID oversize problem would reduce 80% of defects.





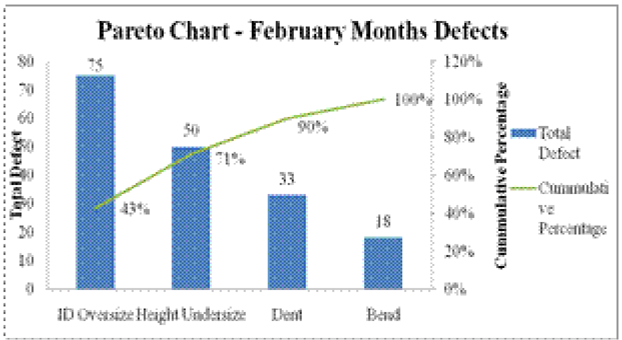


Figure 3: Pareto Charts of brass department for (a) Dec. 2022, (b) Jan. 2023, (c) Feb. 2023

Cause and Effect diagram (QC tool 5):
The Ishikawa or Fish bone diagram, a tool for identifying cause and effect relationships, was created by a Japanese professor named Dr. Ishikawa. This technique, which can be implemented using either the 4M's or 6M's methods, has a distinctive graphical structure. When using the brainstorming technique to develop the cause and effect diagram, the involvement of numerous experts is beneficial since it allows for the identification of a greater number of causes. In December 2022, The data collected from checklists showed that there were many problems occurring frequently. Subsequently, data for January 2023 and February 2023 were also collected using check sheets.

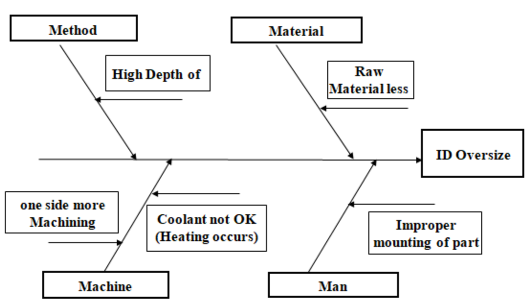
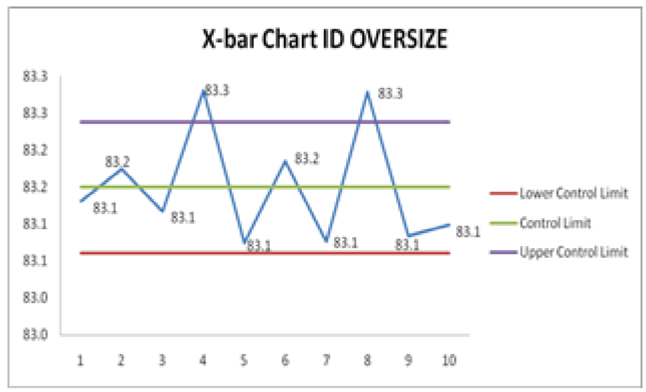


Figure 4: Cause-effect diagram for ID oversize

Control Chart (QC tool 7):
The X bar R chart is a tool that employs binomial distribution to track the number of defect occurrences. This chart can be used to identify whether a process is in statistical control or not, as well as to identify changes in the frequency of defective items when process measurements are taken. Control charts, including the X bar R chart, are also referred to as Statistical Process Control (SPC) charts. To assess a process, 10 defective items are randomly selected and their measurements are plotted on a graph that has three limit lines: the control limit, lower control limit, and upper control limit. It is then verified whether all the measurements fall within the specified limits. If any of the measurements fall outside these limits, corrective action is necessary. The control process chart, depicted in the above figure, was created once the defects were eliminated from the manufacturing process. The chart indicates that the process is fully under control and that there is no variability beyond the specified tolerance level.



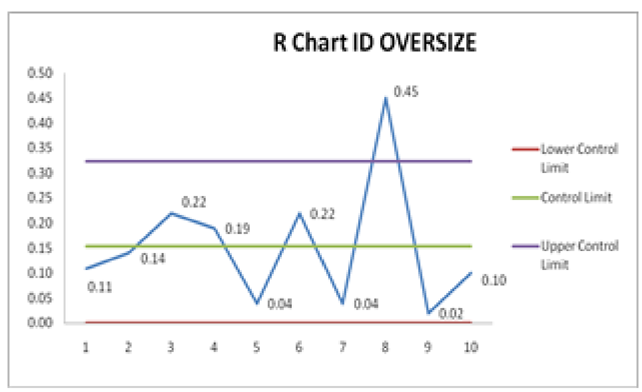
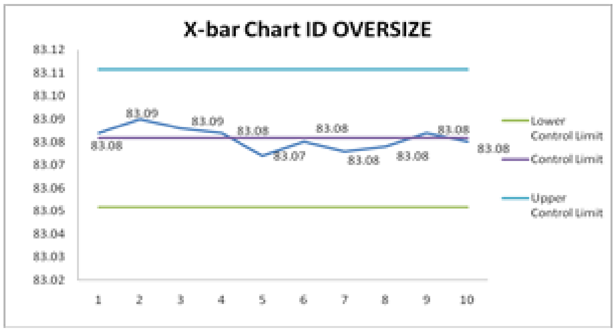


Figure 6: Control Chart (X bar and R chart)

Results and discussion
The application of the 7 Quality tools in the bearing cages manufacturing industry revealed the root causes of major defects, as well as the quality level, process performance, rejection costs, and appropriate QC tools to apply. By implementing these basic quality tools, the root causes of the major defects were identified, enabling the technical and managerial staff to eliminate them from the manufacturing process.



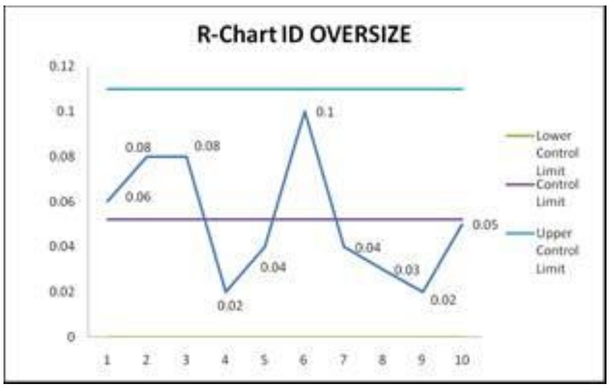


Figure 7: Control Chart (X bar and R chart)

Conclusion

The case study has demonstrated the effectiveness of the seven basic tools of quality in identifying and eliminating defects from the manufacturing process, highlighting their usefulness at every stage of the defect removal process. These findings corroborate the assertion of Dr. Ishikawa, a renowned quality guru, who stated that applying the seven basic tools of quality could solve 95% of quality-related industrial issues.

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