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Reduction in Wastage of Sheet Metals by Using Six Sigma

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ABSTRACT: Six Sigma is used to identify and reduce errors and increase the efficiency of business processes. The primary objective of Six Sigma is customer satisfaction, and to achieve the same, various methods are followed to improve the performance of a product or business process. To Reach 3.4 defects per million opportunities over the long term. Seeks to reduce the variability present in process. Structure data driven methodology for eliminating waste from process, products and other business activities while having a positive impact on financial performance. To develop conceptual understanding of important aspects of six sigma. To develop basic skills in statistical data analysis. To develop basic skills in problem definition and analysis by using six sigma tools. The main goal of any Six Sigma implementation is quality improvement. The term originally comes from the sigma rating used to statistically rate manufacturing processes in engineering. A six sigma process occurs when no defects are expected in 99.99966% of all chances to produce them. This is the goal of any Six Sigma implementation. It focuses on the use of statistical improvements to minimize defects in products and services. Precisely how that goal will be manifested will depend on what the product or service you are trying to improve. In some cases, the goal will be to transform the business. In others, specific problems need to be solved or perhaps the business is looking for strategic improvements. Whatever the goal, the process is essentially the same across implementations.

KEYWORDS: Six Sigma; quality; case study; statistical tools and techniques; Six Sigma methodology

I. INTRODUCTION

The Greek letter “Sigma” a statistical term which measures how much a given process deviates from perfection. Sigma is also known as standard deviation of the process from its mean. Six Sigma process enables an organization to measure the number of “defects” in a process, methods to eliminate them and get close to “zero defects” as much as possible. Six Sigma is a measurement-based strategy for process improvement. It’s a methodology, which aims at improving process and increasing customer satisfaction. The concept behind this approach is to reduce the variation in processes. This reduction leads to consistent and desired outcomes from processes. Hence, Continuous process improvement with low defects is the goal of this method. Six Sigma is a quality management methodology used to help businesses improve current processes, products or services by discovering and eliminating defects. The goal is to streamline quality control in manufacturing or business processes so there is little to no variance throughout.

II. LITERATURE SURVEY

Mohamed K Hassan, etal, discussed the application point of lean six sigma in reduction of wastage in welding wire company. In their work, they pointed out 80% of wastage was accounted through old fashion equipment, process shutdown due to lack of raw materials, poor control of water glass mixing, and poor maintenance planning. 80 – 20 rule was implemented. The cause for 80% of waste generated through obsolescence, insufficient raw material supply, improper maintenance schedule or plan, lack of cleanliness, etc. The researchers set forth the target to around 2% and sort to achieve it through DMAIC of Six Sigma. The monthly waste monitoring and reporting was meticulously designed for the purpose of bringing the waste to below 2%. They installed a new control panel for drawing and cutting machines thus replacing the existing panel of poor condition. As a measure of prevention of lack of material inventory other suppliers for steel wire identified and continuous supply of raw material was maintained. A complete

maintenance program was implemented with experienced person's to look into it. All these steps resulted in increase in yield to 95.75% and the sigma level was found to be 3.22 corresponding to 42,500 units.

Hari Supriyanto, et al^[2] took the case study of gas stove manufacturing unit and classified the type of activities as value added (VA), necessary but non value added (NNVA), and non value added (NVA). Based on a long process and overall activity that flow along the production process, there is 23.3 % value adding activity and 35.19 % is necessary but non value adding activity, as well as 43.52 % is non-value adding activity. It shows that there are still a lot of waste that are peppered throughout the production process flow. Therefore, the non-value added activity must be identified more depth to know the type of wastes that is hidden and does not appear on the surface. Non value adding activity is an activity that causes wastes. In seven types of waste as calculated and weighted seen that the highest weight is on defect waste. This waste connected directly with defects per million opportunities (DPMO) as input to calculate the value of sigma. Based on the identification of defects and critical to quality-CTQ, types of non-conforming that cause its defects waste can be obtained. CTQ can be used as basis for generating alternative solutions. The second waste was inappropriate processing and causes defects in products. Which causes in appropriate processing is inaccuracy in the process of blanking machine, the machine that makes holes for process of joining by using the process of the rivet. The third waste is waiting waste. Waiting waste is a certain amount of time when operator does not use the time to perform value added activities due to waiting for flow of products from the previous process. However, based on the first waste, it can be concluded that a defect and / or nonconformities are caused by the waste that is inappropriate processing waste. The process associated with this defect is blanking process. One reason for the failure is the blanking punch pressure-less; and this is caused the electric power lacking. The emergence of these wastes will result in waste of waiting. This waste gives an indication of the long lead time, and causing a decline in production capacity. Another consequence is the decline in productivity.

Fernanda Gonc, et al^[3], on their research work on improving productivity by reducing operation cost as six sigma process improvement showed the estimated losses in factory due to poor productivity. Estimated losses in factory due to poor productivity exceeded 100 K Euros in 2006-2007 financial year Productivity improvement would generate hard and soft savings. As per data, there is wide variation in process through put times. Assembly lines are highly unbalanced due to no value added content. Component having high Quality issue. Line stoppage, High NVA & TPT, High TPT. The solution provided consist of line stoppage through removal of hex screw, recalibrating the standards, repairing the moulds etc. In the case of high NVA and TPT, they replicated steam iron cooling jig, automated cold setting process, and checked temperature on sampling concept. The sieve unbalance <10 mg and run out occurred with motor coupler were controlled to increase the capacity of pop up testing jig along with simplified packaging and cleaning stages. Reprogramming of m/c. Reduce nozzle diameter. Make work instruction and training. Revision of critical spares list. Change into plastic caps. Modify dimensions. Training was provided. Addition of cooling fans on top. Proper capacity of compressors were incorporated in the design. Gradual phasing in of standing working. One to one communication Channels. Increase the table height.

Vikash Gupta, et al [4], on their six sigma application in tire manufacturing company identified the problem through voice of customer and the variation in the bead splice of a particular product were taken into account. After finding the root causes, the corrective actions were taken in the order of checking the bead splice after setup, set advancer as per guideline to get the target value achievable were done on the higher side 1 and on the lower side 1, measuring tape for every line, follow up on timely basis were made. The process capability index was also computed after implementing corrective actions. After improvement in process, the capability index Cpk value is improved to 2.66 which shows that process is capable. It is clear that variability in the process reduced drastically. To maintain the achieved process performance of the Six Sigma quality level, the above four steps of DMAIC methodology must be applied periodically. Rajeev Trehan, et al [5], in their work on implementation of lean six sigma framework in a large scale industry, collected data was analysed by the team and it was found that most of the defects occurred during the soldering operation and during the de-panelling operation. The collected data indicated that the company is operating at 23% defect rate before implementation of Six Sigma process. The aim of this case study was focused on systematic reduction in the defect rate of LED tube. There were nine types of defects during the production process. These defects are lamp not glow, blinking, low voltage, high voltage, driver not ok, aluminium housing not ok, dry soldering, aging fail and visual not ok. Out of these nine defects frequency of two defects, i.e., driver not ok and aging fail was high. Also, when faced with the increased demand, the prime focus of the management shifted to meeting the target output levels. This resulted in less time and energy left with management for focussing on the quality function. This caused an increase in number of defects (short circuit of driver, weakening of solder joints, aging failure and so on), increased rework cost, scrap cost and work in process inventory. Finally, it was concluded that most of the customer complaints



were related to the unreliable LED tube life (as low as 500 hours in some cases) in comparison to the claimed life (28,000 hours). The aim of the team members was to identify the root cause of problem and to reduce the occurrence of defects in the production process. This situation forced the top management to rethink its strategies in the deployment of quality initiatives taken initially. The management was suggested to hold a brain storming meeting with the senior managers of different departments and finalise various possible projects to avoid any error at later stage. It was decided to use lean as well as Six Sigma tools for continuous improvement. The lean tools help in streamlining the process and elimination of waste existing in the form of idle time and excessive in process inventory thus helping organisation uncover the nonvalue added activities of the process. On the other hand, Six Sigma tool involves the use of various statistical tools with a defined methodology for finding the root cause and reducing variation thus facilitating the process of continuous improvement.

Thus, the team proposed solutions to overcome the two problems being analysed. To improve the aging failure problem, the team suggested conducting the aging test for eight hours. This will at least reduce the frequency of external failures. When the test was carried out for eight hours it was observed that many LED tubes failed during this test because of short circuit of driver. The cause of the short circuit was found to be decomposition of extra flux deposited on the PCB during the wave soldering operation. The flux gets decomposed as it gets charged during the aging test of the driver thus leading to short circuit of driver. To overcome this problem, it was necessary to identify and remove the extra flux on PCB. The quality control inspector, who was inspecting PCB driver informed the project team that many a times the drivers being inspected carry dust and due the dust, extra flux is not immediately visible and the inspector fails to identify the defect. The housekeeping and cleaning situation in the company was not very good and was one of the main reasons for dust accumulation on driver PCBs.

To ensure the supply of cleaned driver PCB required for accurate inspection, it was decided to introduce 5S system in the organisation. The aim behind 5S system is to eliminate the hidden waste by implementing a set of actions to maintain the work place. Organisations use this 5S system to reduce the non-value-added time. 5S stands for Seiri (sort), Seiton (set in order), Seiso (shine), Seiketsu (standardise) and Shitsuka (sustain). The results showed increased visibility of the extra flux left on PCB after soldering. Hence the detection of flux during inspection became easier. In order to reduce the idle time during the production process, workers were provided with the rack facility so that they can pick the component very easily. Moreover, marking was done on each rack which helped to reduce the time for tracing the required component. Proper floor cleaning was introduced in the shop floor area which ensured the health and safety of the worker. Routine maintenance was implemented, i.e., cleaning, lubrication of machines and inspection. This practice increased the availability of machines and tools and helped in achieving the daily production target.

III. PROBLEM IDENTIFICATION

Laxmi Metals manufacturers of pressure cooker in different capacities (3L, 5L, 7.5L, 10L and 12L) in total of 800 pieces per day are manufactured. In an average, 64 numbers of defects per day were observed and moved to scrap. In a day, overall 8% of production defects are observed. Revenue loss to the company is about Rs.1,276 per day and overall Rs.459,360 per year.

Scope:

- Streamline the production process.
- Identify and troubleshoot manual errors in production unit.
- Standardizing the machinery capabilities and calibration process.
- Eliminating variations in production process.
- Identifying the Production imperfection.

What type of company?

Household cook wares manufacturing company

Project Implement Section: Pressure cooker

IV. PROPOSED METHODOLOGY

The DMAIC methodology should be applied:

- When an existing process or product already exists but still needs to meet a Six Sigma level or customer specification.
- DMAIC - Define, Measure, Analyze, Improve, Control



- DMAIC is a data-driven quality strategy used to improve processes. It is an integral part of a Six Sigma initiative, but in general can be implemented as a standalone quality improvement procedure or as part of other process improvement initiatives. DMAIC is used by a project team that is attempting to improve an existing process. DMAIC provides structure because each phase of the process contains tasks and tools that will lead the team to find an eventual solution. The main goal of DMAIC is to eliminate expensive variation from business and manufacturing processes.

DEFINE:

The main objective of this phase is to summarize the project plan. This phase focuses on clearly specifying the problems; the goals of the process improvement project what is the scope of the project and identifying the customers (internal and external) along with their requirements. An input to this phase comes from the voice of customer (VOC) and the voice of business (VOB). With the help of these inputs, six sigma projects are identified. In this phase, we identify opportunity for six sigma projects. We develop a project plan and high-level process map.

MEASURE:

The main objective of this phase is to collect the data that is relevant to the scope of the project. This phase focuses on identifying the parameters that need to be quantified, ways to measure them, collect necessary data and carry out measurement by different techniques. It gives common language & understanding of data being collected. After data collection, data is analysed to ascertain its nature through frequency distributions. The histogram can be used to understand the distribution of data. Depending upon data nature data - analysis tools are decided. Current Process capability is also an important aspect to be understood in this phase. Two commonly used measurement techniques are – Defects Per Million Opportunities (DPMO) and Process Sigma.

ANALYSE:

The main objective of this phase is to find the root cause of business inefficiency. It identifies the gaps between actual and goal performance, determine its causes and opportunities for its improvement. Analyse phase follows a drill down approach to reach exact root causes from various potential causes identified initially. This phase starts with exploring all possible causes to the main problem. Then, these causes are verified & validated through hypothesis & statistical tools. The outcome of this phase is verified root causes – which need to be acted upon to improve the process. Analyse phase requires due care to identify & verify root causes. Because the effectiveness of process improvement through six sigma project lies on the correct identification of root causes. Commonly used tools in Analyse phase are Fishbone Diagram, Brainstorming, Histogram, Hypothesis testing, Time series plots and Scatter plot.

IMPROVE:

This phase improves the process by determining potential solutions, ways to implement them, test and implement them for improvement. In this phase, process owners are consulted and improvements are suggested. Action plan for the improvement is circulated to relevant stakeholders. This action plan specifies – Action to be taken; By when By whom etc. The improvement plan is designed to mitigate the risk and include customer feedback and satisfaction. With the formation of improvement action plan, implementation phase starts simultaneously. Tools used to eliminate the defects are Brainstorming, Mistake-proofing (Poka Yoke), Simulation software, Prototyping, Piloting and Pugh Matrix. During implementation, actions are carried out, tested for effectiveness and implemented finally.

CONTROL:

The main objective of this phase is to generate a detailed solution monitoring plan. This plan ensures that the required performance is maintained. It defines and validates the monitoring system, develops standards and procedures, verifies benefits and profit growths, and communicates to business. Hence, the main purpose of Control phase is to ensure – Holding the gains. During this phase, post-implementation results are evaluated. Progress is ascertained. And Changes are incorporated - if any, correction or modification is required. Control phase in most of the cases is a transition phase. Transition happens from current practices and systems into new practices. The most important part of this phase is to provide training on new changes to all relevant stakeholders. Important tools used in control phase are Process sigma calculation, Control charts, Cost saving calculations and Control plan.

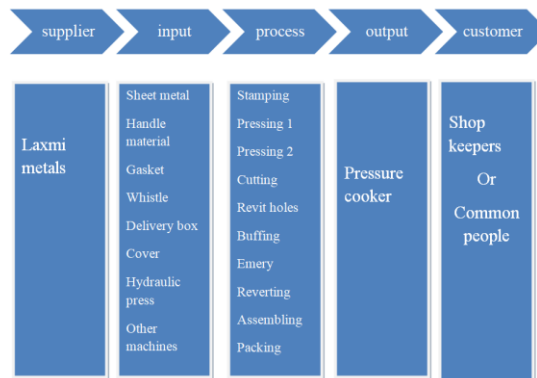


V. DATA COLLECTED RELATED WITH PROBLEM

DEFINE:

During this phase, we select the most critical and impactful opportunities for improvement. This phase is about mapping the process, focus, scope and the ultimate goal.

SIPOC :



VOC:

Less availability.

VOB:

- Material loss is high
- Revenue loss due to defect product.

MEASURE:

This phase provides baselines which are drawn to assess the performance of a given process.

Total number of products manufacturing per day : 800 units.

Defects per day : 64 units

Total time taken for single product : 15 mins

STEP	PROCESS	INPUT	OUTPUT	REWORKED	SCRAPPED
A	Raw Material	820	800	--	20
B	Pressing 1	800	775	--	25
C	Pressing 2	775	770	3	5
D	cutting	770	764	4	6
E	Revit holes	764	761	2	3
F	Buffing	761	759	1	2
G	Emery	759	757	1	2
H	Reverting	757	756	0	1



SI . NO	PROCESS	NO OF MANUFACTURING PRODUCTS	DEFECTS	LOSS OF COST(Rs.)
1	Stamping	800	0	0
2	Pressing 1	800	25	725
3	Pressing 2	775	5	145
4	cutting	770	6	174
5	Revit holes	764	3	87
6	Buffing	761	2	58
7	Emery	759	2	58
8	Reverting	757	1	29
9	Packing	756	0	0

Rs.1276/day

Without considering process loss

Process Sigma using DPMO Method,

- Total number of products manufacturing per day (T) = 800
- Numbers of defects per day (Z) = 64
- Defects per Unit (DPU) = 0.08
- Percentage of defects (n) = 8
- Defects per Opportunities (DPO) = 0.01
- Defects per Million Opportunities (DPMO) = 10000
- Sigma level = 2.55
- Target 4 Sigma
- Target DPMO = 63

ANALYSE:

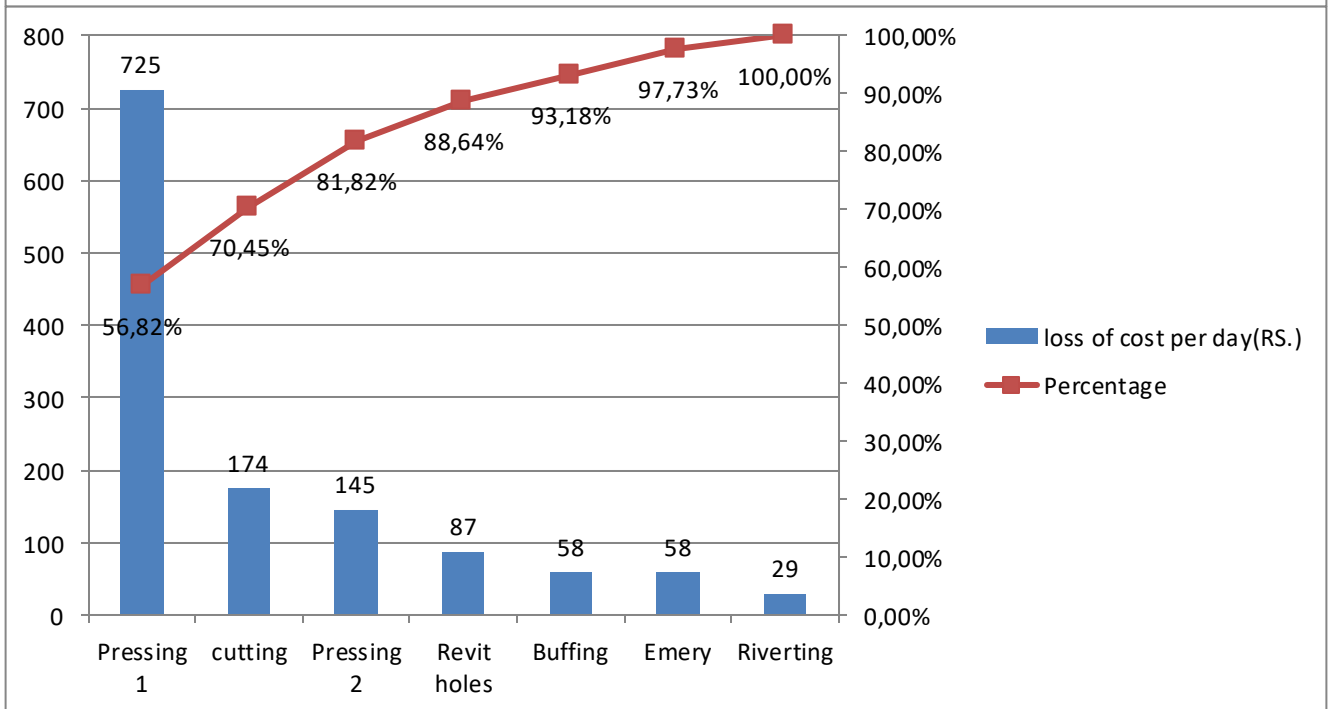
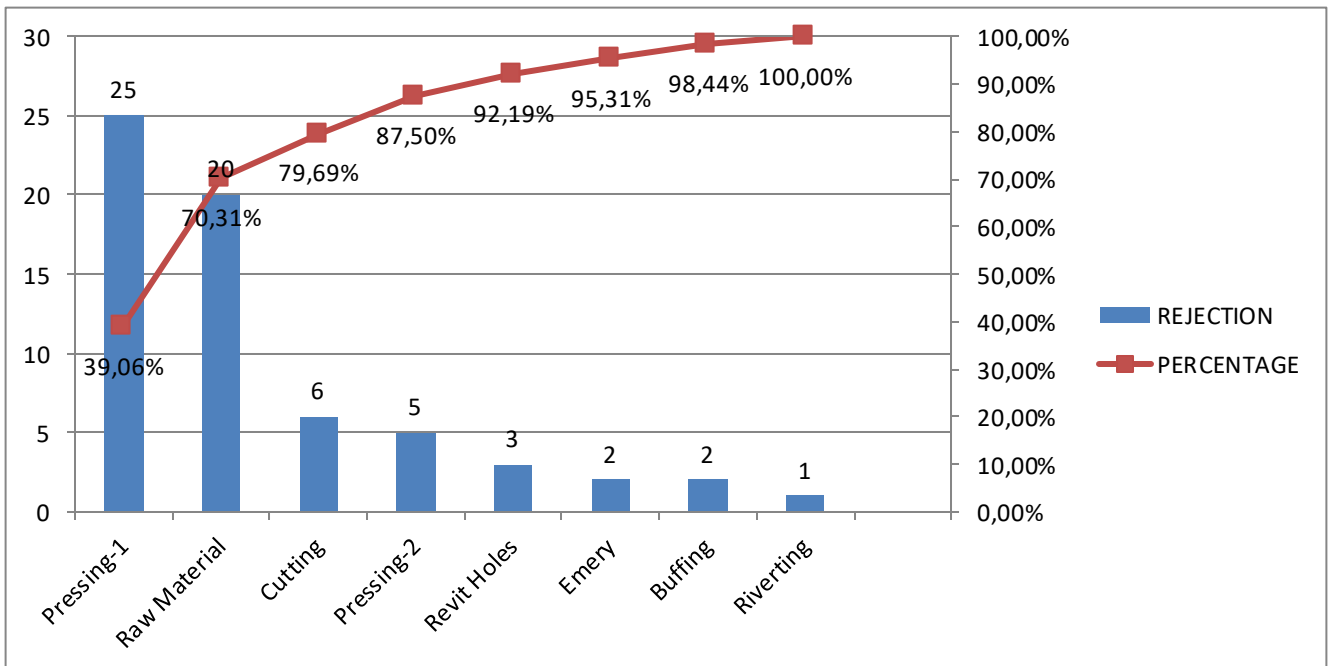
In this phase, our goal is to identify and test the underlying causes of problems to make sure that improvement takes place from deep down where the problems stem from.

Brain Storming:

- Using 80/20 rule, we solely thought of concentrating in 20% of the process, where 80% of the defect occur (ie.,) in Raw Material, Pressing and cutting, leaving out other 80% of the process which produce 20% of waste.

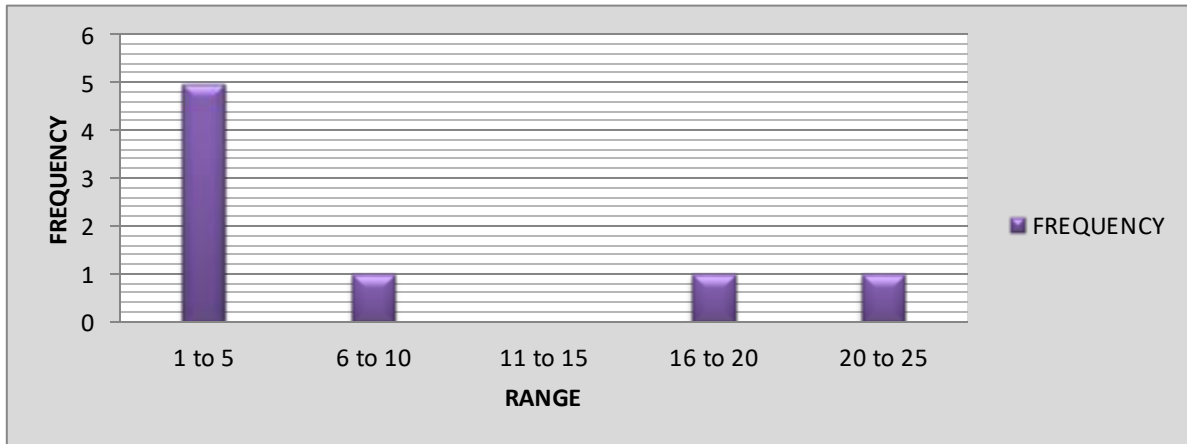
PARETO CHART:

A Pareto chart is a graph that indicates the frequency of defects, as well as their cumulative impact. Pareto charts are useful to find defects to prioritize in order to observe the greatest overall important.



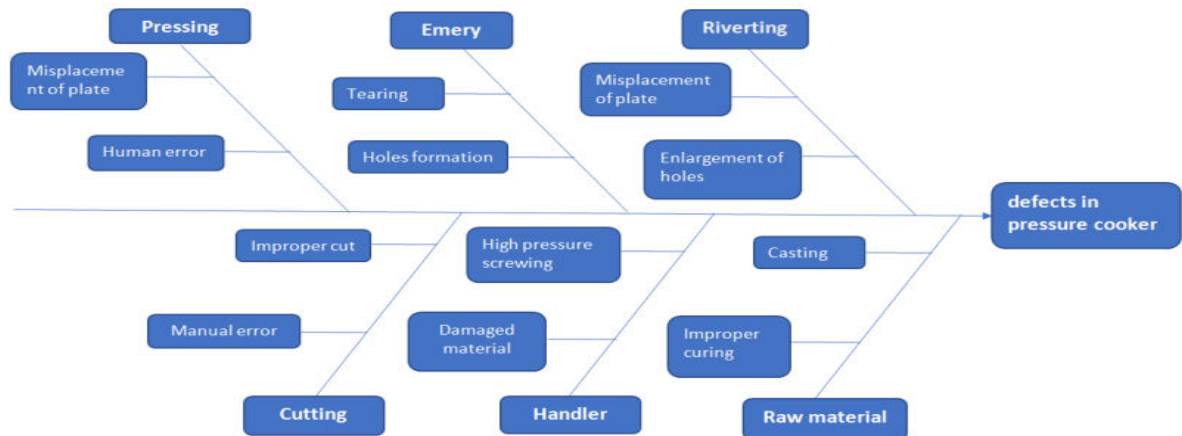
HISTOGRAM:

Histogram provides a visual interpretation for the project which is used to determine count range of damage in number of processes.

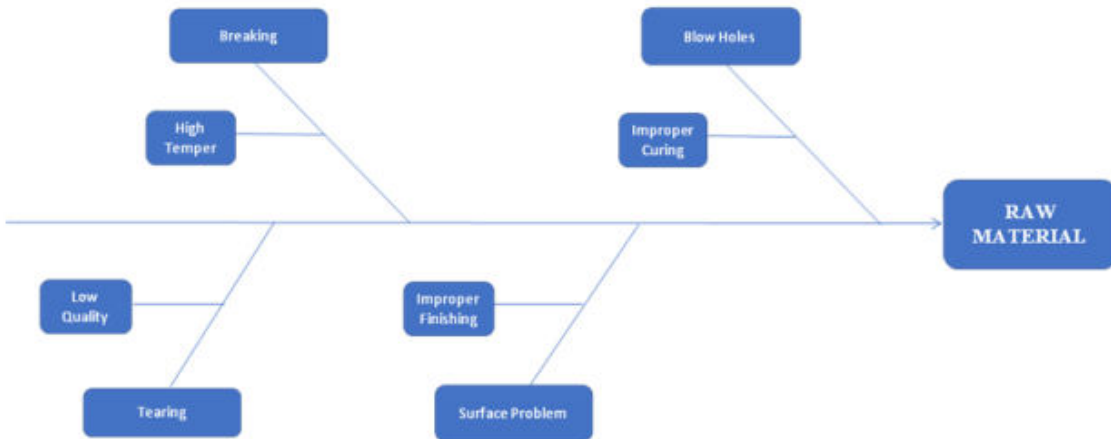


FISH BONE DIAGRAM:

A cause and effect diagram, often called a “fishbone” diagram can help in brainstorming to identify possible causes of a problem and in sorting ideas into useful categories.

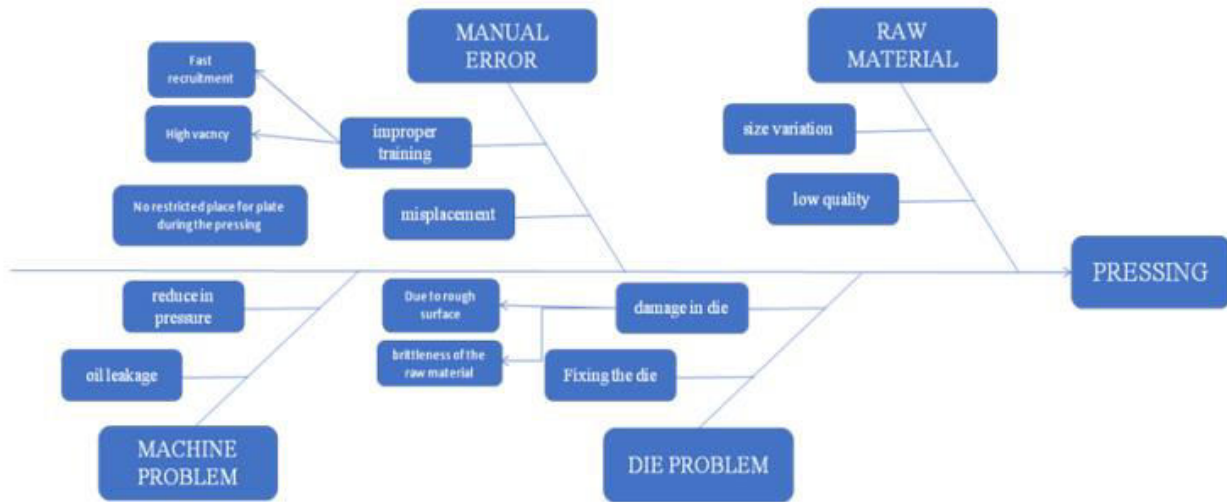


For Raw Material





For Pressing



VI. PROPOSED SOLUTION

IMPROVE :

Improve process performance by addressing and eliminating the root causes.

Brain Storming:

- At the time of pressing, we will get 20 defects (due to misalignment) based on the defects will introduce a stopper. A stopper should be semi automated or manually operatable .
- Raw material, we would suggest NDT machine (Ultra sonic testing machine) .Is used to analyze raw material defects.
- During cutting process, we suggest to hammer with minimum force to remove the cut section, in case problem arise.

Total no of defects reduced using ideal solution = 35

PROCESS	INPUT	NUMBER OF DEFECTS BEFORE ANALYSE PHASE	NUMBER OF DEFECTS RECTIFIED USING IDEAL SOLUTION
Pressing 1	800	25	24
Pressing 2	775	5	5
Cutting	770	6	6



DPMO & Sigma level calculation for reduced defects:

Total number of defects before analyzing (Z) = 64
 Total number of defects after the improve phase (Zi) = 29
 Total number of products manufacturing per day (T) = 800
 Defects per Unit (DPUi) = 0.03625
 Percentage of defects (ni) = 3.6%
 Defects per Opportunities (DPOi) = 0.0045
 Defects per Million Opportunities (DPMOi) = 41

Sigma	Level	=	4.1
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CONTROL :

Percentage of profit from lost (ie.,) from Rs.1276 to Rs.261

79.54%

Overall revenue profit per day = Rs.1015

Overall revenue profit per year = Rs.3,70,475

The before mentioned conditions should be followed strictly to maintain 96.37% of profit.

- The testing machine should be installed according to the preference of the company, each and every plate must be tested.
- In pressing the plate should be placed in between the stoppers
- The employees must be trained, negligence not allowed.

RESULT:

The target DPMO & Sigma level is reached and the revenue profit obtained is Rs.3,70,475/ year.

VII. CONCLUSION

Studied theoretically and applied practically to reduced the wastage of sheet metals by using Six Sigma. 8% of defect percentage is reduced to 4% of defect by applying DMAIC method. Defined and mapped the process to find where the criticality occurs then measured the parameters that need to be quantified after that analyzed by using Six Sigma tools like pareto chart, histogram, fishbone diagram, etc., and finally improved the process and controlled the parameters that causes defects. After control the defect materials are reduced and production is increased and the revenue is also increased by 96.37%. Rs.1276 loss per day is reduced to Rs.261 and the total revenue profit of Rs. 3,70,475/ year is obtained.

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