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Pareto, Scatter, Cause & Effect Analysis Carried Out for Optimizing Process Route to Achieve Defects Less VMC Machined Copper Components

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Abstract*:* The objective of the work is to investigate the various reasons for the defects that occur in forged/machined components. During mid-low volume production, quality check for each and every component is tedious work leading to increase in production cost. Hence causes for the defect should be addressed during the process itself. Reducing the inspection time and number of rejections during manufacturing is addressed using Lean-Six Sigma principles. The techniques are applied to understand the defect and then to eradicate the same during serial production. This helps to reduce the inspection as well as rework times leading to reduction in cost. Deviations in hole diameters are identified and improvements suggestions such as are made. Improvements such change in lubricants & cutting fluids during high speed machining which increase the production rate and reduce the defects. Through the improvement in coolant oil & lubricant oil during high speed machining process are key points suggested through lean six sigma approaches.

Keywords: Cause and Effect Diagram, Check sheets, Scatter& Pareto chart.

1. Introduction

The Lean Six Sigma is a mix of lean and Six Sigma that emphasis on nonstop process change. Lean Manufacturing is an idea of enhancing the speed and effectiveness of an association by dispensing with squander [1]. Then again Six Sigma is a persistent change arrange for that is proposed to diminish fluctuation. At the point when connected fittingly in a procedure industry, can help in taking out waste, improve the nature of item, and accomplish [2] better and smooth control on operations and in this manner decreasing the generation cost and creation time [3]. An efficient way to deal with distinguishing and dispensing with squander through consistent change, streaming the item at the draw of the client in quest for flawlessness [4].

2. Methodology:

The methodology used for manufacturing forged component contains following sequence of processes with selection of raw material, pre-heating, forging, trimming, pickling turning, drilling, milling and final inspection. From the table 2 the forging and previous operations are carried out [5]. Vertical milling centre (VMC) is used for removal of surface layer of the material with specified dimensions using milling tool and there milling parameters are mentioned in table 3. Drilling process is also peformed on the components with require dimension in same VMC machine itself and the drilling paramters are mentioned in table 4. Finally inspection for components, to check with requied dimension and whether it is accepted to standards & specification mentioned by the customer, Otherwise it will be considered as defective product. Quality control and assurance makes regular inspection to each and very process at different stages should have there own standards to maintain to evaluate the process and reduce the defect of the product [6].

Table: 1 Process Plan

Process Description	Machine, Jigs, Fixtures	Process	Evaluation, Measurement, Technique
Receipt of Raw Material	-	Inwards	Weighing machine & RMTC

Heating	Induction Furnace Machine	Heating	Pyrometer, Controller
Forging	Friction Screw Press 400 Tones	Forging	Thermocouple, Pyrometer, Radius Gauge, 2D Height Gauge, CMM, Dig. Vernier Calipers
Trimming	Trimming Press 100 Tones	Trimming	Visual
Pickling	Pickling Setup	Acid	Visual
Coining	Friction Screw Press 200 Tones	Coining	Visual, Radius Gauge, 2D Height Gauge, CMM, Dig. Vernier Calipers
Turning	CNC Machine 1.Rough Facing 2.Rough Turning 3.Finish Facing 4.Finish Turning	Turning	2D Height Gauge, CMM, Dig. Vernier Calipers, Roughness Tester, Contracer, Visual
Slot Milling	Gang Milling	Turning	Dig. Vernier Calipers, 2D Height Master, Roughness Tester, Contracer, Visual
Drilling	VMC Machine	Drilling	Plain Plug Gauge, 2D Height Gauge, Dig. Vernier Calipers, Contracer
Final Inspection	Manual	Manual	CMM, Vernier Calipers, Conductivity Meter, Visual

Table: 2 Forging Parameters

Process Parameters	Values
Slug Temperature	680°-720°C
Die Temperature	100°-200°C
Friction Screw Press	400T

Table: 3 Milling Parameters

Process Parameters	Values
Feed	28mm/min
Speed	750 rpm

Table: 4 Drilling Parameters

Process Parameters	Values
Machine	VMC
Tool Diameter	6.225mm drill
Feed	200mm/min
Speed	100 rpm
Drill Depth	19.0 max
Coolant Oil	Water Soluble Oil
Tool Bit Material	Carbide Tool
Cycle time	53
Cutting Time	44

Figure: 1 Vertical Milling Machine

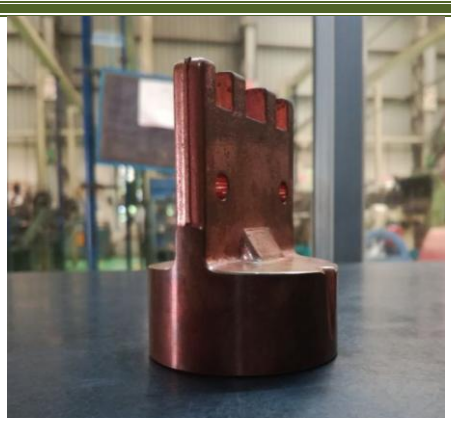

Figure: 2 Electrical BreakerComponent

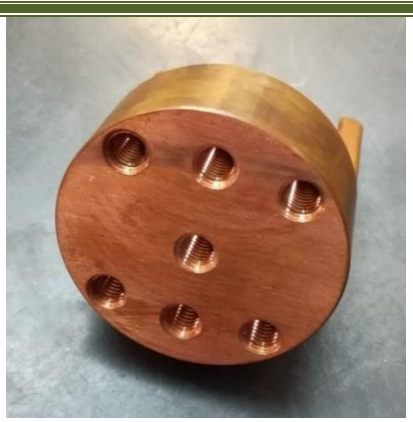

Figure: 3 Component Bottom View

3. Data Collection & Analysis of Data for Product – Bottom Holes

3.1 Cause & Effect:

According to the manufacturing process of forged component, it involves in various process. During the various process causes deviations within the dimensions, it leads to defects. It can be reduces by using the cause and effect process in each and every process. It is easy to find where the effects are raised due to some causes. Here the cause and effects diagram is drawn, according to process that are involved in the manufacturing in forged component.

Cause-and-effect Diagram: For Drilling

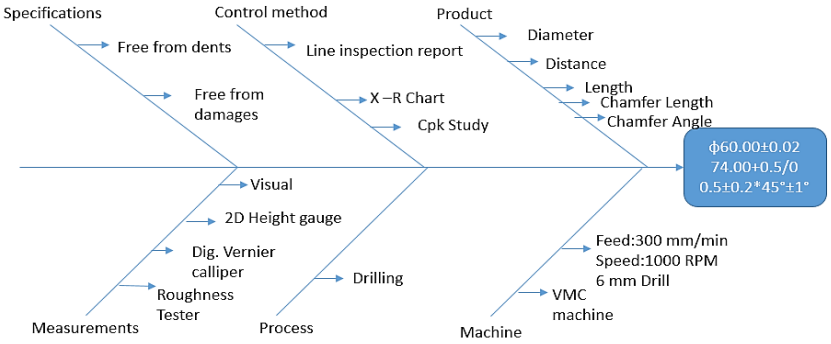

Figure: 4 Cause & Effect for Drilling

3.2 Pareto Chart:

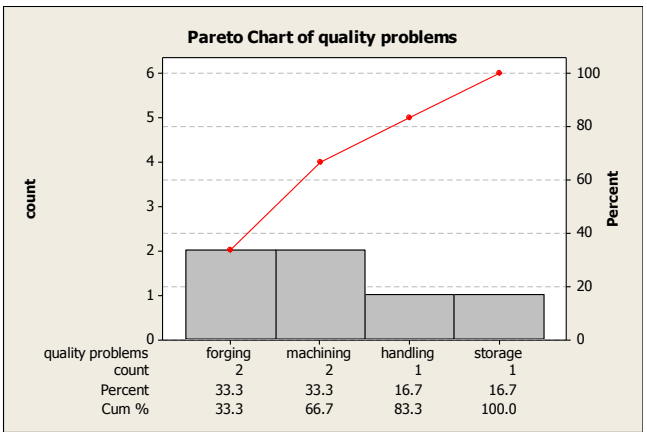

Figure: 5 Pareto Chart

Pareto Analysis:

Pareto Analysis is a statistical technique in decision-making used for the selection of a limited number of tasks that produce significant overall effect

- Create a vertical bar chart with causes on the x-axis and count (number of occurrences) on the y-axis
- Arrange the bar chart in descending order of cause importance that is, the cause with the highest count first
- Calculate the cumulative count for each cause in descending order
- Calculate the cumulative count percentage for each cause in descending order. Percentage calculation: {Individual Cause Count} / {Total Causes Count}*100.
- Plot the cumulative count percentage of each cause on the x-axis.
- Join the points to form a curve.

3.3 Scatter Diagram:

Table: 5 Scatter Diagram Readings

S.NO	1	2	3	4	5	Average	Cycle Time
1	6.8920	6.7820	6.7800	6.7500	6.7580	6.7924	59
2	6.7880	6.6980	6.7900	6.8750	6.7780	6.7858	55
3	6.8000	6.8020	6.7580	6.8000	6.7700	6.7860	57
4	6.7800	6.7900	6.7820	6.7680	6.8010	6.7842	55
5	6.7680	6.8000	6.7600	6.8020	6.8100	6.7880	57
6	6.7800	6.7500	6.7500	6.8000	6.7700	6.7700	53
7	6.8000	6.7700	6.7860	6.7700	6.7900	6.7832	55
8	6.8020	6.7800	6.8020	6.7600	6.7600	6.7808	55
9	6.8100	6.7600	6.8100	6.7580	6.800	6.7876	58
10	6.8100	6.800	6.7800	6.7770	6.7800	6.7894	58

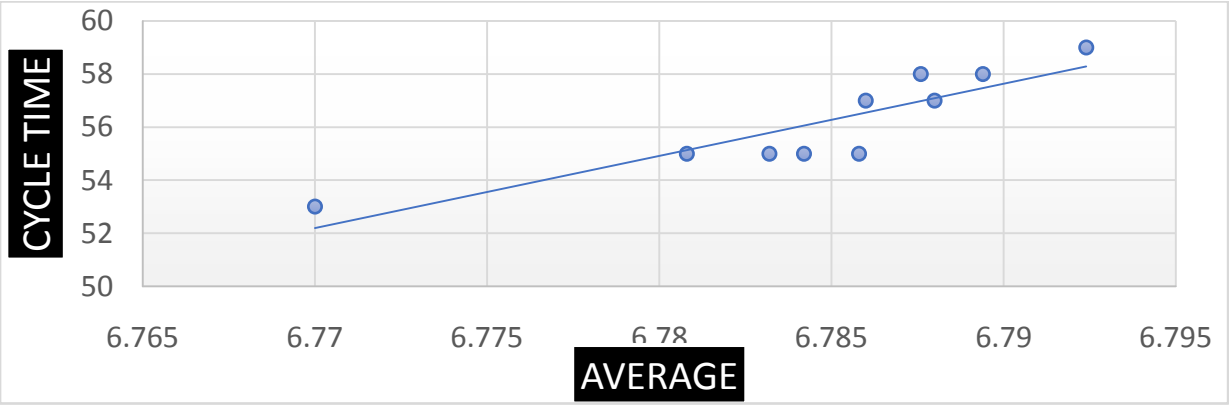

Figure: 6 Scatter Diagram

Scatter diagram:

Scatter diagrams are a graphical tool that attempts to depict the influence in one variable as on the other one. A common diagram of this type usually displays point representing the observed values of one variable corresponding to another variable.

- On the vertical axis, we take cycle time of each sub-group size and on the horizontal axis, we take average of diametrical values. Take the cycle time of 5-components in each sub-group size
- As the cycle time increases the number of deviations that are occur within the components
- Not only the cycle time, may also involve some other parameters to causes deviations within the hole

- It is easy way to estimate the components furtherly how many are going to defect with respective to required value

4. Results & Discussion

Coolant:

Metal cutting generates heat due to friction and energy lost deforming the material. The surrounding air has low thermal conductivity meaning it is a poor coolant. Ambient air cooling is sometimes adequate for light cuts and low duty cycles typical of maintenance, repair and operations (MRO). Production work requires heavy cutting over long time periods and typically produces more heat than air cooling can remove. By using liquid coolant the tool get cools and significantly removes more heat rapidly, and can also reduce the friction and tool wear. However, it is not just the tool which heats up but also the work surface. Excessive temperature in the tool or work surface can ruin the temper of both, soften either to the point of uselessness or failure, burn adjacent material, create unwanted thermal expansion or lead to unwanted chemical reactions such as oxidation.

5. Conclusion:

The objective of the work is to investigate the various reasons for the defects that occur in forged/machined components. During mid-low volume production, quality check for each and every component is tedious work leading to increase in production cost. Hence causes for the defect should be addressed during the process itself. Reducing the inspection time and number of rejections during manufacturing is addressed using Lean-Six Sigma principles. Cause and Effect diagram are plotted to for the thorough understanding about the forging & machining parameters which influence on the manufacture product. Scatter plot and the Pareto analysis are used to find the defect which are occurring in region and need to be consider through special response to eliminating the causes and optimize the parameter for the operation. The above techniques are applied to understand the defect and then to eradicate the same during serial production. This helps to reduce the inspection as well as rework times leading to reduction in cost. Deviations in hole diameters during the manufacturing of forged cum VMC machined components are identified. Improvements such change in lubricants & cutting fluids during high speed machining which increase the production rate and reduce the defects. Through the improvement in coolant oil & lubricant oil during high speed machining process are key points suggested through lean six sigma approaches.

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