IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)
e- ISSN: 2278-1684,p-ISSN: 2320-334X
PP. 16-22
www.iosrjournals.org

Process Failure Mode Effect Analysis of Cutting Operation of Needle for Roller Bearing

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Abstract: *In this Paper, the needle cutting process is considered the mapping process customer requirements and product functions. Customer requirements are considered as the input information indicating the needs of customers, and they are usually obtained and organized in a marketing department through the market research activity.*
Failure modes and effects analysis (FMEA) is a process improvement tool to analyze and control the potential impacts from failures. Through the practice of FMEA, it is expected to anticipate the possible failures from a product or system after it is actually implemented. In such a way, engineers can improve the process by deliberately controlling the causes of failures or limiting their negative effects.
Keywords: *PFMEA Process Failure Mode Effect Analysis, RPN Risk priority number, S- severity, O- Occurrence, D- Detection*

I. Introduction

Product functions indicate the intents of the process without stating the specific solutions. For example, if I want to open the food from the can, the function can be described as "open the can". Notably, there can be various ways to open the can. Processes are referred to the specific process solutions that are implemented to achieve the product functions. For example, an "electric can opener from Company ABC" can be one design component to achieve the function "open the can".

The PFMEA is developed and maintained by a multi-disciplinary (or cross-functional) team typically led by the responsible engineer. During the initial development of the PFMEA, the responsible engineer/team leader is expected to directly and actively involve representatives from all affected areas. These areas should include but are not limited to design, assembly, manufacturing, materials, quality, service, and suppliers, as well as the area responsible for the next assembly. The PFMEA should be a catalyst to stimulate the interchange of ideas between the areas affected and thus promote a team approach.

1.1 Process Failure Mode and Effect Analysis

The PFMEA should be consistent with the information in the process flow diagram. The scope of the process flow diagram should include all manufacturing operations from processing of individual components to assemblies including shipping, receiving, transportation of material, storage, conveyors, labeling, etc. A preliminary risk assessment using the process flow diagram may be performed to identify which of these operations or individual steps can have an impact on the product manufacturing and assembly and should be included in the PFMEA. The PFMEA development continues by identifying the requirement(s) for each process/function. Requirements are the outputs of each operation/step and relate to the requirements for the product. The Requirements provide a description of what should be achieved at each operation/step. The Requirements provide the team with a basis to identify potential failure modes. In order to assure continuity, it is highly recommended that the same cross-functional team develop the Process Flow Diagram, PFMEA, and Control Plan.

1.2 The PFMEA Objectives

The FMEA should give a description of the different failure modes for all the items of equipment in respect of their functional objectives. In this way, all catastrophic or critical single point failure possibilities can be identified, and either eliminated or minimized at an early stage in the project through design correction or the introduction of clear operational procedures. The FMEA considers a single failure only at any one time (single point failure). A failure that is not revealed to an operator by way of monitoring and alarm is classed as a hidden failure. These failures, such as a backup unit without a failure alarm, must also be considered.

Essentially the PFMEA is to:

- Identify the equipment or subsystem, mode of operation and the equipment;
- Identify potential failure modes and their causes;
- Evaluate the effects on the system of each failure mode;
- Identify measures for eliminating or reducing the risks associated with each failure mode;
- Identify trials and testing necessary to prove the conclusions; and Provide information to operators and maintainers of the system in order that the understand the capabilities and limitations of the system to achieve best.

1.3 Problem Definition

According to the department of marketing and customer care department have received 23 no of complaints in last year regarding and they have lost their primary function. Before FMEA the SOD of the operation is 634 and which is more than others so that the cutting operation gives a special class. As we described the importance of needle specifically the importance and current problems with information from management short needle context, the aim of this project is to contribute to the academic knowledge FMEA.

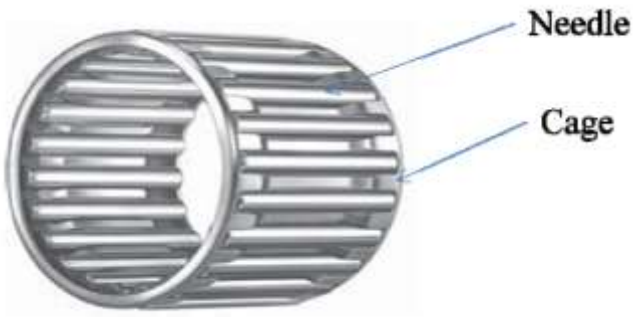


Fig. 1 Needle Roller with Cage

1.4 Research Objectives

To achieve the research aim we identified integration of PFMEA and statistical process control research objectives. This research objective has a main research question which is described in the following paragraphs. Quality systems like TS 16949 and Six Sigma require the use of FMEA and SPC. Many text books and consultants advocate the use of these techniques to control and improve processes. Hardly any text book explains how FMEA, Control Planning and SPC can be logically integrated and how to setup these different techniques in an efficient and effective way to get the best of both worlds without large amounts of engineering time to support these methods.

II. Statistical Process Control

Statistical Process Control (SPC) charts offer users the chance to monitor the very heartbeat of their processes. By collecting data they can predict performance. Taking sample readings from a process seems straightforward. Or does it? Look more closely. Do we understand our process fully? In manufacturing areas we probably do. In non-manufacturing areas we may be less confident. And who collects the data? What sample size is required? How often are samples taken? These are vital questions to those intending to daily use the control chart with a view to improving process performance, particularly in nonmanufacturing, or service, areas where the techniques are new. The control chart has been with us since 1924. It has been tried and proven, and accepted as a highly effective tool in improving processes. In view of the fact that there is currently renewed interest in Shewhart's work, it is important to consider how the control limits were originally set up. However, at the end of the day, it is the logic and rules of collecting data and interpreting the pattern of points on the chart that is the important issue in understanding process behavior and the discovery of insights for process improvement.

2.1 Process Flow Diagram

The process flow diagram is plotted for the components undergoing needle cutting operation by visually studying the process and then mapping the sub-activities in the bending

operation. The process map is then viewed and reviewed by the improvement group assembled for the project work. The process mapping is represented in the steps as shown in figure2.

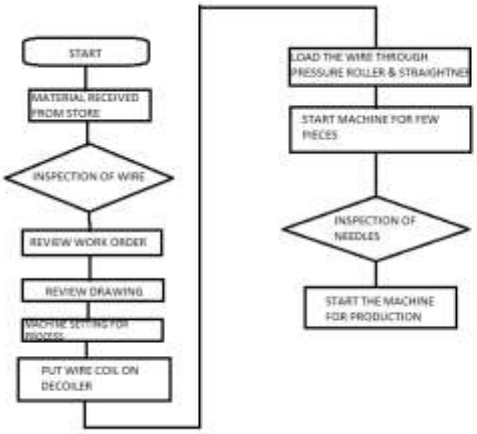


Fig2. Flow chart for wire cutting

2.2 Ishikawa Diagram for Needle Roller Bearing

The cause and effect diagram also known as Ishikawa diagram is used to find problems in the wire cutting process. The improvement group developed a diagram with brainstorming session conducted. The starting point of the cause and effect diagram was the question [Klefsjo B.1999], "What causes customer complaints in wire cutting process?" The improvement group was able to find the important root cause to the problem. For example-

1. Lack of motivation
2. Incorrect setting
3. Poor maintenance
4. Raw material variation.

These causes were chosen, since they were detected frequently and will work as input to the process FMEA.

Fig 3 Ishikawa Diagram for wire cutting

Selection of Ranking

Severity: PFMEA Custom Ranking, Customer Satisfaction Examples

Ranking	Example
10	In-service failure that threatens safety.
9	Extensive product recall.
8	Unscheduled engine removal.
7	Premature (unscheduled) component replacement.
6	Oil leak but system still operational.

5	Air-conditioning system not operating properly.
4	Interior panel rattles.
3	Variation in seat colors.
2	Door plugs missing.
1	Scratch on interior of housing.

Occurrence: PFMEA Custom Ranking, Piece-Based example

Ranking	Example
10	Cpk < 0.33
9	Cpk ≈ 0.33
8	Cpk ≈ 0.67
7	Cpk ≈ 0.83
6	Cpk ≈ 1.00
5	Cpk ≈ 1.17
4	Cpk ≈ 1.33
3	Cpk ≈ 1.67
2	Cpk ≈ 2.00

Detection (Control): PFMEA Custom Ranking, Manual Detection Examples

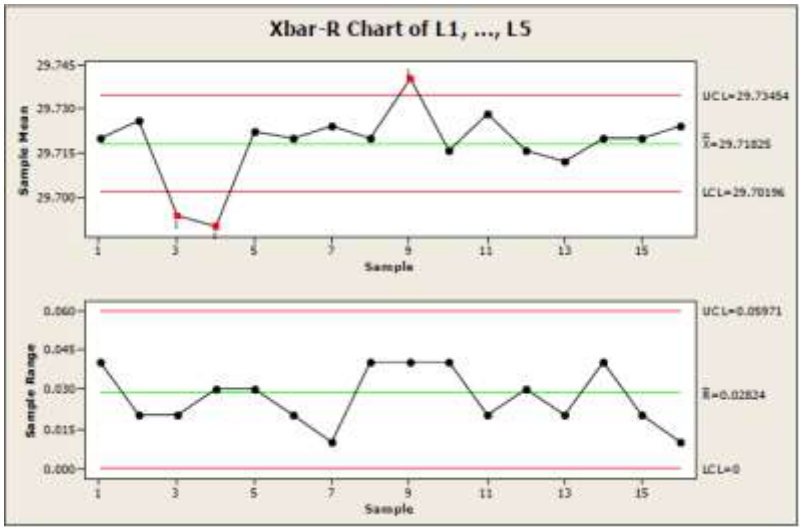
Ranking	Example
10	No monitoring, measurement, or sampling.
9	Acceptable Quality Level (AQL) sampling plan used for Final Inspection.
8	100% visual inspection.
7	100% visual inspection with visual standards.
6	100% manually inspected using GO/NOGO gauges.
5	Statistical Process Control (SPC) used in-process with Cpk 1.33 or higher.
4	SPC used in-process with Cpk 1.67 or higher.
3	Does not apply.
2	Does not apply.
1	Does not apply.

III. Analysis

A study of the needle length allowance was conducted in order to understand what would be the maximum tolerated length without implementing the new ideas in the regular production. At this point remark is required so this study is important in the way that it affect the product. In fact the measurement and analysis are carried out on product which is undergoes the process in order to make decision on future product.

In order to assess whether the process is under control or not a control chart X bar R chart was developed. Since the population is not normally distributed, this chart is suitable because it considers subgroups of the sample and their average which are, according to the central limit theorem, normally distributed. From the chart we deduce that the process is under control. Nevertheless, in order to draw a definitive conclusion it would be better to have more data. X bar refers to the mean of subgroup. The mean of subgroup are calculated and plotted on an x bar graph. R refers to the range of a subgroup essentially a measure of depression of data. The range is simply calculated by subtracting the lowest value of data set from highest.

After checking a length of needle that mean and range charts are used to monitor different variables. The mean or x-bar chart measures the central tendency of the process, whereas the range chart measures the dispersion or variance of the process. Since both variables are important, it makes sense to monitor a process using both mean and range charts. It is possible to have a shift in the mean of the product but not a change in the dispersion.

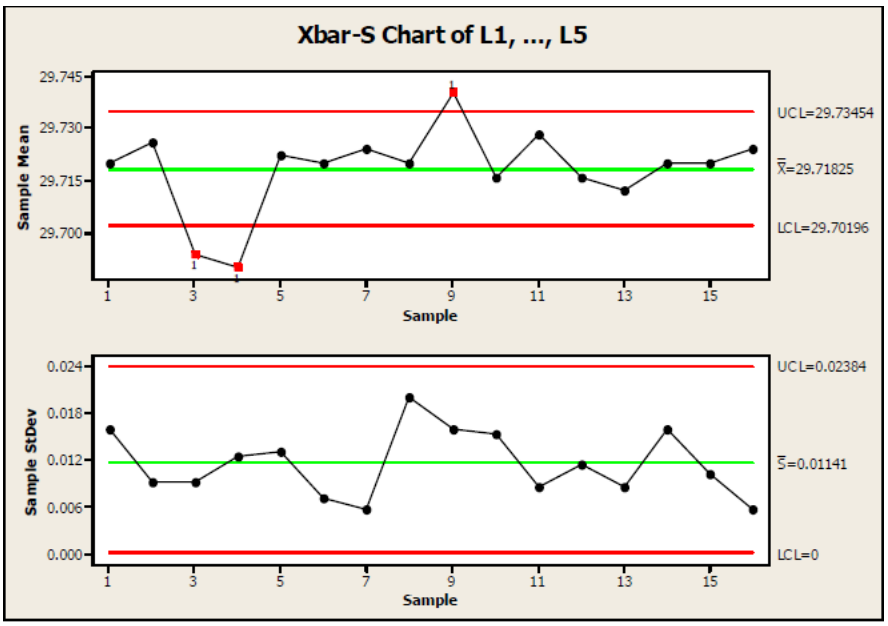


Graph 1. Xbar-R Chart of analysis

One point more than 3.00 standard deviations from center line. Test Failed at points: 3, 4, 9 All the readings of sample are in between specification limit but according to SPC point 3, 4, 9 are out of control limit. X bar and s chart are used to monitor the mean and variation of process based on sample taken from the process at given time one hour. The measurement of sample at a given time constitutes a subgroup. Typically, an initial series of subgroup is used to estimate the mean and standard deviation of each subgroup. During this initial phase, the process should be in control. If points are out of control during the initial phase, the assignable causes should be determined and subgroup should be removed from estimation.

A X bar S chart was developed for this set of data. Being this a control chart for subgroups of a sample, it features the same advantages discussed for the previous one, moreover S is the best estimator of variation and the great sample size allows its application.

The chart shows point 3,4 lying just below and 9 lying just above the upper control limit in the X bar chart and right below the lower control limit of the S chart. In order to check if this was caused only by a random and exceptional event so we have doing a again machine setting with master pin and checking again all parameter of needles.

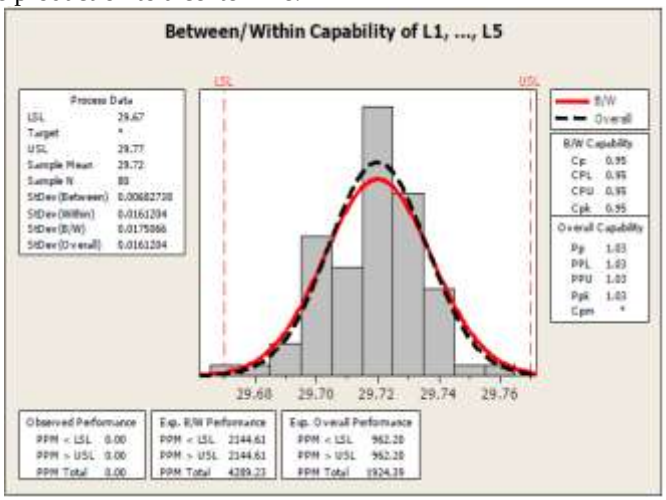


Graph 2. Xbar-S Chart of analysis

Test Results for Xbar Chart of L1, ..., L5
TEST 1. One point more than 3.00 standard deviations from center line.
Test Failed at points: 3, 4, 9

IV. Process Capability

Once a process is stable, it is necessary to determine whether the outcomes of the process can meet customer expectation as described by tolerance limits in most product oriented application and service level agreements in service oriented application. Capability evaluation is method by which we determine whether process is up to the job of meeting up to the job of meeting the specification. It is important, before attempting to establish the capability of process to ensure that the process is stable. The key issue is that if process is not stable the capability will be constantly changing due to transient effect of special causes and hence be uncertain. According to the below figure the producing components in between control limit but it is near to the limits line that's why still there is scope for process to control the production to a center line.



Graph 3: Between/ within Capability for analysis

From above graph we conclude that if Cp is less than 1 the six sigma process spread is greater than the tolerance. From the above Graph the curve is shifted little towards left hand side so that process is not centered. The Cp of cutting operation before process FMEA is 0.95.

V. Conclusions

FMEA is a systemic approach that initially identifies errors, defects and failures which exist in the system/process/project. Secondly, by adopting proper decisions are intended to remove them. Due to this fact, FMEA is named as one of the very important and practical tools for continuous improvement in product quality and service companies. Since quantitative methods have always a special place in the management and scientific studies. Cause and Effect Diagram helped to think through causes of a problem thoroughly by pushing us to consider all possible causes of the problem, rather than just the ones that are most obvious. Ishikawa Diagram and FMEA is a team-oriented development tool used to analyze and evaluate potential failure modes and their causes in wire cutting process. It prioritizes potential failures according to their risk and drives actions to eliminate or reduce their likelihood of occurrence. FMEA provides a discipline/methodology for documenting this analysis for future use and continuous process improvement. It is a structured approach to the analysis, definition, estimation, and evaluation of risks.

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