FMEA for improvising the quality Perspectives in a Small Scale Industry

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***Abstract*—Quality plays an important role in a small scale industry. Their customers are the major industries who give importance to the quality, cost and the time concerned about the product. This paper aims to identify and eliminate current and future problems in a company. Ishikawa diagram and the Failure mode effect analysis is used to reduce errors and shorten the development duration and increase product reliability. It also increases the knowledge base in small scale manufacturing company. So, future and current risks are identified. Current controls are evaluated and risk reducing actions are proposed in advance. Furthermore, some measures are proposed to be taken as early as possible to avoid potential risks.**

***Index Terms*—Quality, Bending process, Failure mode effect analysis, Ishikawa diagram, precision press parts, press brake, product reliability, potential risk, sheet metal parts.**

1. INTRODUCTION

Press brake set up needs to be both efficient and accurate in order to eliminate rework and waste in both time and materials (Dale B.G. 1999). 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 (Melan E.H.1995). The press brake can be one of the most difficult machines to run in a precision metal fabrication shop.

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 (Pande S.2000). Modern press brakes have many features to take the guesswork and art out of bending with thickness compensators, automatic spring-back adjustments, and so forth. While these features are invaluable, the feature richness just adds to the knowledge needed by the operator to understand the setup possibilities. Metal fabrication shops 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(Pyzdek T.2003). Failures are prioritized according to how serious their consequences are, how frequently they occur, and how easily they can be detected. The purpose of FMEA is to take actions to eliminate or reduce failures, starting with the highest priority number(Florina C.F.2002).

Implementing standard operating procedures and proper training in process execution go a long way towards achieving consistency in producing high quality parts with minimal waste. This is especially true when comparing part variations produced by multiple operators with different skill levels(Gowen 2002).

2. BRIEF ABOUT THE COMPANY

The company is a medium scaled company and is involved in manufacturing of precision sheet metal parts as per the orders of the customers. More than 2500 different parts are produced per annum. Machinery like CNC Laser Cutting, CNC Punching and CNC Press Brakes are used for production. Bending workstation contributes with 87 out of 221 customer complaints in the year 2011.

The customer complaints for these components were as follows:

1) Fitment Problem with mating part
2) Aesthetically poor
3) Cracks

With these data, decision is taken to concentrate the efforts on the part families contributing maximum number of customer complaints. Air bending, bottoming, coining are the types used in this process.

The primary goal of the project is to eliminate the actual and potential causes for customer complaints in Bending(Barney M.2002). If this succeeds it would mean 40% reduction in customer complaints and subsequent reduction in downtime of bending workstation.

2.1 Formation of Improvement Group

To be able to measure, analyze and improve the current situation there is a need of process knowledge. Thus, it is decided to form an improvement group containing a variety of competences (Sanders D.2000).

The group consists of case company's production engineer, two press brake operators, Quality engineer, PPC In charge, besides two authors.

3. PROCESS FLOW DIAGRAM

The process flow diagram is plotted for the components undergoing bending 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 figure1.

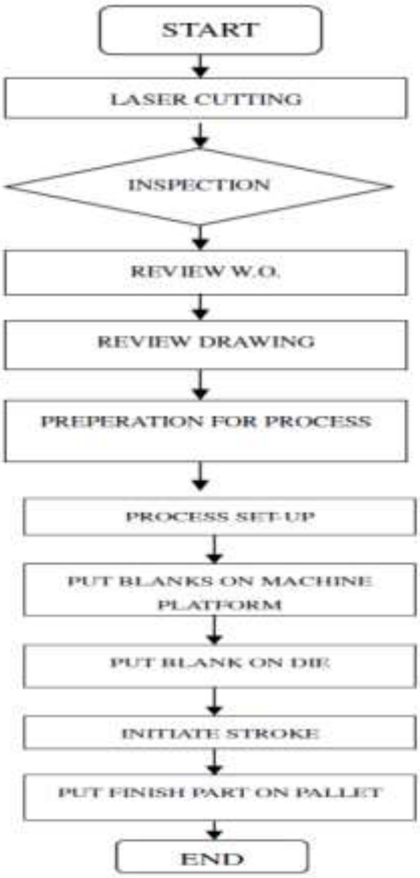

Figure 1: Process flow diagram

3.1 Ishikawa Diagram

The cause and effect diagram also known as Ishikawa diagram is used to find problems in the bending 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 bending process?‖ In the X-Y model, Y corresponds to the number of complaints and X to the causes to these complaints.
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.

4. PROCESS FMEA

The process FMEA was carried out to detect the possible failure modes related to the bending operation and prioritize among them. When working with FMEA the starting point was the process map. The improvement group carried out the tool by looking at each box and to each sub activity and discussing possible failure modes and gives them the Risk Priority Number (RPN). The causes with the RPN number can be viewed in Table1.
The potential failure cause and their effects shown in table -1 are explained here in brief.
Seven main causes were present from the beginning, Method, Machine, Material, People, Environment, Measure and Management.

1) *Lateral shifting of blank*-At the time of placing the blank the blank may shift due to its own weight or slippage due to which bending height vary.

2) *Bending direction missing*- The operator may place the blank on the die with upside down due to which reverse side bend can occur. The operator cannot watch the display of machine to see the bend position every time as one part have minimum 5 to 20 number of bends. This leads to frequent change of operator focus.

3)*Drop height too high*- After the completion of last bend ,the operator drop the part on the wooden pallet or keep on stacker which is not of the suitable size to stack those parts creating distortion in the parts.

4) *Programming error*-Small modifications or changes (made by customers) if not updated immediately or if sufficient test runs are not done by the programmer, it will lead to non conformity in the parts.

5) *Burr at edges*- Small bur left at the edge of blank during laser cutting leads to insufficient contact with the back gauge finger causing to taper bend or bend height undersize.

6) *Incorrect ram speed*- Incorrect selection of ram speed leads to crack at bend radius.

7) *Incorrect pressure selection*- This leads to variation in bend angle as the spring back effect is not compensated.

8) *Improper maintenance*- Sharp edges of dies and punch produce scratches on the surface of base metal. Deformed die lead to variation in bend angle.

9) *Incorrect die*- This leads to bending angle variation, clogging of material in die, deformation of slot near the bend.

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Table 3: Process FMEA

				PROCESS FMEA	KO-Operator control ,visual inspection				
	PROCESS: Bending operation			KO-Operator control, visual inspection		PART NAME:			
	COMPANY:SEL		SIX SIGMA PROJECT	K2-First piece control		RESPONSIBLE:			
	Date of first FMEA:25/2/12		ANALYSIS PHASE	FA-Functional alarm in machine		REVISION NO			
No	OPERATION IN BENDING	POTENTIAL FAILURE MODE	POTENTIAL FAILURE CAUSE	POTENTIAL FAILURE EFFECT	Existing CONTROL	OCCURANCE	SEVERITY	DETECTABILITY	RPN
1	Laser Cutting	Revised program not loaded	No error proof program	parts with missing slots/holes	KO	3	10	7	210
2	check for visual inspection by operator	Inadequate inspection	Large no. of parts	Parts with burn holes pass on	KO	4	10	3	120
				Parts with deflection pass on	KO	2	6	3	36
3	Review of Work Order	W.O. not available to operator	not communicated by PPC	Details of operation not known	KO	3	10	2	60
4	Review Drawing	small details not studied	Material type, grade not highlighted	wrong setting	KO	3	10	2	60
5	preparation for process	discrepancies in data sheet,	modification not approved	discrepancies in parts produced	KO	3	7	3	63
		program nesting, W.O. and drawing							
6	set-up	incorrect set-up	incorrect die	bending angle variation	K2	4	10	2	80
				material crack	K2	3	10	2	60
				material clogged in die	KO	5	5	2	50
				slot/hole deformation	KO	2	10	4	80
			incorrect punch	bending radius variation	K2	4	10	2	80
				material crack	K2	3	10	2	60
			incorrect positioning centered	variation in bend angle	FA	3	7	3	63
		deformed die	improper maintenance	variation in bending angle	KO	3	7	2	42
				pressure setting to be adjusted	K2	3	4	2	24
7	put parts on m/c platform	improper position of parts	manual lifting of parts from	easy and natural rhythm not achieved	KO	3	6	2	36
		and improper stacking	ground level	leading to missing bending sequence					
8	put blank on die	blank not resting properly in	lateral shifting due to self weight	bending height undersize	KO	6	10	8	480
		accurate robust gauge	of blank	other bend dimensions vary	KO	5	10	8	400
			burr at edge	taper bending	KO	4	10	3	120
9	initiate stroke	slippage of blank	improper holding of blank as	taper bending	KO	3	7	2	42
			punch contacts the work			3	7	2	42
10	put finished parts on pallet	handling damage	drop height too high	distortion in finished parts	KO	8	7	6	336

Table 1: Potential failure causes with highest RPN from process FMEA
O-Ocuurance, S-Severity, and D-Detectability

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Potential failure cause	Potential failure effect	O	S	D	RPN
Lateral shifting of blank	Dimensions vary	6	10	8	480
Bending direction missed	Reverse bending	7	10	6	420
Drop height too high	Distortions in finished parts	8	7	6	336
Programming error	Part not conforming	3	10	7	210
Burr at edges	Taper bending	4	10	3	120
Incorrect ram speed	Material crack	6	10	2	120
Incorrect pressure selection	Bending angle variation	8	6	2	96
Improper maintenance	Scratches and dents	3	10	3	90
Incorrect die	Slot/hole deformation	4	10	2	80
Incorrect punch	Variation in bend radius	4	10	2	80

Due to large variety of parts produced in the case company, programs of those parts which are regular are saved. Remaining parts need small readjustment in the program by the operator. Though selection of tooling is done automatically, some parts require operator skill. The tree diagram tool was used to develop improvement measures. When the tool was carried out, instructions in Kliefsjo, Eliasson, Kennerfolk, Lundback and sandstorm were followed The problem was step by step broken down to concrete measures. Those were graded with the Criteria, Efficiency and Feasibility. The scale had four levels namely 0, 1, 3 and 9 points. The points were then summarized which concludes that maximum point is 18.

Total 22 numbers of measures were identified from the tree diagram. It is not possible to implement all these measures at once with respect to cost connected to implementation. The improvement group had a discussion concerning in which order the measures should be implemented A Matrix Diagram was developed with the problems from the FMEA with high RPN rank and measures that seemed to correlate to those problems With the help of matrix diagram and discussions, group suggests that the following measures are implemented as soon as possible

1. Development of Standard Operating Procedure for set-up
2. Development of Standard Operating Procedure for the programmer
3. Design of experiment on bending data(possible subject for Project)
4. Development of Daily checks List for operators.
5. Monitoring of incoming material quality (involving the concerned suppliers)
6. Designing of frame stackers as per physical characteristics of parts.
7. Auto monitoring of blank insertion (to avoid reverse bending and lateral shifting)

Design of experiments on bending data
Mapping of spare parts
Eliminate drop height by designing frame stackers
More strict demand on incoming m/t
Auto monitoring of blank insertion position
Study bending problem for each type for longer period
Develop check list for the programmer
Develop daily check list for operator
Develop Standard operating procedures
econsider part designing w.r.t. the slot/hole position

	MEASURES	E	F	TP
•	Retrieve all stop causes and discard "others"	9	9	18
•	Integrate log book in D-log	9	9	18
•	Permanent items on the agenda with positive things	9	9	18
•	Training in quality	9	9	18
•	Introduce a signal when to measure	9	9	18
•	Conduct capability study	9	9	18
•	Laser cut quality monitoring	9	9	18
•	Development of error proof method	9	9	18
•	Planned stops better planned	9	9	18
•	Start round activity to seek shortages	9	9	18
•	Design of stacking frames as per physical characteristics of parts	9	9	18
•	Create projects	9	9	18

5. 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 bending process. It prioritizes potential failures according to their risk and dries 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.

Following a standard set-up procedure will reduce set-up time and improve part accuracy thereby increasing the press break efficiency. Many measures like standard operating procedures, incoming material variation control, auto monitoring of blank insertion, designing of frame stackers, integration of log book, quality training, immerged to be the most important issues in this project work.

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