A Survey & Comparison of Quality Control Techniques in Gauge Design

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Abstract

This research paper provides the study of various quality control methods and also their comparison with their advantages as well as applications. This study has helped us in our project which is based on gauge designing and as has also helped us understand the need of quality control. The company that has sponsor our project is a TQM (Total Quality Management) adapted company and demands an increased quality controlled product. Also the global industry depends on quality and metrology to establish confidence between customer and supplier. Global trade is open to all and in order to take part effectively in today’s global economy QSTM (Quality, Standardization, Testing and Metrology) activities are essential to improve productivity and social as well as economic development .The National measurement system provides a coherent formal system which ensures that measurement can be made on consistent basis throughout the country. The quality council of India has been established in India to implement accreditation system in line with international practice to oversee and regulate conformity assessment process. In any measurement there is always a degree of uncertainty resulting from measurement error.

Keywords: Quality Control Techniques for Gauge Design, Gauge Design

I. INTRODUCTION

In recent years, an increasing number of companies have used different types of quality programs in order to increase internal and external customer satisfaction as well as to reduce quality cost. Process improvement has often been accomplished through an integrated approach, using problem-solving techniques such as total quality management (TQM) and classic statistical analysis. Different types of quality control methods are now used for the increase in product quality as well as to have précised and effective production. FMEA, ABC, Six Sigma, etc. are some quality control methods that widely used in the industries for quality products considering various aspects that are involved. Due to increased demand of complex parts and need of quality these quality control method are very important for the précised product manufacturing.

We at our final year project are working on “Design and Manufacturing of Two Wheeler Handlebar Gauge”. And as the project demands the higher “Quality Control”, we are studying the quality control methods as well as comparing them to find out the best quality control method that can be used for our project. Gauge designing and manufacturing for checking the handle bar tube profile as well as switch panel mounting holes in a single loading and unloading process. We are mainly focusing on quality control as well as work measurement to increase the total quality control. For working measurement we are using time study technique as it is the best suited for short and repetitive process.
II. LITERATURE REVIEW

A. Rakesh.R, Bobin Cherian Jos, George Mathew have reviewed on “FMEA Analysis for Reducing Breakdowns of a Sub System in the Life Care Product Manufacturing Industry”

FMEA is a concept in TQM was first developed in 1960 in aerospace industries. FMEA is a systematic method of identifying and preventing system, product and process problems before they occur. It is focused on preventing problems, enhancing safety and increasing customer satisfaction. FMEA is a tool that allows us to prevent System, Product and Process problems before they occur. It reduces costs by identifying system, product and process improvements early in the development cycle. It prioritizes actions that decrease risk of failure. Traditionally, criticality or risk assessment in FMEA is carried out by developing a risk priority number (RPN). First FMEA was observed that the traditional FMEA based on crisp RPN is not supportive and robust enough in priority ranking of failure modes. FMEA innovation can become a more powerful tool for safety and reliability analysis of systems, processes, designs and services in the organization when know the risk factor and risk priority method are appropriate and suitable to the specific risk evaluation problems.

B. Six Sigma process improvement approach

By Tutorials Points, helps to give an idea about the features of the six sigma. Six Sigma is a data driven methodology, and requires accurate data collection for the processes being analyzed. The word Sigma is a statistical term that measures how far a given process deviates from perfection. The central idea behind Six Sigma: If you can measure how many "defects" you have in a process, you can systematically figure out how to eliminate them and get as close to "zero defects" as possible and specifically it means a failure rate of 3.4 parts per million or 99.9997% perfect. Six Sigma is recognized problem solving method that uses quality and statistical tools for basic process improvement. Six Sigma is mainly based on understanding the customer needs and expectations, using the facts, data and statistical analysis and a thorough approach to managing, improving and creating new business, production and service processes. Analyze the numbers to find out how well or poorly the processes are working, compared to what's possible and what the competition is doing. Process analysis includes creating a more detailed process map, and analyzing the more detailed map, where the greatest inefficiencies exist. Quality is at the heart of Six Sigma philosophy. Reducing defects has everything to do with striving for perfection. Whether we reach perfection or not, the effort defines our attitude toward quality itself.

C. “Engineering metrology” (Including quality management and reliability analysis) written by ER. R.K. Jain

It gives idea about ABC standards and it helps to know about acceptable quality level. AQL values in the standard may be interpreted either as defects per 100 units. In ABC standard sample size code letter depends upon the lot size and inspection level and also not influenced by AQL. In all AQL systems acceptance criteria under normal inspection have been chosen to protect the producer against rejection of lots meeting the quality standard. The ABC analysis provides a mechanism for identifying items that will have a significant impact on overall inventory cost, while also providing a mechanism for identifying different categories of stock that will require different management and controls. The results of an ABC Analysis extend into a number of other inventory control and management processes. Normal inspection must be reinstated whenever ‘a lot or batch is rejected’ or ‘production becomes irregular or delayed, or other conditions warrant that normal inspection shall be instituted.

III. FMEA- FAILURE MODE AND EFFECT ANALYSIS

The Failure Modes and Effects Analysis (FMEA), also known as Failure Modes, Effects, and Criticality Analysis (FMECA), is a systematic method by which we get to know type of failures of a product or process design are identified, analyzed and documented. If we identified what are the effect of these failure on performance we can take appropriate action to minimize effect of that failure. An FMEA is a very important tool that helps avoid costs incurred from product failure and liability.

FMEA is systematic approach for:
- To determine where & how product/process might fail
- To determine specific causes associated with these failures and risk
- To determine impact of failure on process
- Take appropriate action to reduce effect of failure
- Identify which part is need to replace

A. Types of FMEA

- Design: The DFMEA is typically the first FMEA tool used in product development.
- Process: Used to analyze manufacturing, assembly & administrative processes.

DFMEA is used to uncover design risk, which includes possible failure, degradation of performance and potential hazards. It is widely used in development and manufacturing industries in various phases of the product life cycles, which helps in increasing the life of the product.
PFMEA is to be carried out in the next phase of the work where in the manufacturing of the product is involved. The following points are to be considered in this activity:
- Proper knowledge of machining tolerances and machine tools.
- Material properties and selection of the appropriate one based upon the requirement conditions.

**B. FMEA Procedure**

The process for conducting FMEA is explained with the help of flow chart shown below
- Step 1: Identify components and associated functions
- Step 2: Identify type of failure modes
- Step 3: Identify effects of the failure modes
- Step 4: Determine severity of the failure mode
- Step 5: Identify cause of the failure mode
- Step 6: Determine probability of occurrence
- Step 7: Identify controls
- Step 8: Determine effectiveness of current controls
- Step 9: Calculate Risk Priority Number (RPN)
- Step 10: Determine actions to reduce risk of failure mode.

**C. Risk Priority Numbers (RPN)**

RPN is the indicator for the determining proper corrective action on the failure modes. It is calculated by multiplying the severity, occurrence and detection ranking levels resulting in a scale from 1 to 1000. After deciding the severity, occurrence and detection numbers, the RPN can be easily calculated by multiplying these 3 numbers: 
\[ RPN = \text{Severity} \times \text{Occurrence} \times \text{Detection} \]

The small RPN is always better than the high RPN. The RPN can be computed for the entire process and/or for the design process only. Once it is calculated, it is easy to determine the areas of greatest concern. The engineering team generates the RPN and focused to the solution of failure modes.

**IV. SIX SIGMA**

Six Sigma is a useful methodology for quality control and provides a valuable measurement approach. It is based on statistics which help to improve the quality of both product and process. In addition to providing data-driven statistical methods for improving quality, Six Sigma also focuses on some vital dimension of business processes, reducing the variation around the mean value of the process. At many companies, Six Sigma simply mean a measure of quality that strives for near perfection. It is used to reduce defects in any process, covering manufacturing and transactions, as well as products and services. The main objective of the Six Sigma methodology is the implementation of a measurement-based strategy that focuses on process improvement and variation reduction. This is accomplished with two methodology: DMAIC and DMADV. The DMAIC (define- measure- analyze-improve- control) is an improvement system process for existing processes falling below specification and looking for incremental improvement, and the DMADV (define- measure- analyze- design- verify) apply to the product development and design at Six Sigma quality levels. It is a myth that Six Sigma works only in large companies.

**A. The phase of Six Sigma implementation**

In order to reduce process variation and the associated high defect rate, Six Sigma focuses on improvement methodology application, then the DMAIC is mentioned most frequently now and a lasting improvement method. The representative's meanings of five English letters are as follows:

1) Define
   The top management shall identify the problem according to customer feedback, strategy and mission of company, define customer requirements, and set goal.

2) Measure
   Measurement is a key transitional step on Six Sigma road, one that helps the project team refined the problem and being the search for root causes which will be the objective of Analyze step in DMAIC. Therefore, the project team needs to validate problem/process, Define problem/goal, and measure key steps/input.

3) Analyze
   In analyze stage, the project team shall use data analysis tools and process analysis techniques to identify and verify root causes of the problem. For the reason, the project team needs to develop causal hypotheses, identify vital few root causes, and validate hypothesis.

4) Improve
   The goal of the improve stage is to find and implement solutions that will eliminate the causes of problems, reduce the variation in a process, or prevent a problem from recurring. So the project team needs to develop ideas to remove root causes, test solutions, and standardize solution/measure result.
5) Control
Once the improvement has been made and results documented, continue to measure the performance of the process routinely, adjusting its operation. It is very important for the project team needs to establish standard measures to maintain performance and correct problems as needs. Without control efforts, the improved process may well revert to its previous state.

B. Comparison between FMEA And Six Sigma
- Six Sigma is an evaluation of the process. It measures how good the process is with respect to the defects it is delivering or causing.
- FMEA is a tool that can be used in Six Sigma.
- Six sigma is an outcome, FMEA is a means to achieve that outcome.
- If I have to use an analogy - may not be the best, zero breakdowns of a car is an outcome and regular maintenance of the car is a means to achieve this outcome. Trust this helps.
- FMEA is a technique used in analysing a process / product / service either during design / production / functional stage to find out the possible reasons for failure and its effect. It is also used in improving a process, reducing defects or rework. It is a mandatory requirement in Production Part Approval Process of a product.
- Six Sigma on the other hand is a data driven disciplined method using DMAIC (Define, Measure, Analyse, Improve, Control) approach to improve a process by reducing the variation. It is a technique used for solving more intrinsic problems the effect of the problem results in heavy loss. It requires a systematic study of the problem and more data driven.

V. ABC STANDARD STATES

“When normal inspection is in effect, tightened inspection shall be instituted when 2 out of 5 consecutive lots or batches have been rejected on original inspection”.

The statement regarding requalification for normal inspection is as follows: “when tightened inspection is in effect, normal inspection shall be instituted when five consecutive lots or batches have been considered acceptable on original inspection”.

Criteria for Qualification and loss of Qualification for Reduced Inspection. The ABC standard states the following conditions for a shift from normal to reduced inspection:
- The preceding 10 lots or batches (or more as indicated in relevant table have been on normal inspection and none has been rejected on original inspection.
- The total number of defective (or defects) in the samples from the preceding 10 lots or batches (or such other number as was used for condition (a) above is equal to or less than the applicable number given in the relevant table.
- Production is at a steady rate
- Reduced inspection is considered desirable by the responsible authority. Normal inspection must be reinstated whenever “a lot or batch is rejected” or production becomes irregular or delayed, or other conditions warrant that normal inspection shall be instituted.

A. Poka Yoke
- Poka-yoke is a Japanese improvement strategy for mistake-proofing to prevent defects from arising during production processes.
- Poka-yoke is a preventive action that focuses on identifying and eliminating the special causes of variation in production processes, which inevitably lead to product nonconformities or defects.
- It is one of the important tools to add to any organization’s Continuous improvement. In short poka-yoke is a continual improvement strategy that offers a way to move the QMS (quality management system) towards a higher level of performance.
- The ability to find mistakes at a glance is important because, as Shingo states, ”The causes of defects lie in worker errors, and defects are the results of neglecting those errors. It follows that mistakes will not turn into defects if worker errors are discovered and eliminated beforehand"
- The Poka-Yoke is a technique for to keep away human error at work. A defect or imperfection exists in either of two states; the defect either has already occurred in that case calling for defect detection, or is about to occur in that case calling for defect prediction.
- The technique starts by analyzing the process for potential problems, identifying parts by the characteristics of dimension, shape, and weight, detecting process deviation from nominal procedures and norms.
- Methodology of Poka Yoke
  1) Step 1. Identify problem
  2) Step 2. Observation at work stations
  4) Step 4. Select best ideas
5) Step 5. Implementation plan and implementation

6) Step 6. Monitoring and sign off

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<tr>
<th>Table - 1</th>
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<tbody>
<tr>
<td>Quality control methods and their advantage, disadvantage and applications</td>
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<table>
<thead>
<tr>
<th>Type</th>
<th>Advantages</th>
<th>Disadvantages</th>
<th>Application</th>
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<tbody>
<tr>
<td>FMEA</td>
<td>Improved product quality, reliability and safety</td>
<td>It takes time to get into the details</td>
<td>Used to evaluate the design of products and processes to anticipate and address potential failure modes early in the process when they are less expensive to correct.</td>
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<td></td>
<td>Early identification and elimination of potential</td>
<td>The initial output of an FMEA is the prioritizing of failure modes based on their risk priority numbers</td>
<td>Used to investigate the reliability of existing systems/processes</td>
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<td></td>
<td>Identification of critical areas of the system</td>
<td></td>
<td>Provides a knowledge base for future troubleshooting efforts.</td>
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<td>Six Sigma</td>
<td>Enhances teamwork, understanding and cross-functional working relationships</td>
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<tr>
<td>1</td>
<td>Six Sigma is driven by the customer and thus aims to achieve maximum customer satisfaction and minimizing the defects</td>
<td>Six Sigma gives emphasis on the rigidity of the process which basically contradicts the innovation and kills the creativity.</td>
<td>Reducing variation in all the critical parameters that impact the finished product.</td>
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<td>2</td>
<td>Implementation of Six Sigma methodology leads to rise of profitability and reduction in costs</td>
<td>Six Sigma implementation constantly require skilled man force</td>
<td>Using design FMEA to understand and prevent any possible design failures.</td>
</tr>
<tr>
<td>3</td>
<td>Six Sigma is prospective methodology as compared to other quality programs as it focuses on prevention on defects rather than fixing it.</td>
<td>While converting the theoretical concepts into practical applications there are lot to real time barriers which needs to be resolved</td>
<td>Reducing manufacturing defects at each stage.</td>
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VI. CONCLUSION

After studying the above quality control methods, FMEA (Failure Mode Effect & Analysis) is the best suited quality control method for our project “Design and Manufacturing of a Two-wheeler Handlebar Gauge”. FMEA covers all the causes and effect aspects that are involved in the checking the accuracy of the handlebar tube profile. Also by FMEA we can achieve higher quality control as expected by the company that has sponsored our project. By time study work measurement technique we can calculate the new standard work time required to check the accuracy over the old gauges and conclude how the process can be done quickly and accurately than old gauges increasing the no. of components checked giving higher quality control.

VII. CASE STUDY

In our project, we are going to design gauge for checking the 3-D profile of two-wheeler handlebar, tapered angle at the ends of handlebar as well as switch positioning holes. FMEA quality control method is suitable to check the various modes of failure of handlebar.

Firstly by the use of DFMEA, we can detect the failure modes in the design process itself so as to avoid the errors in the gauge. Design of gauge is very important as the total manufacturing and hence working solely depends of the gauge. Therefore, the gauge has to be perfectly accurate. In design stage, by use of DFMEA modes of failure such as:

1) Poorly constrained design.
2) Poor scale measurements.
3) Inaccurate dimensions.

These modes can be analyzed. These analyses will prevent the effect of the failure modes during the design stage so as to create perfectly accurate design of the gauge.

Various modes of failure that can cause failure of the handlebar tube are:

1) Defective bends in profile of handlebar tube.
2) Unevenness of handlebar tube.
3) Non-Tapered end of the handlebar tube.
4) Positioning holes shift.

All these modes of failure can be easily detected while the checking of handlebar tube and can be plotted accordingly to analyze the various modes of failure according to their frequent occurrence as well as to determine the severity of the failure mode.

Also by the use of DFMEA, we can detect the failure modes in the design process itself so as to avoid the errors in the gauge. Design of gauge is very important as the total manufacturing and hence working solely depends of the gauge. Therefore, the gauge
has to be perfectly accurate. In design stage, by use of DFMEA modes of failure such as, poorly constrained design, poor scales of measurements, inaccurate dimensions, etc can be analyzed. These analyses will prevent the effect of the failure modes during the design stage so as to create perfectly accurate design of the gauge.

REFERENCES


