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Investigation of Variability of Cylinder Head Machine

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Abstract: **Six sigma tools and techniques have been implemented by the various business organizations. Now a day's manufacturing sector is also widely accepting as a high performance strategy tool for the continuous process improvement. Process improvement is nothing but an understanding between current process and new process that improves the quality of product, efficiency of process and reduce the defects. This methodology can be applied to find out critical causes of the process variation. This paper presents the different types of defect like dowel pin shift, variation in bore size of cylinder head is reduced by using six sigma DMAIC and FTA. The data for defects is collected and experimentation has been done by using six sigma and fault tree analysis which results in process improvement and reduction of defect of cylinder head.**

Keywords: **Six sigma DMAIC (Define - Measure - Analyze - Improve -Control), fault tree analysis (FTA), Project charter, process capability**

I. INTRODUCTION

In the manufacturing sectors like automobile the real challenges are arising for improvement of the process which improve the quality as well as the productivity of manufacturing firm. The defects in the product could lead to poor quality and high rejection. The rejection of product has negative impact on the economical growth of the organization. In 1950 the introduction of total quality management concept helps to improve the performance of the process. But there was some limitation to total quality management which evolves the new concept of six sigma. Now days introduction of six sigma DMAIC methodology is recognize as simple and powerful problem solving methodology. Six sigma is used to analyze the variation in the process stages for reducing the defects less than 3.4 defects per million opportunities (DPMO).In this paper the defects in the cylinder head has been identified. These defect is reduced by using different phases of six sigma DMAIC. In define phase the critical to quality Characteristic which cause process variation and rejection is defined and the data collection is done. After that in analyze phase the process variation factors are calculated and improvement by using cause and effect diagram and Fault tree analysis is done.

II. LITERATURE REVIEW

Today many manufacturing industries are adopting six sigma methodologies. Six sigma is highly focused for the quality program. Also various researchers on process improvement and defect reduction using six sigma DMAIC.In present studies K.Srinivasana et al. (2014) they study focuses on reduction/elimination of two imperative responses in spray painting process producing shock absorbers, namely peel off and blisters using the six sigma (DMAIC) approach that highly impacts quality at customer end. G. V. S. S. Sharma et al. (2014) their present work elaborates on DMAIC approach applied in reducing the process variations of the stub-end-hole boring operation of the manufacture of crankshaft. This statistical process control study starts with selection of the CTQ characteristic in the define stratum. Virender Verma et al. (2014) this paper presents DMAIC approach is a business strategy used to improve business profitability and efficiency of all operation to meet customer needs and expectations. In the present research work, an attempt has been made to apply DMAIC approach. The emphasis was laid down towards reduction in the defects Blow holes, Misrun, Slag inclusion, Rough surface occurred in the sand castings by controlling the parameters with DMAIC technique. G. Furga et al. (2009) this paper gives the methods of achieving results like the reduction of variability of manufacturing processes and the optimization of their control. This paper presents the possibilities granted by the Six Sigma methodology in efficient identification of special factors influencing pre-heat of ceramic moulds and casting parameters, in the minimization of the frequency at which they occur, and in the reduction of key process parameters variability.

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III. METHODOLOGY

Six sigma is highly disciplined concept for reducing process variation to give customer satisfaction, cost reduction and economical growth of organization. Six sigma mainly has two methodologies DMAIC and DMADV. DMAIC as stands for the Define, Measure, Analyze, Improve and Control. While, DMADV is stand for Define, Measure, Analyse, Design and Verify. DMAIC methodology generally used for improving process or reducing the variability of process.

A. Define phase

The define phase is the process or problem that forms the focus of the project A study of cylinder head manufacturing and machining company was undertaken to reduce the variation in the process of machining which causes defect and rejection. The face milling, chamfering, finish boring drilling is performed on the block of cylinder head. Various operations are performed on cylinder head could lead to defects. As Fig.1 shows dowel shifted, Fig.2 defines the bore oversize of 40 mm respectively. For the dowel shifted the operation is performed on the Vertical machining center no.1 where first rough boring and then finish boring operation were performed on Vertical machining centre 3.this machine has hydraulic circuit mechanism and various cutting tools. For oversize of bore it is found that hydraulic pressure is also a critical factor. Due to this increase in rejection takes place.

Fig.1 Cylinder Head Dowel Shift and patch mark

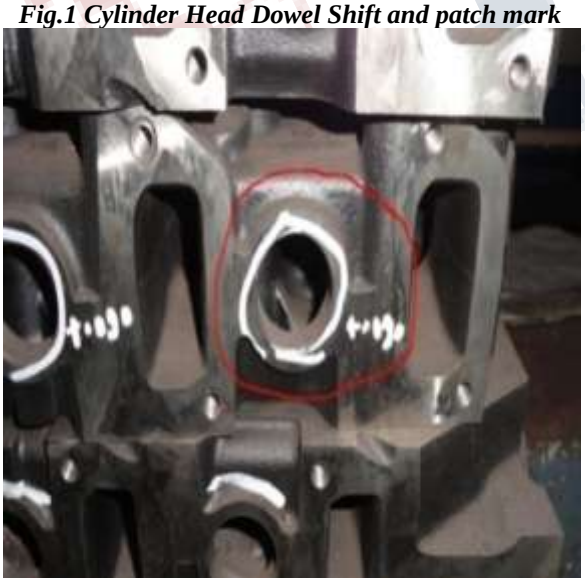
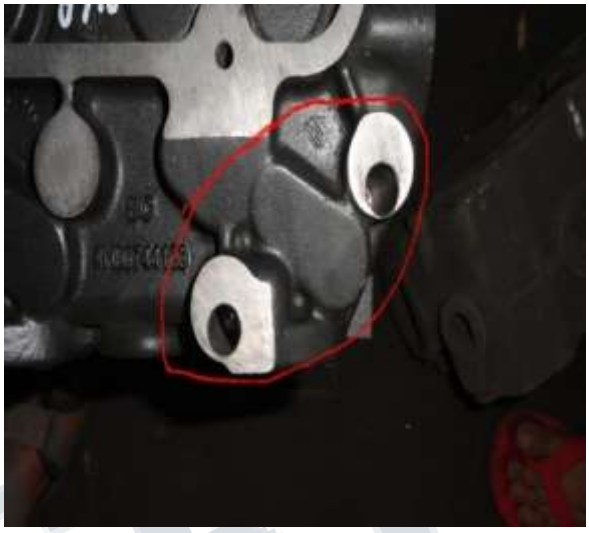


Fig.2 Oversize of bore



So, the project charter team is deployed to identify the potential causes. The motive of project charter is to define the scope and variables. The project charter consists of project manager, quality manager, operator and scholars as in Table I

Table. 1 Project charter of cylinder head

Project Title	Defects and variation reduction of cylinder head machining.
Business Care	Variation causes the defects which results in rejection and rework of cylinder head
Problem statement	To reduce variation and defects using six sigma DMAIC and FTA in manufacturing firm.
Voice of customer	High rejection and poor productivity
Project Member	project manager, quality manager, operator and scholars
Project Frame	To focus on machining process of cylinder head
Benefits	Reduction in process variation and enhance productivity as well as quality

B. Measure phase

Measure phase is the next phase where robustness of the processing stage against unnecessary variations which occurs due to uncontrollable factors is measured by process capability analysis. In the process capability analysis the data

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collected which is responsible for the defects as dowel shift and bore over size. The fig 3 illustrate the current process for dowel shift and patch mark which looks very lean the sigma level is 0.49 and fig.4 illustrate the process capability for bore oversize is of sigma level 2.23. From below capability analysis it seen that process improvement should be enhanced.

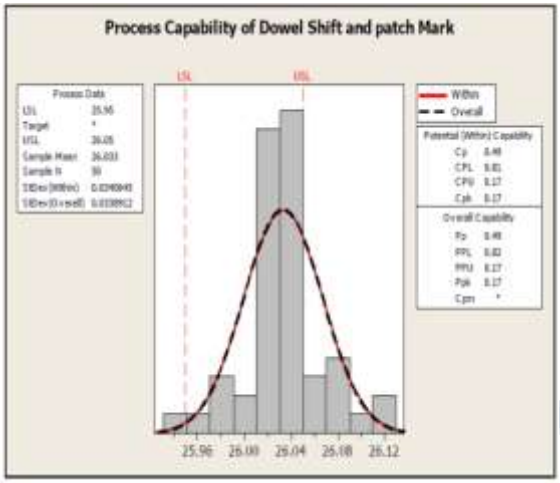

Fig.3 Process capability of dowel shift and patch mark

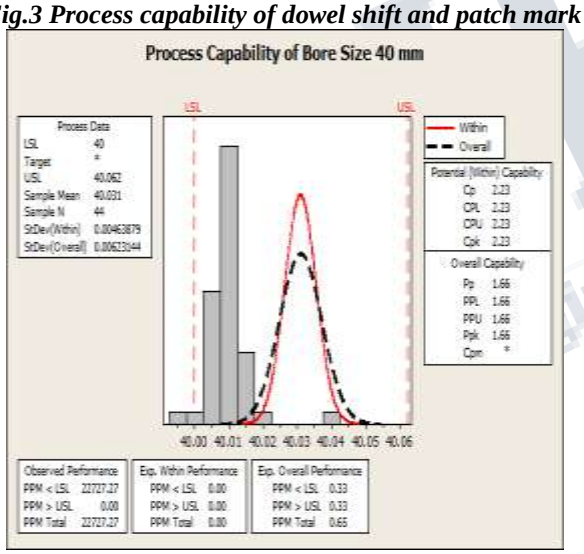

Fig.4 Process Capability of bore size 40 mm

C. Analyze Phase

The analyze phase is the crucial phase. It is the phase where the new process set up actions has been taken by analyzing the sources of variation. Mostly there is more than one cause of variation. But there is usually a root cause more important than the other causes, this root cause has to be identified and eliminated later on. This phase describes the potential causes identified which have the maximum impact on the high rejection rate, causes for low productivity.

Pareto Analysis: The Pareto diagram shows the total number of defects and Nature of defect on Y axis and X axis respectively. From the diagram percentage of defect occurred from the counts as shown in fig.5.the most cumulative percentage is of dowel shift and bore oversize which required to be controlled.

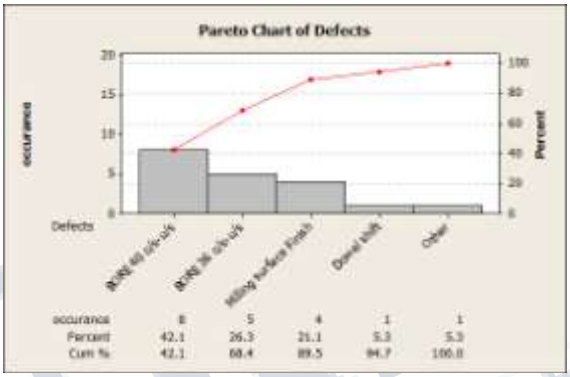

Fig.5 Pareto analysis of Various defects

Fishbone Diagram for Dowel shift

For dowel shift cause and effect diagram is constructed. Cause-and-effect diagrams also called fishbone diagrams. They show the relationships between potential causes and the problem. Once the Cause-and-effect diagram is constructed, the analysis would proceed to find out which of the potential causes were in fact contributing to the problem.

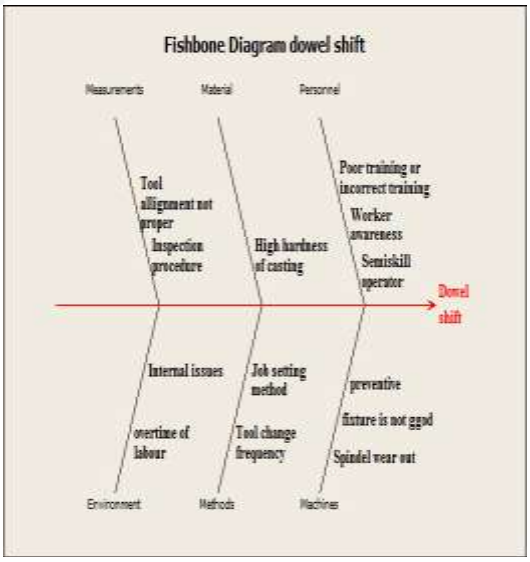

Fig 6. Fishbone diagram dowel shift

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Fault Tree Analysis (FTA) of Oversize of bore Ø 40mm

The fault tree analysis is the tool which is used when problem has been occurred.FTA gives the tree diagram It is started with problem like. Variation in Bore. For this oversize of bore primary factors and secondary factors were find out. After performing the FTA, data was collected between all the input parameters and the output parameter. This data was used to perform statistical test to find out the possible statistical relationship between the output parameter and the input parameters. Regression tool was used to model this relationship. In fig.8 factors like spindle wear, tool angle, rest clamp wear, tool insert setting are major factors and ambient temperature, hydraulic oil pressure, slide pressure are secondary factors

From below fig.7 it is seen that all theses input parameter can affect the oversize of the bore so, we are now to develop the hypothesis testing for whether the data is related or not.

Ho: Data are not related which called as null hypothesis

Ha: Data are related is alternate hypothesis.

Also P value gives the appropriate answer about whether the statistical relationship exist or not. So,

If P >=0.05 then accept null hypothesis

If P < 0.05 then reject null hypothesis. by collecting data the residual plot for formed from input parameters.

The input parameter like ambient and hydraulic oil pressure was taken for correlation but it was found that both parameters was not affecting the output. Thus for multi variant regression analysis theses parameter rejected.

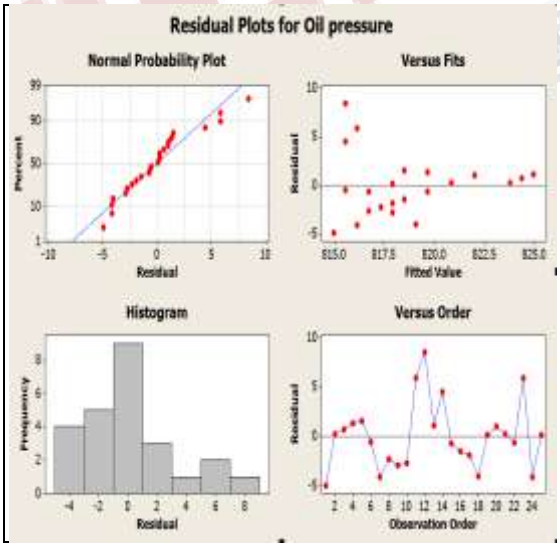

Fig.7: Residual Plots for oil pressure

Now the regression analysis for input parameters like hydraulic oil pressure and slide pressure are taken and correlation is done shown in Table.2 from equation it is found that oil pressure and slide pressure are related. After that regression analysis is shows that R-sq test is below 45%.

Regression analysis: Oil pressure Vs Slide pressure

The regression equation is

Oil pressure = 709 + 0.058 Slide pressure

Table .4 Regression Table

Predictor	Coef	SE coef	T	F
Constant	709.32	25.20	28.15	0.0612
Slide Pressure	0.5870	0.1353	4.34	12
S = 3.42865 R-Sq = 45.0% R-Sq(adj) = 42.6 %				

It proves that this continues input parameters are not affecting output parameter so null hypothesis was failed. From this we can conclude that other machine factors are related to defect of bore oversize. For this we can take cause and effect analysis.

IV. RESULT

A. Improve phase

Analysis phase gives good idea about what to be improved so, in this phases we are going to improve the process by taking right action plan for causes. This could lead to improvement of the process.

For dowel shift it is operation in which drilling of 8mm is done which require precision of hole so, this type of defect occurs mostly due to fixture is not set properly and semi skilled operator.

For boring operation require high precision so by taking continuous data of bore size it is found after some samples the oversize of bore has been take place. This is due to change in the indexing of tool insert which gives increase in tolerance up to +0.008 mm which is above specification limit so, by checking tool insert after 40 cylinder head the tolerance remain within range. Also spindle wear causes the oval shape of bore which gives the rejection. That has been eliminated by changing spindle.

The action plan for improvement of process as

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Table.3 Improvement plan

Improvement Action Plan	Action
Hydraulic pressure	Multi vari analysis
Fixture Setting	Visual analysis
Indexing of tool	Insert tool 002" Back
Play in boring tool	Replacement of Bush

V. CONCLUSION

Industries have to deal with a problems related to quality control. Substandard quality affects the productivity of the plant which directly affects the company targets. The rejection of cylinder head causes the loss of quality. Also the defect like dowel shifts and bore oversize eliminated by using Six sigma DMAIC methodology. Six Sigma technique was adopted for the problem resolving. The factors for dowel patch mark eliminated by brainstorming and bore oversize done by regression analysis from that it is found that hydraulic oil pressure and ambient temperature are not affecting but other factors like play in boring tool indexing tool insert at 0.002" back and replacement of bush has been done which give play in boring tool reduces bore size also indexing of tool in action plan by 0.002" reduces the rework by 5% from the data collected. Dowel shift of cylinder head has occurred due to resting pad wear out which causes misalignment of dowel pin hole so that was replaced. By using six sigma the rejection and process variation of machining process has been controlled by statistical tools.

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