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Cost Based Process Failure Mode Effect Analysis of Blanking, Forming And Piercing of Hinge L Nova

Dr.S.B.Chikalthankar[1], Dr.V.M.Nandedkar[2] ,G.K.Sahane[3]

[1] *(Department of mechanical engineering, GEC, Aurangabad, India)*
[2] *(Department of production engineering SGGSI&T, Nanded, India)*
[3] *(Department of mechanical engineering, GEC, Aurangabad, India)*
Corresponding Author: Dr.S.B.Chikalthankar

Abstract: FMEA is a methodology used for product and process design, by identifying the potential failure modes and prioritizing them subsequently reduces the error in the process. FMEA technique is systematic tool based on team working which usually can be used for identify, prevent, eliminate, or control of potential error causes in process In this work it is also used as a process development which is implemented in press work part manufacturing industry. The objective of this experimental work is to analyze different failures associated with blanking, forming and piercing operations of press part using Failure Mode Effect Analysis (FMEA). The values of severity, probability of occurrence and detection of each failure mode are taken according to the FMEA criteria and based on these values; Risk Priority Number of each failure mode is calculated. the blanking, forming and piercing operations performed on Hinge L nova part is under study on experimental of FMEA.it observed the RPN of length variation because of burr, forming height variation and piercing hole variation is higher. it is recommended to take 0.5 mm grinding cut on blanking die block , proper locating stopper on die block of forming tool and providing stripper plate with proper hardening of punches maintained up to 58-60 HRC .

Keywords: FMEA-Failure mode effect analysis, Potential failure mode, Risk Priority Number (RPN)

I. Introduction

Press work parts which is set up on die blocks needs to be both efficient and accurate in order to eliminate waste in time and materials [1]. The most expensive part of any operation is in the setup as from a production point of view, no parts are being made. To achieve both accuracy and speed, proper training and operating procedures for repetitive jobs through a standard setup process can help deliver superior results [2].

Press tools are commonly used in hydraulic, pneumatic and mechanical presses to produce components at high volumes. Generally press tools are categorized by the types of operation performed using the tool such as blanking, piercing, forming, trimming etc. Despite all the technology improvements, the operator needs the knowhow and skills to think through the steps to create the part and anticipate problems ahead of time [3].

The press tools machines have many features to take the guess work, the feature richness just adds to the knowledge needed by the operator to understand the die setup possibilities. Press work part manufacturing companies today face the demands of many small runs and tighter tolerance demands by their customers. FMEA is a step by step approach for identifying all possible failures during process. “Failure modes” means the ways or modes, in which something might fails. Failures are any defects or errors, especially ones that affect the customer and can be potential or actual.”Effect Analysis” refers to studying the consequences of those failures [4].

II. Objectives Of Project Work

The main objective of our project work is make improvements in process to reduce rejection in the blanking forming and piercing operations using FMEA. To achieve this following sub-objectives are formulated.

Suggest and implement necessary actions Validate the effectiveness of implemented actions Evaluate the effect of each failure mode Prioritize failure modes based on its RPN and reduce the high RPN.

III. Performance Analysis

2.1 Brainstorming Potential Failure Modes

The manner in which the process could potentially fail to meet

The process requirements (including the design intent). The failure modes of the product which could originate during processing are identified and listed as given in table 1 for each process by method of problem solving and observing customer complaints and rejection/rework records.

Table 1- Brainstorming to find potential failure mode

SN	Process	Potential failure modes
1	Blanking	-Ejection mark problem
		-Blank is not within tolerance limit
		-Length variation in blank because of burr
		-Blanking punch broken
2	Forming	-Forming is not within tolerance
		-Forming Height variation problem
		-Ejection mark
		-Forming punch broken
3	Piercing	-burrs
		-Improper clearance
		-Piercing punch ejection mark problem
		-Piercing hole variation because of frequently punch broken problem
		-Piercing hole oversized

2.2 Ranking Criteria

The criteria used for ranking the severity, probability of occurrences and detection of failure modes are given in table 2 to 4.

2.3 Prioritize the failure mode

The calculated RPN is be used to identify where the team should focus first for improvement. The higher the RPN, higher the relative risks. The table 5 below shows failure modes taken on priority for improvement.

Table 2- Process FMEA severity evaluation criteria

Rank	Effect	Criteria
10	Hazardous to operator	May endanger operator without warning
9		May endanger operator with warning
8	Major disruption	100% of product may have to be scrapped.
7	Significant disruption	100% of production run may have to be rework. (Major rework)
6	Moderate disruption	100% of production run may have to be rework. (Minor rework)
		A portion of the production run may have to be scrapped
5		
4		A portion of the production run may have to be reworked (Major rework)
3		A portion of the production run may have to be reworked. (Minor rework)
2	Minor disruption	Slight inconvenience to process or operator
1	No effect	No effect on product

Table 3- Process FMEA occurrence evaluation criteria

Probability of Failure	Possible Failure Rates	Ranking
Very High: Persistent failures	≥ 100 Per thousand items	10
	≥ 50 Per thousand items	9
High: Frequent failures	≥ 20 Per thousand items	8
	≥ 10 Per thousand items	7

Moderate: Occasional failures	≥ 5 Per thousand items	6
	≥ 2 Per thousand items	5
	≥ 1 Per thousand items	4
Low: Relatively few failures	≥ 0.5 Per thousand items	3
	≥ 0.1 Per thousand items	2
Remote: Failure is unlikely	≤ 0.01 Per thousand items	1

Table 4- process FMEA detection evaluation criteria

Rank	**Likelihood of Detection**	**Criteria**
10	Almost Impossible	No current process control to detect failure mode
9	Very Remote	Failure mode/cause is not likely to detect at any stage.
8	Remote	Failure mode detection in **post-processing** by operator. (visual/audible/tactile means only)
7	Very Low	Failure mode detection **post-processing** by operator (using visual and variable gauging)
6	Low	Failure mode detection **post-processing** by automated controls; stop process to prevent further defectives
5	Moderate	Failure mode/cause detection **in-process** by operator (visual/audible/tactile means only)
4	Moderately High	Failure mode/cause detection **in-process** by operator (using variable gauging)
3	High	Failure mode/cause detection **in-process** by automated controls; automatically stop line
2	Very High	Failure mode/cause detection **in-process** by automated controls; prevent discrepant material from being made
1	Almost certain	Discrepant materials cannot be made because process has been error proofed

Table 5- list of defects taken on priority**:**

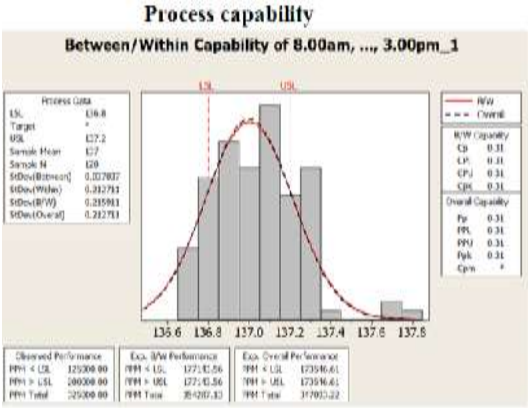
S.N.	**Type of defect**	**RPN**
1	Length variation in blank because of burr	270
2	Forming Height variation problem	112
2	Piercing hole variation because of frequently punch broken problem	252

IV. Case Study And Fmea Analysis

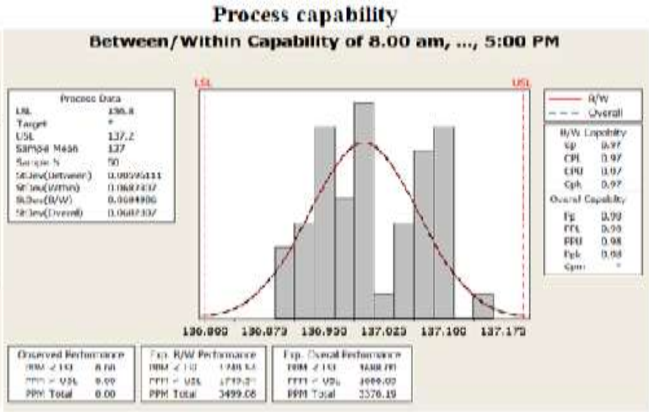
3.1 Burr formation in blanking problem:

Observations from Process Capability Graph:

Process data approximately follow a normal distribution Also the process samples mean of the observed length(136.98mm) is approximately equal to the target length of 137 mm and both the tails of the distribution fall inside the specification limits. Here, the Cpk index is 0.97, indicating that variation in the length is reduced and mean is centered to the required target value. Therefore we can say that the variation in length because of burr is improved after 0.5 mm grinding cut taken on die block of blanking tool and it is capable of meeting customer’s requirement



Graph :Between/within capability of blanking length 137 before FMEA



Graph :Between/within capability of blanking length 137 after FMEA

3.2 forming height variation problem:

Similarly by using process capability graphs ,we find that process samples mean of the observed forming height size is approximately equal to the target forming height size of 12 mm and both the tails of the distribution fall inside the specification limits.Here, the Cpk index is 2.1, indicating that variation in the forming height is reduced and mean is centered to the required target value. Therefore we can say that the variation in forming height size is reduced because by providing locating stopper on die block of forming tool to avoid forming height variation problem**.**

3.3 Piercing punch broken problem:

Similarly the variation in piercing hole size because of frequently punch broken problem is reduced. By providing stripper plate with proper hardening of punches maintained up to 58-60 HRC.

V. Results

After implementing corrective actions, risk priority numbers are recalculated to see the impact of the improvement on process. The RPN after improvement are calculated .

4.1 Percentage Reduction in RPN

The reduction in RPN after performing recommended action represents the effectiveness of FMEA technique.
Percentage reduction in RPN=

$$= \frac{\Sigma \text{Initial RPN} - \Sigma \text{Final RPN}}{\Sigma \text{Initial RPN}} \times 100$$

$$= \frac{1424-1009}{1424} \times 100$$

=29 %

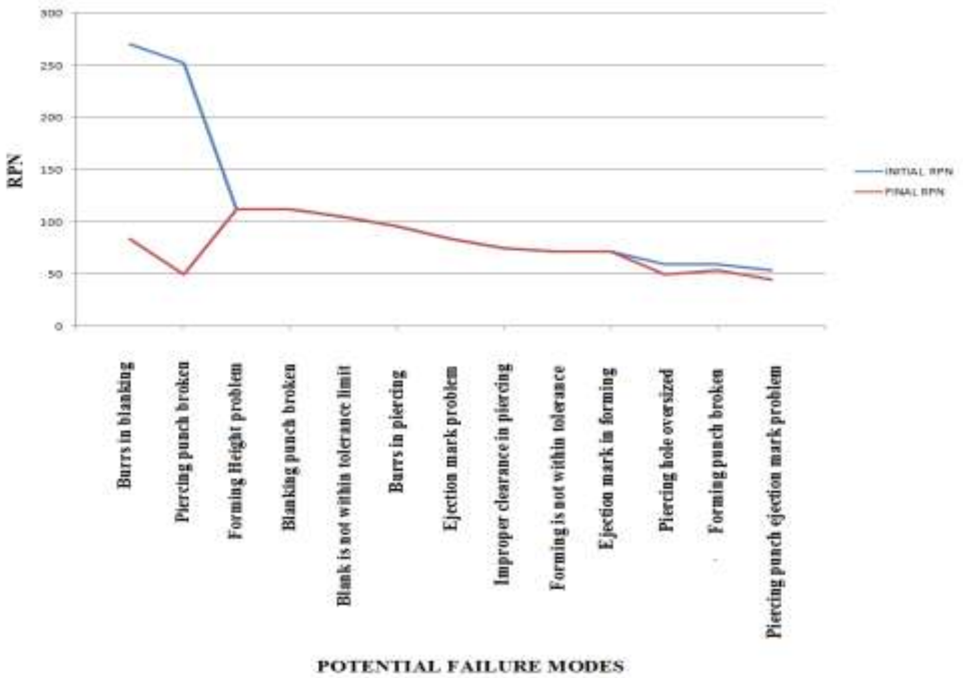


Figure 1: Comparison of RPN's before and after PFMEA

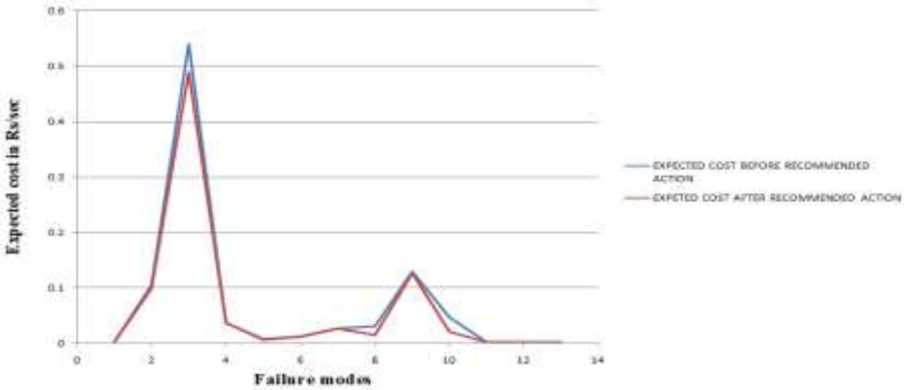


Figure 2: Failure Expected cost before and after action

VI. Result And Discussion

$$\text{Expected cost} = \sum_{i=1}^{13} PxC$$

Expected cost before recommended action=0.93 Rs/sec
Expected cost after recommended action=0.88Rs/sec

$$\text{Percentage Expected cost Reduction} = \frac{(\text{Ec Initial} - \text{Ec Final})}{\text{Ec initial}} x100$$

$$= \frac{(0.93 - 0.83)}{0.93} x100$$

=10.75 %

After performing cost based FMEA, we can save process failure expected cost
Up to maximum Rs 0.1075Rs/sec or 387.108Rs/hr or 3096.86 Rs/shift

VII. Conclusion

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. After performing process FMEA in industry ,the material rejection due to defect of length variation in blank, forming height variation and piercing hole variation are reduced. It is a structured approach to the analysis, definition, estimation, and evaluation of risks. It is found that risk reduction by Cost Based FMEA also explain the saving of cost *i.e.* 0.93-0.83=0.10Rs/sec. Failure cost is reduced by 10.75 %. By providing recommended action process is improved and the improvement can be identified from process failure cost.

After implementing recommended action in Process FMEA about 29% reduction in Risk Priority Number (RPN) is observed.

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