

RIVETING PROCESS CHARACTERIZATION IN BRAKE LINED SHOE ASSEMBLY USING SIX SIGMA TOOL

Submitted in partial fulfilment of the requirements for the award of

MASTER OF BUSINESS ADMINISTRATION

by

PRASANTH M

Register No.40410121



SCHOOL OF MANAGEMENT STUDIES

SATHYABAMA

**INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)**

**Accredited with Grade "A" by NAAC I 12B Status by UGC I Approved by AICTE
JEPPIAAR NAGAR, RAJIV GANDHI SALAI, CHENNAI - 600 119**

APRIL 2022



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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of **PRASANTH M 40410121** who carried out the project entitled “**RIVETING PROCESS CHARACTERIZATION IN BRAKE LINED SHOE ASSEMBLY USING SIX SIGMA TOOL** “ under my supervision from 07TH February to 31st March 2022.

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Dean – School of Management Studies

Submitted for Viva voce Examination held on _____

Internal Examiner

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DECLARATION

I **PRASANTH.M (40410121)** hereby declare that the Project Report entitled “**RIVETING PROCESS CHARACTERIZATION IN BRAKE LINED SHOE ASSEMBLY USING SIX SIGMA TOOL**” done by me under the guidance of **DR. DHIVYA SATHISH** is submitted in partial fulfilment of the requirements for the award of Master of Business Administration degree.

DATE:

PLACE:

PRASANTH M

ACKNOWLEDGEMENT

I am pleased to acknowledge my sincere thanks to Board of Management of **SATHYABAMA** for their kind encouragement in doing this project and for completing it successfully. I am grateful to them.

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PROJECT COMPLETION CERTIFICATE

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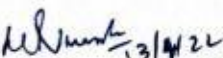
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C E R T I F I C A T E

This is to certify that Mr. **Prasanth M**, 2nd year **MBA** Student of **SATHYABAMA INSTITUTE OF SCIENCE AND TECHNOLOGY, Chennai** has done his **Project Work in Drum Brake Unit** from **7th February 2022** to **31st March 2022**.

His Project Work on "**Riveting (Orbital) process characterization in Brake Lined shoe Assembly**" was completed successfully.

We wish him success in all his future endeavours.


N Lakshminarasimhan
General Manager (P& HR- LVBU)



Regd. Office: 21, Patullos Road, Chennai 600 002.



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ABSTRACT

Brakes India is a leading Automobile Brake system manufacturer for four wheelers from passenger cars to heavy commercial trucks serving its customer in India & abroad. Brakes India adopts various tools like Total Productive Maintenance (TPM), Toyota Production System (TPS) in its business process to improve the productivity & fulfilling the customer needs. Now we started using Six sigma tools, so as per company objective & management direction we have identified Riveting process characterization for New Model Lined Shoe assembly.

We have taken the project of Riveting process (orbital machine) characterization in lined shoe assembly which is one of the key processes in Rear Brake assembly. In this project we have used the DMAIC approach to characterize the riveting parameters. In “Define” phase we have identified the Process parameter for Product requirements in riveting process (orbital machine). In “Measure” phase, the response (product requirements) & factor (process parameters) are identified and trial runs are Identified through Minitab Software and trials were conducted. In “Analyze” Phase, collected data has been analyzed and arrive the factors which contribute & which don’t contribute for response. In “Improve” phase, trials were conducted to validate the contributing factors with response. The optimized parameters are arrived & validated. In “Control” Phase, based on contributing factor, optimized parameters factor is standardized in SOP. which gives the desired response. The optimized parameters are updated in relevant documents. From the above project analysis using six sigma, the application of six sigma tools & DMAIC were well learnt & understood.

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CHAPTER-01

INTRODUCTION

1.1 INTRODUCTION TO SIX SIGMA:

Six Sigma (6σ) is viewed as a systematic, scientific, statistical and smarter approach for management innovation which is quite suitable for use in a knowledge –based information society. The essence of six sigma is the integration of four elements (Customer, Process, Manpower & Strategy) to provide management innovation as shown below.

SMART MEANS

S – SPECIFIC

M –MEASURABLE

A – ATTIANBLE

R – RELEVANT

T – TIME BOUND

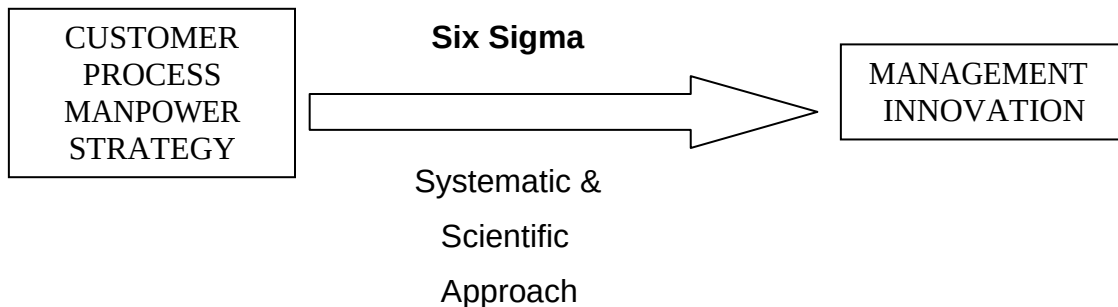
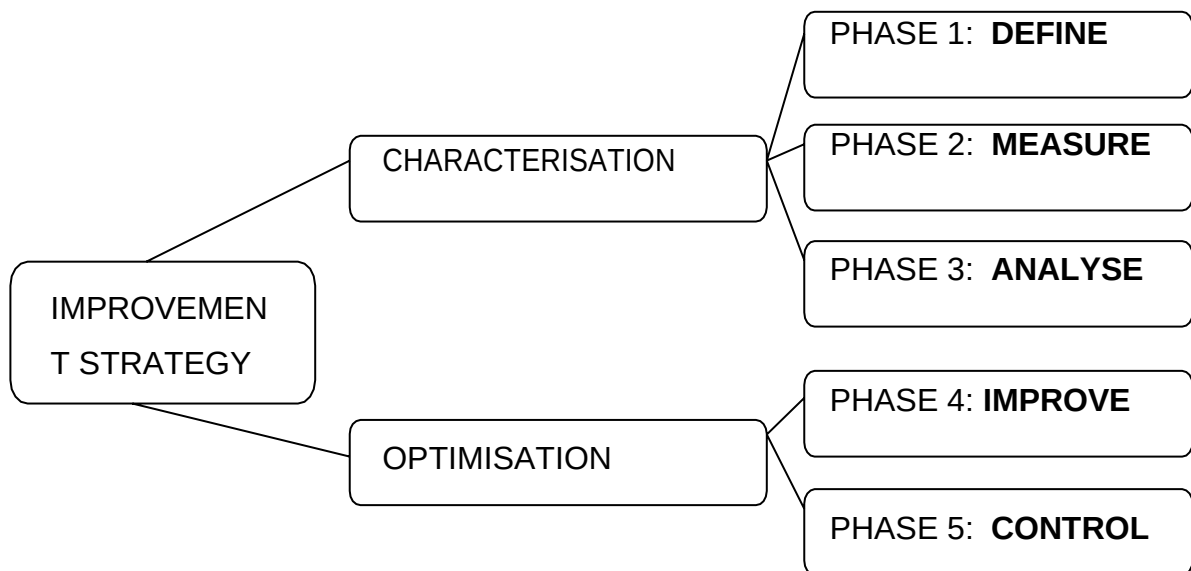


Figure 1.1

Six sigma provides a scientific and statistical basis for quality assessment for all the activities through measurement of quality levels. The six-sigma method allows us to draw comparisons among all processes, and tells how good a process is. Through this information, we can (our team) learns what path to follow to achieve process innovation and customer satisfaction.

Six sigma statistical tool which is widely followed by major industries for problem solving in the business processes from manufacturing to service segments. The advantage of the six sigma it has simple inbuilt statistical tools like Shainin DOE, Component search, Multi Vary analysis etc. The tools can be used easily with minimum statistical knowledge & calculation in all manufacturing process. It also reduces the no of trails, testing time & testing rejection. The decision making in six sigma are based on the current data or past data trend, here we don't give room for the "Atmospheric Analysis" (Decision making based on Judgment). Hence it helps to find out exact root cause for the problem.

The most important methodology in six sigma management is perhaps the formalized improvement methodology characterized by DMAIC approach. This DMAIC approach works well as break through strategy. Companies everywhere apply this six-sigma methodology as it enables real improvement and results. The methodology works equally well on variation, cycle time, yield, design and others. It is divided into five phases. In each phase the major activities are as follows.



SIX

Figure 1.2- DMAIC

Six sigma follows the 5-phase approach – DMAIC approach. DMAIC process (Define, Measure, Analyze, Improve & Control) is scientific approach moves step by step, which ensures problem is defined properly, Ensure Measurement system & method are good so that data captured are accurate without any errors. Then the problem is analysed properly through various tools and root cause are identified. In Improve phase, corrective action is taken, the corrective actions are validated with response. Finally in Control phase, sustenance of counter measures is also ensured.

1.2 BREIF OF DMAIC APPROACH:

Six sigma methodology is characterization of DMAIC Approach is followed in this process optimization project.

It contains following 5 Phases:

- Define
- Measure
- Analyze
- Improve
- Control

Process optimization of mixing process is identified for analysis through Six Sigma to reduce the power cost.

1.3 DEFINE PHASE

The define phase consist of following activities

➤ Team Chartering

- Business case
- Problem Statement
- Project scope
- Timing plan & mile stone.
- Roles & responsibilities.

➤ Customer Focus

- Critical to Quality (CTQ)

- Critical to Satisfaction (CTS)
- Critical to Cost (CTC)

➤ **Process Mapping**

The process is defined as any activities which takes certain input & creates certain desired or required output.

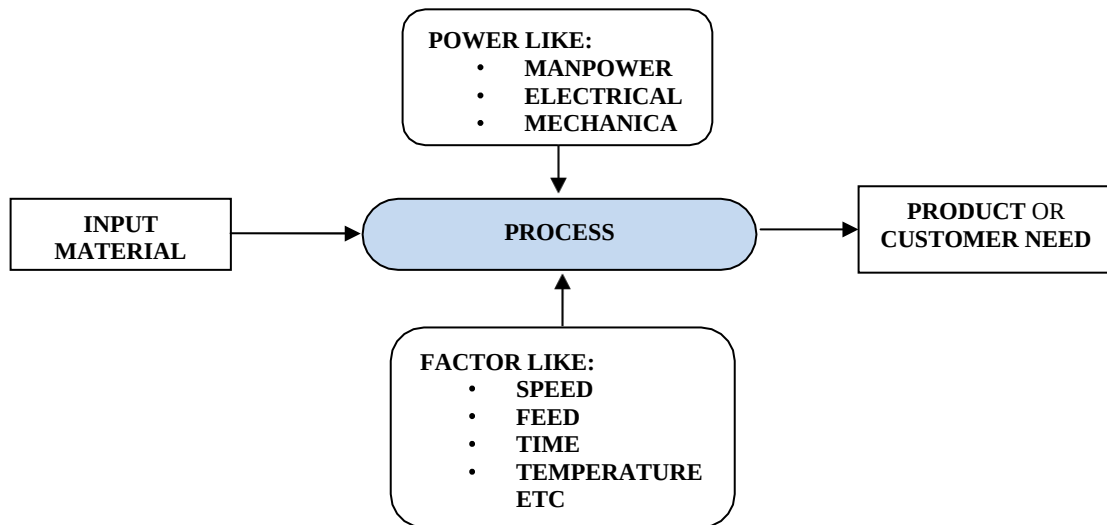


Figure 1.3 - PROCESS

The process mapping is schematic representation of the activities or step, sequence of the events & operations which contributes a process. It helps to understand how a product or service is made. Process mapping is technique used to document & analyze processes. Analysis of the process will reveal some obvious areas for improvement.

The process mapping is represented in many ways. The two easy ways are

➤ SIPOC

Supplier input process output customer chart outlines the inputs & output of a process and the corresponding supplier & customers.

➤ MACRO MAP

A bird's eye view of the process with steps before & after.

EXAMPLE OF SIPOC:

SIPOC COFFEE SHOP				
SUPPLIER	INPUT	PROCESS	OUTPUT	CUSTOMER
SUPPLIER OF MILK	MILK	TEMPERATURE	GOOD COFFEE	PEOPLE
SUPPLIER OF COFFEE POWDER	COFFEE POWDER	MIXING OF MILK, COFFEE POWDER & SUGAR		
SUPPLIER OF SUGAR	SUGAR	FILTERING		
	BOILER, CUPS, FILTERS	STIRRING		

Table 1.1

1.4 MEASURE PHASE

The measure phase describes about the measurement system, data type, data collection, variation.

- ✓ MEASUREMENT SYSTEM ANALYSIS
- ✓ DATA COLLECTION
- ✓ VARIATION
- ✓ TYPE OF DATA

➤ **Measurement System Analysis:**

The measurement defines about measurement system analysis, which helps to identify the variation in the measurement system, appraiser & measurement method. It is also used to find the instrument error like linearity, bias etc. measurement helps to understand the difference between input, process & output measure. It relates & measure how input relates to output & each other.

➤ **Data collection**

The data collection process consists of 5 steps

1. Clarify the data collection,
2. Develop operational definition, sample size & frequency.
3. Study data consistency & stability,
4. Start data collection &

5. Improve the measurement consistency.

➤ **Types of data**

6. Variable or Continuous data

7. Discrete or attribute data.

Variable data: When the variable can obtain any value between a ranges of values.

Discrete data: When the variable can obtain values from fixed set of values.

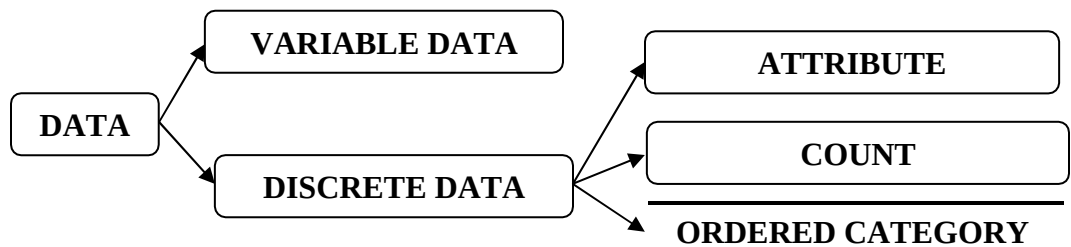


Figure 1.4

➤ **Variation:**

The data is only as good as the process that we measure it. Measurement system analysis helps to identify the true process variation by minimizing the measurement variation. Variation in data is cumulative of process variation & measurement variation. We need to reduce the measurement error. So that we measure the exact variation due to process.

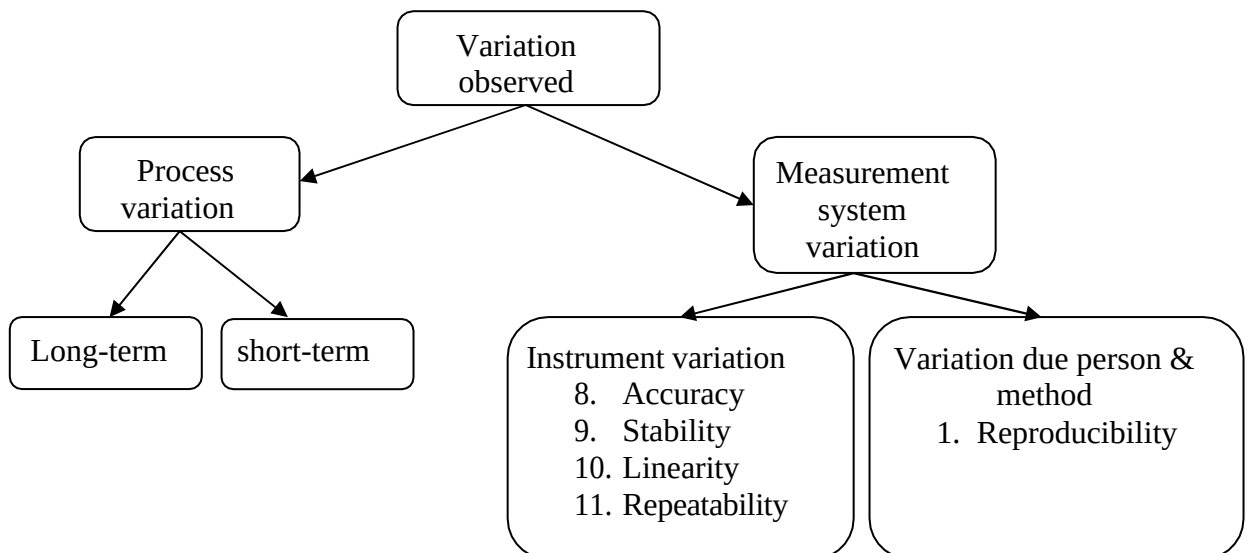


Figure 1.5

1.5 ANALYSIS PHASE:

The analysis phase is the important phase of six sigma. Here we use various six sigma tools to determine the root cause of the problems & defects. The analysis helps to find out which factors are really contributing for the response. It avoids jumping to judgment based or premature solution. It also explains the magnitude of the problem & quantify the opportunity.

In analysis phase, we focus on the response & factors. We derive a statistical relationship (equation) for the factors & response with the help of various six sigma tools, which best fits with factors & response. From this we can estimate how the response gets changed for every change in the factors.

Response is output or requirement. Generally, “Y” is

- Dependent variable,
- Output
- Effect & Symptom.

Factor is input parameters or variables. Generally, “X” is

- Independent
- Input process
- Cause & Control

➤ ROOT CAUSE ANALYSIS

The some of the root cause analysis methods are

- Why - why analysis
- Cause effect diagram
- Brain storming
- Potential failure mode analysis

➤ VERIFICATION METHODS

- Hypothesis testing
- Regression analysis

- Scatter diagram
- Design of experiments.

1.6 IMPROVE PHASE:

In this phase we need to generate various solutions, ideas, Narrow down the list of solutions for potential problem. The important part of the improve phase is to validate the solution with the desired response & ensure that which factor are really contributing for the desired output, problem or defects.

After arriving the solution, the team must develop a project plan, create a plan for implementing the solutions, begin to develop the strategy. The test plan for potential problems & to modify the activities to eliminate the problems. The solutions are to be permanent one. Resource requirements, cost implications & Risk management plan are also to be taken care implementing plan.

1.7 CONTROL PHASE:

The very important phase in six sigma project is control phase. After implementing the improvement plan, we need do documentation of

- Control plan
- Work instruction
- Standard operating procedures
- Develop ongoing process control charts
- Standardization
- Response plan

A process control is a system of activities whose propose is to maintain the process performance at a level that satisfies customer's needs & drives the ongoing improvements of process performance. We need to monitor the process through control charts.

Response plan is a documented method, which inform how a process owner should respond to any out of condition that may occur in a process. In control phase the team should revisit the Risk assessment; PFMEA, periodic audits of the data collection procedures of the control plan are necessary part of an effective process control monitoring plan. Besides the monitoring system Mistake proof system, robust designs are to be developed & adopted.

1.8 IDENTIFIED PURPOSE STATEMENT

Brakes India has drum brake manufacturing unit in which lined shoe assembly is a significant part in drum brake assembly. Taken project in handbrake lever riveting process (orbital machine).

1.9 NEED OF THE PROJECT

- Subject riveting process (Orbital machine) would be validated for each new product.
- Need to establish an effective and efficient process
- To study the factors which are influencing the lever riveting (Orbital machine) will be studied in detail without compromising quality functions.
- Hence this new product riveting (orbital) process characterization has been taken for the study.

1.10 SCOPE OF THE PROJECT

- To characterize the Lined Shoe riveting (Orbital) process
- Application of DMAIC approach of Six sigma for Process characterization

1.11 TERMINOLOGIES USED IN SIX SIGMA

- BIG Y = Main Response for the Problem
- SSV's = Factors (parameters) or Suspected sources of Variation (Causes) for the problem. They are also called as X's
- Cause(s) = SSV's that are confirmed as cause(s) for the problem using the DOE tools, but are not controllable and need to be funneled further. They will become the intermediate Y's.

1.12 DOE TOOL SYNOPSIS

In this process optimization project, we have two factors, so we can go for DOE tool FULL factorial analysis. The no of trial required for full factorial analysis is 2^n which is equal to 4 trials. So, the total number of trials are 4.

Before going to the trial, we need to find out the levels of the factor in which the process produces good response & bad response. To find the levels of the factor we have adopted shainin DOE technique.

There are “Three” stages in Full factorial

- **Stage # 0** – To identify the design parameters and identify the ‘-’ and ‘+’ setting for each parameter.
- **Stage # 1:**
 - Make a factorial table.
 - Collect data as per the combinations in table.
 - If the response is variable, then manufacture one piece in each combination and check the response.
 - When conducting the experiments, preferably randomize the experiments. Do not conduct in same sequence as constructed in the factorial table.
- **Stage # 2:**
 - Using the contribution, we have to make the math equation using the same method as discussed earlier.
 - Process optimization is done to find out the best setting for getting response.

CHAPTER-2

REVIEW OF LITREAUTURE

2.1 REVIEW OF LITERATURE

Benny Tjahjono (August 2010): The purpose of the work presented in this paper is to capture the current state of Six Sigma as well as to document the current practices of Six Sigma through a systematic literature review. These include the interpretation of Six Sigma, tools and techniques, implementation of Six Sigma, benefits, adoption, enablers and links to other disciplines.

Wincet (2009): There has been considerable number of papers published related to Six Sigma applications in manufacturing and service organizations. However, very few studies are done on reviewing the literature of Six Sigma in all the areas including manufacturing, construction, education, financial service, BPOs and healthcare etc.

Adan valles (2017): This paper presents a Six Sigma project conducted at a semiconductor company dedicated to the manufacture of circuit cartridges for inkjet printers. They are tested electrically in the final stage of the process measuring electrical characteristics to accept or reject them. Electrical failures accounted for about 50% of all defects. Therefore, it is crucial to establish the main problems, causes and actions to reduce the level of defects. With the implementation of Six Sigma, it was possible to determine the key factors, identify the optimum levels or tolerances and improvement opportunities.

Souraj salah (January 2009): Industries are continuously facing fierce competition and the challenge of meeting increasing demands for higher quality products at economic costs. The success of an organisation is directly related to how effective its implementation of continuous improvement (CI) is. For any manufacturing system, Total Quality Management (TQM) and Six Sigma are important CI methodologies. Finally, this research introduces how they fit together in order to develop a new structure for integrating them together which will provide an improved approach for CI.

Mahtab baha (July 2016): Rivet is one of the most significant methods of joining materials, used in various industries especially in Aviation industry. Rivets are used in

permanent connections of sheets in the body of aircraft constructions. Failure of rivet joints depends directly on tension status of the joint. Various parameters such as riveting load, friction ratio, and tolerance effect directly on the stress and fatigue life of rivet joint. There are several different procedures for riveting, such as press riveting, pop riveting, explosion and radial frictional riveting, use in different industries. This research has studied the newest technology of riveting which known as rotational radial frictional riveting. The function of this machine is hyperbolic and this cause uniformity and minimum displacement in the molecular structure of the piece.

Sawangi (Meghe) (November 2014) : The objective is to design and analyse the drilling cum riveting machine which reduces the operation as well as transportation time required for completing the job. Riveting operation is till now performed manually, but by using Orbital Riveting Machine (ORM) it can be performs automatically. The concept is that the plate (raw material) having different size and thickness are drilled on drilling spindle first and then riveted on orbital riveting spindle. Both the operations perform on same machine having two separate spindles. The purpose of this machine is to replace manual hammering into automation, to increase productivity in operation also to reduce cost. To get accuracy in riveting the spindle is offset by 3 to 6 degree, the upper part of rivet stud is expanding over plates without hammering. It is more beneficial to use in workshops, industries where drilling and riveting operations can perform simultaneously.

H. Satbhai (Feb 2017) : The successful implementation of any manufacturing sector is largely depend upon the quality & its productivity. In traditional machining process for performing the different operation a separate machine required which becomes a time consuming also the inaccuracy in productivity due to involvement of human error which affects to productivity cannot be get improved at faster rate .the main purpose of this paper to develop special purpose machine for drilling and riveting machine which leads to improve the quality and productivity by minimizing the time period. in this process two or more operation can be performed simultaneously due to this cost of a material reduces.

Tushar A patil (Jan 2016) : In Manufacturing aspect it is very important to know about all machining processes. Conventionally all these processes were performed manually by the workers but that was very tedious work. It is impossible to get higher production in such a case also there is chances of human error in the processes which affects the quality of the product. Today we have been suffering from lack of problem to achieve maximum productivity. it is impossible to get higher production by performing these processes separately on different machines it is time consuming as well as it is very difficult to maintain accuracy in the product. So it is necessary to design and manufacture a machine which performs two or more operation on a single machine. The objective of paper is to design the drilling cum orbital riveting machine, which will help to increase production by minimizing time constrain

CHAPTER 3

DMAIC – METHODOLOGY

3.1 DEFINE PHASE

- **PURPOSE**

To characterize the process parameter of the Riveting process (orbital machine) without change in desired quality requirements.

- **SCOPE**

To characterize riveting process (Orbital machine) for new model lined shoe

- **GOAL STATEMENT**

To characterize riveting parameters for new model

- **TEAM MEMBERS**

Mr. E. Prabhu	– New product quality.
Mr. Rajesh	– Quality control - Drum brake unit
Mr. Sarangapani	– Manufacturing - Drum brake unit.

3.1.1 PROJECT TIMING PLAN_

	Wk 01 Feb '22	Wk 02 Feb '22	Wk 03 Feb '22	Wk 04 Feb '22	Wk 05 Mar '22	Wk 06 Mar '22
Define						
Measure						
Analyze						
Improve						
Control & Report creation						
		Planned		Completed		

Figure 3.1

3.1.2 RIVETING PROCESS (ORBITAL) DESCRIPTION

It is the process in which lever and lined shoe is fastened through riveting process in Orbital make machine.

- Peen tool at the angle of 3,4 and 6 degree is kept and downward pressure is applied on the rivet where riveting is done, no heat is applied on the tool in this process
- It is used in Drum brake assembly.
- It is a sub assembly assembled in the drum brake assembly.
- Function of this riveting (orbital) process is to secure the lined shoe and lever intact, when the hand brake is applied the lever will push the Lined shoe outwards and the brake will be applied while parking.

3.1.3 RIVETING PROCESS (ORBITAL) FLOW:

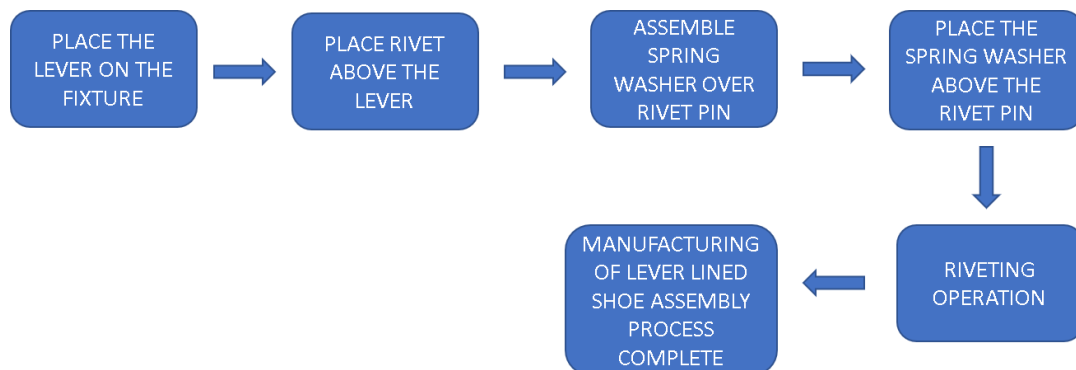


Figure -3.2 Process mapping

3.1.4 RIVETING PROCESS (ORBITAL) SIPOC:

SUPPLIER	INPUT	PROCESS	OUTPUT	CUSTOMER
Child part vendors	Rivet Lever Spring washer Lined shoe	Riveting (Orbital machine)	Lined shoe assembly with lever	OEM Customer

Table 3.1

3.1.5 RIVETING PROCESS (ORBITAL)

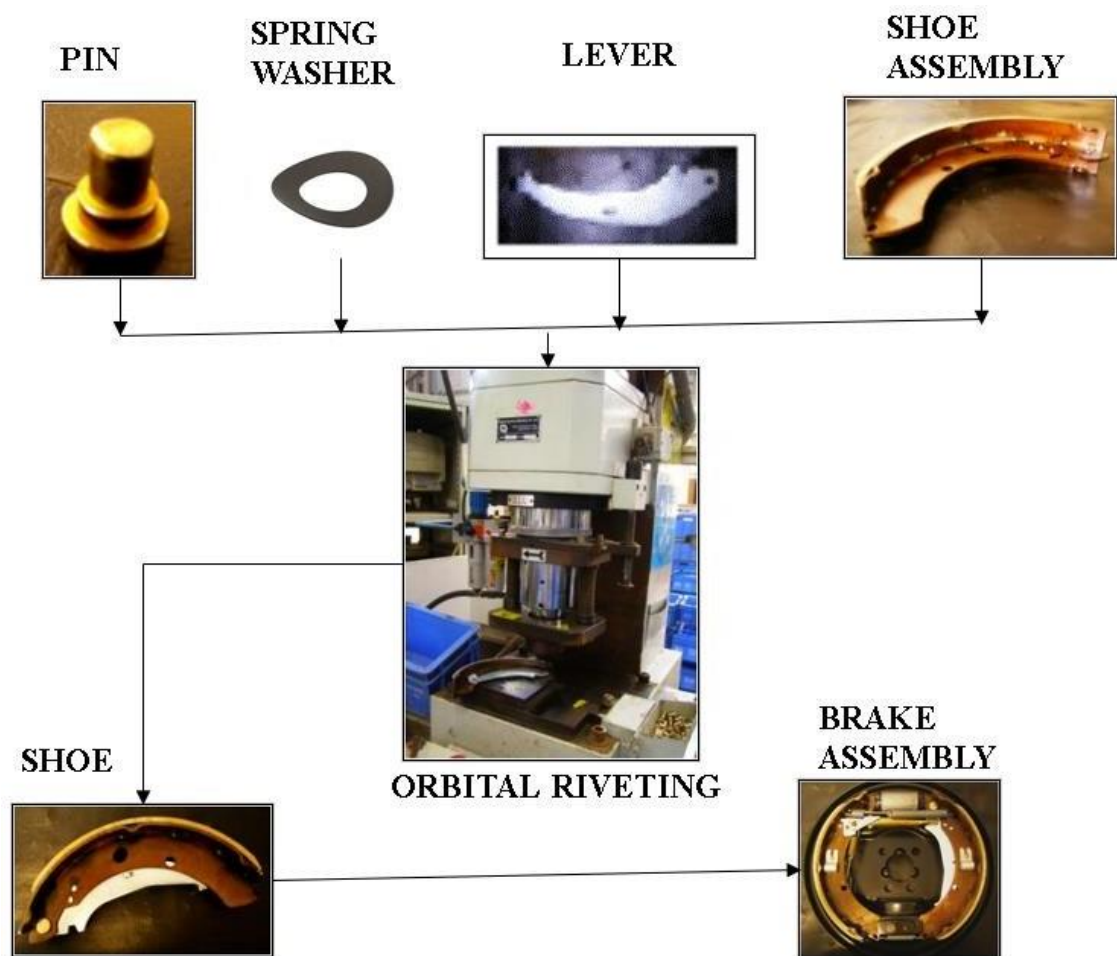


Figure 3.3

3.2 MEASURE PHASE

- **Stage # 0** – To identify the design parameters and identify the ‘-’ and ‘+’ setting for each parameter.

3.2.1 FACTORS OR PROCESS PARAMETERS

Factors are denoted by “Xⁿ”. The function of the all factors gives the desired response “Y”

<i>f (x)</i>		
SSV X1	Set height	0.3 – 0.9 mm
SSV X2	Timer	7 – 16 seconds

Table 3.2

*Air pressure kept constant

3.2.2 PROCESS RESPONSE

The output of the process or the requirement of the customer is called Response denoted by “Y”.

“Y “RESPONSE		
Y1	Height	Measured using height gauge
Y2	Diameter	Measured using vernier caliper

Table 3 .3

CHAPTER 4

DATA ANALYSIS & INTERPERTATION

4.1 DATA ANALYSIS (ANALYSIS PHASE)

4.1.1 SHAININ DOE TRIAL 1

Since it is a new model both '-' and '+' setting is atmospheric setting based on experience.

TRIAL – 01		
Factors	(-) Setting	(+) Setting
Set height	0.95 mm	0.3mm
Timer	16 sec	7 sec

Table 4.1

TRIALS	(-) SETTING	(+) SETTING
1ST Run	1.70	2.34
2ND Run	1.78	2.63
3RD Run	1.64	2.50

Table 4.2

TRIAL – 01 RESPONSE – HEIGHT

TRIALS	(-) SETTING	(+) SETTING
1ST Run	1.70	2.34
2ND Run	1.78	2.63
3RD Run	1.64	2.50
Median	1.70	2.50
Range	0.14	0.29
D	0.8	
d	0.215	
D/d	3.7209	

Table 4.3

CONCLUSION:

Since D/d ratio is >3. The selected '+' setting parameters are ok and proceed for further steps.

4.1.2 SHAININ DOE TRIAL 2

Since it is a new model both '-' and '+' setting is atmospheric setting based on experience

TRIAL – 02		
Factors	(-) Setting	(+) Setting
Set height	0.95 mm	0.3mm
Timer	16 sec	7 sec

Table 4.4

TRIALS	(-) SETTING	(+) SETTING
1 ST Run	11.95	9.00
2 ND Run	12.01	8.70
3 RD Run	11.95	8.90

Table 4.5

TRIAL – 02 RESPONSE - DIAMETER		
TRIALS	(-) SETTING	(+) SETTING
1 ST Run	11.95	9.00
2 ND Run	12.01	8.70
3 RD Run	11.95	8.90
Median	11.95	8.90
Range	0.06	0.3
D	3.05	
d	0.18	
D/d	16.94	

Table 4.6

CONCLUSION:

Since D/d ratio is >3. The selected '+' setting parameters are ok & proceed further steps.

4.1.3 CONSTRUCTION OF FACTORIAL TABLE

Stage # 1 – To construct factorial table and collect data for each combination in the factorial table and quantify the contributions. (Using Minitab software).

S.no	Timer (seconds)	Set height (mm)
1	7	0.9
2	16	0.3
3	7	0.3
4	16	0.9

Table 4.7

Trials conducted in machine and responses are measured in each trial

- Collect data as per the combinations in table.
- If the response is variable, then manufacture one piece in each combination and check the response.
- When conducting the experiments, preferably randomize the experiments. Do not conduct in same sequence as constructed in the factorial table.

S.no	Timer (seconds)	Set height (mm)	Y1 – diameter (mm)	Y2 – height(mm)
1	7	0.9	9.26	2.57
2	16	0.3	11.94	1.89
3	7	0.3	8.9	2.50
4	16	0.9	11.95	1.70

Table 4.8

Using Minitab software, Analyzed each parameter significance to Response, Main effect, Interaction effect and Mathematical model for both Responses (Rivet Diameter and Rivet Height)

4.1.4 PARETO CHART

A) Rivet Height_ - Parameter Contribution (Pareto):

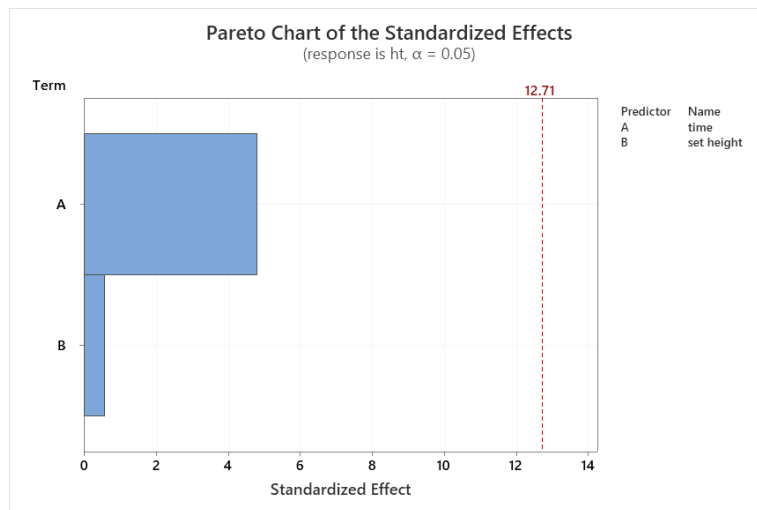


Figure 4.1

Inference:

Time parameter is significantly influencing than set height.

B) Rivet Diameter- Parameter Contribution (Pareto):

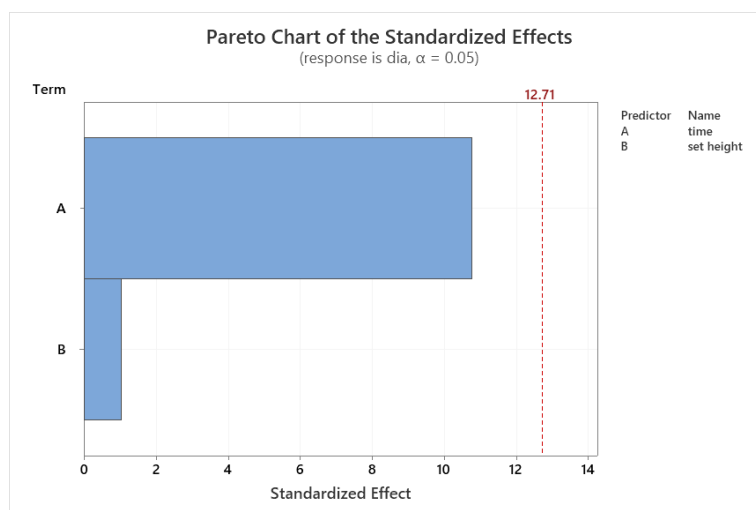


Figure 4.2

Inference:

Time parameter is significantly influencing than set height.

4.1.5 MAIN EFFECT PLOT

- **Rivet Height- Parameter Contribution:**

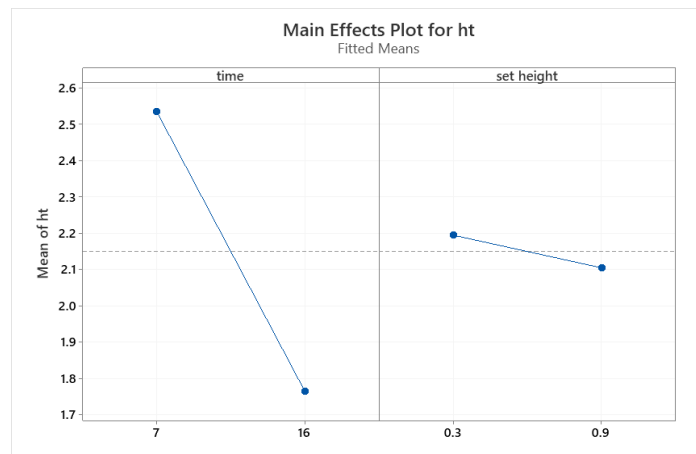


Figure 4.3

Inference:

- Time and the Rivet height are inversely proportional. When the time increases the rivet height decreases
- Set height and Rivet height are inversely proportional. when the set height increases the rivet height decreases. Set height is marginally influencing response

- **Rivet Diameter- Parameter Contribution**



Figure 4.4

Inference:

- When the time increases the rivet diameter decreases.
- when the set height increases the rivet diameter marginally decreases. Set height is marginally influencing response.

4.1.6 INTERACTION PLOT

- Rivet Height- Parameter Contribution:

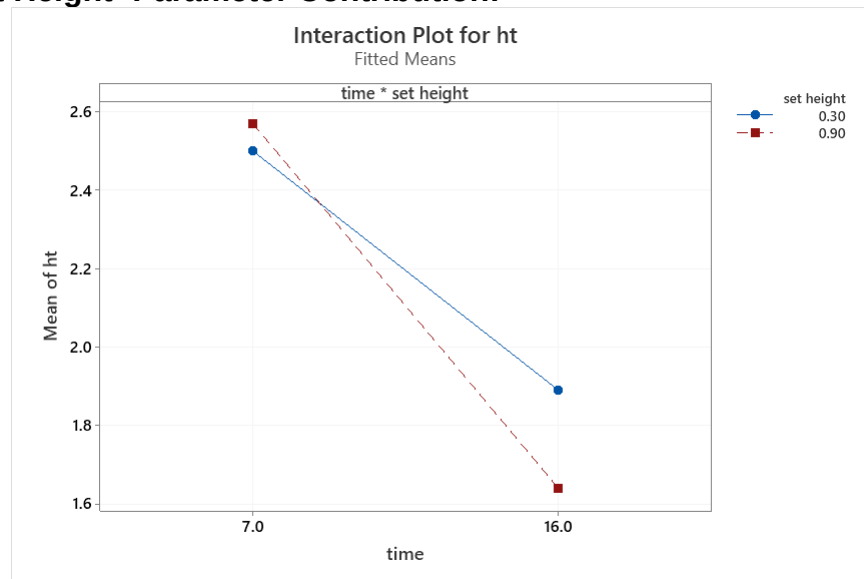


Figure 4.5

Inference

There is an interaction effect between the time and set height on rivet height.

- Rivet Diameter- Parameter Contribution:

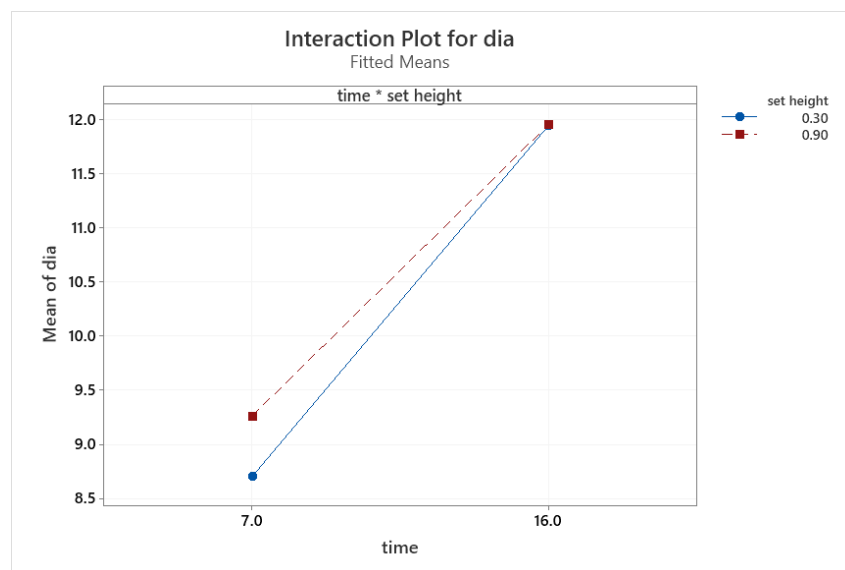


Figure 4.6

Inference :

- There is interaction effect between the time and set height on rivet diameter.

4.1.7 MATH EQUATION AND OPTIMIZATION (Using Minitab Software)

- Using the contribution, we have to make the math equation.
- Process Characterization is done to find out the best settings for getting the responses.
- Identifying the optimal Y value for response where the objective is higher is better.

$$\text{➤ } Y (\text{Optimal}) = LSL + 2.3 *d$$

Here LSL for Rivet height is 1.5 m (Product Design requirement)

For Rivet height,

$$Y = 1.5 + 2.3 *(0.215)$$

$$Y (\text{Rivet Height}) = 1.99 \text{ mm.}$$

Here LSL for Rivet Diameter is 9.5 mm (Product design requirement)

For Rivet diameter,

$$Y = 9.5 + 2.3*(0.18)$$

$$Y = 9.5 + 2.3*(0.18)$$

$$Y (\text{Rivet diameter}) = 9.914 \text{ mm}$$

4.1.8 MAKING MATH EQUATION FOR OPTIMIZATION

Y (OUTPUT) =

Constant + Coefficient of A*A + Coefficient of B*B + Coefficient of A* Coefficient of B * A*
B

In our study,

A – Set height

B – diameter

A*B – set height * diameter.

4.1.9 ESTIMATED CODED EQUATION (Thro. Minitab software)

With the coefficient values derived from Minitab software, various combination can be plotted to choose the best optimal setting parameter with the help of MS Excel - what if analysis

A. Estimated Coefficients for height using data in uncoded units for Rivet Height

S, NO	TERM	COEFFICIENTS
1	Constant	2.83833
2	Set height	0.453704
3	Timer	-0.0533333
4	Set height *timer	-0.0481481
OUTPUTS DERIVED USING MS EXCEL WHAT IF ANALYSIS COMMAND FOR HEIGHT		

	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1	1.1	1.2
7	2.500229	2.511895	2.523562	2.535228	2.546894	2.558561	2.570227	2.581893	2.59356	2.605226
8	2.432485	2.439336	2.446188	2.453039	2.459891	2.466742	2.473594	2.480445	2.487297	2.494148
9	2.36474	2.366777	2.368814	2.37085	2.372887	2.374924	2.37696	2.378997	2.381034	2.383071
10	2.296996	2.294218	2.29144	2.288661	2.285883	2.283105	2.280327	2.277549	2.274771	2.271993
11	2.229251	2.221658	2.214065	2.206473	2.19888	2.191287	2.183694	2.176101	2.168508	2.160915
12	2.161507	2.149099	2.136691	2.124284	2.111876	2.099468	2.087061	2.074653	2.062245	2.049837
13	2.093762	2.07654	2.059317	2.042095	2.024872	2.00765	1.990427	1.973205	1.955982	1.93876
14	2.026018	2.003981	1.981943	1.959906	1.937869	1.915831	1.893794	1.871757	1.849719	1.827682
15	1.958274	1.931421	1.904569	1.877717	1.850865	1.824013	1.797161	1.770309	1.743456	1.716604
16	1.890529	1.858862	1.827195	1.795528	1.763861	1.732194	1.700527	1.66886	1.637193	1.605526

Table 4.9

B. Estimated Coefficients for Diameter using data in uncoded units for Rivet Diameter

S.NO	TERM	COEFFICIENTS
1	Constant	5.68611
2	Set height	1.6463
3	Timer	0.390556
4	Set height *timer	-0.101852
OUTPUTS DERIVED USING MS EXCEL WHAT IF ANALYSIS COMMAND FOR DIAMETER		

	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1	1.1	1.2
7	8.700003	8.793336	8.88667	8.980004	9.073337	9.166671	9.260004	9.353338	9.446672	9.540005
8	9.060003	9.143152	9.2263	9.309448	9.392597	9.475745	9.558894	9.642042	9.72519	9.808339
9	9.420004	9.492967	9.56593	9.638893	9.711856	9.78482	9.857783	9.930746	10.00371	10.07667
10	9.780004	9.842782	9.90556	9.968338	10.03112	10.09389	10.15667	10.21945	10.28223	10.34501
11	10.14	10.1926	10.24519	10.29778	10.35038	10.40297	10.45556	10.50815	10.56075	10.61334
12	10.5	10.54241	10.58482	10.62723	10.66964	10.71204	10.75445	10.79686	10.83927	10.88167
13	10.86001	10.89223	10.92445	10.95667	10.98889	11.02112	11.05334	11.08556	11.11778	11.15001
14	11.22001	11.24204	11.26408	11.28612	11.30815	11.33019	11.35223	11.37427	11.3963	11.41834
15	11.58001	11.59186	11.60371	11.61556	11.62741	11.63927	11.65112	11.66297	11.67482	11.68667
16	11.94001	11.94167	11.94334	11.94501	11.94667	11.94834	11.95001	11.95167	11.95334	11.95501

Table 4.10

To arrive the parameter, we have tabulated the equation in excel and optimal setting has been chosen.

OPTIMAL SETTING

	INPUT (X)		OUTPUT (Y)	
S.NO	TIMER	SET HEIGHT	DIAMTER	HEIGHT
1	11	0.3	10.14	2.22

Table 4.11

4.2.0 REGRESSION EQUATION (Additional option for finding optimal setting)

Using Minitab software, we derived the regression equation for finding the diameter and height

Diameter

PREDICTOR	COEFFICIENT	SE COEFFICIENT	T	P
Constant	6.3889	0.4669	13.68	0.046
Set height	0.4750	0.4583	1.04	0.489
Timer	0.32944	0.03056	10.78	0.059
S = 0.2750 R-Sq = 99.2% R-Sq(adj) = 97.5%				

Table 4.12

The equation for diameter is,

$$\text{Dia} = 6.39 + 0.475 \text{ set ht} + 0.329 \text{ timer}$$

For ex Timer is 7 seconds and set height is 0.9,

Applying the values on the equation,

$$\text{Diameter} = 6.39 + 0.475 (0.9) + 0.329 (7)$$

$$\text{Diameter} = 9.12 \text{ mm.}$$

Height

PREDICTOR	COEFFICIENT	SE COEFFICIENT	T	P
Constant	3.1706	0.2207	14.36	0.044
Set height	-0.1000	0.2167	-0.460	0.725
Timer	-0.08222	0.01444	-5.69	0.111
S = 0.1300 R-Sq = 97.0% R-Sq(adj) = 91.1%				

Table 4.13

The equation for height is

$$\text{Height} = 3.17 - 0.100 \text{ set ht} - 0.0822 \text{ timer}$$

For example, timer is 7 seconds and set height is 0.9,

Applying the values in the formula,

$$\text{Height} = 3.17 - 0.1000 (0.9) - 0.0822 (7)$$

$$\text{Height} = 2.47 \text{ mm.}$$

Hence the diameter and the height can also find using the regression equation.

CHAPTER 5

FINDING, SUGGESTION AND CONCLUSION

5.1 IMPROVE PHASE

For confirming set parameters, Rivet diameter and Rivet height were checked trials were taken for 30 samples.

Process capability trial values

S.no	Height	Diameter
1	2.3	10.2
2	2.31	10.21
3	2.31	10.21
4	2.32	10.22
5	2.32	10.22
6	2.33	10.23
7	2.33	10.23
8	2.34	10.24
9	2.34	10.24
10	2.35	10.25
11	2.35	10.25
12	2.36	10.26
13	2.36	10.26
14	2.37	10.27
15	2.37	10.27
16	2.39	10.28
17	2.39	10.29
18	2.39	10.3
19	2.4	10.31
20	2.4	10.32
21	2.41	10.33
22	2.42	10.35
23	2.43	10.5
24	2.44	10.37
25	2.45	10.39
26	2.46	10.41
27	2.47	10.43
28	2.49	10.44
29	2.49	10.45
30	2.5	10.45

Table 5.14

➤ **PRELIMINARY PROCESS CAPABILITY INDEX**

- Preliminary process capability for height

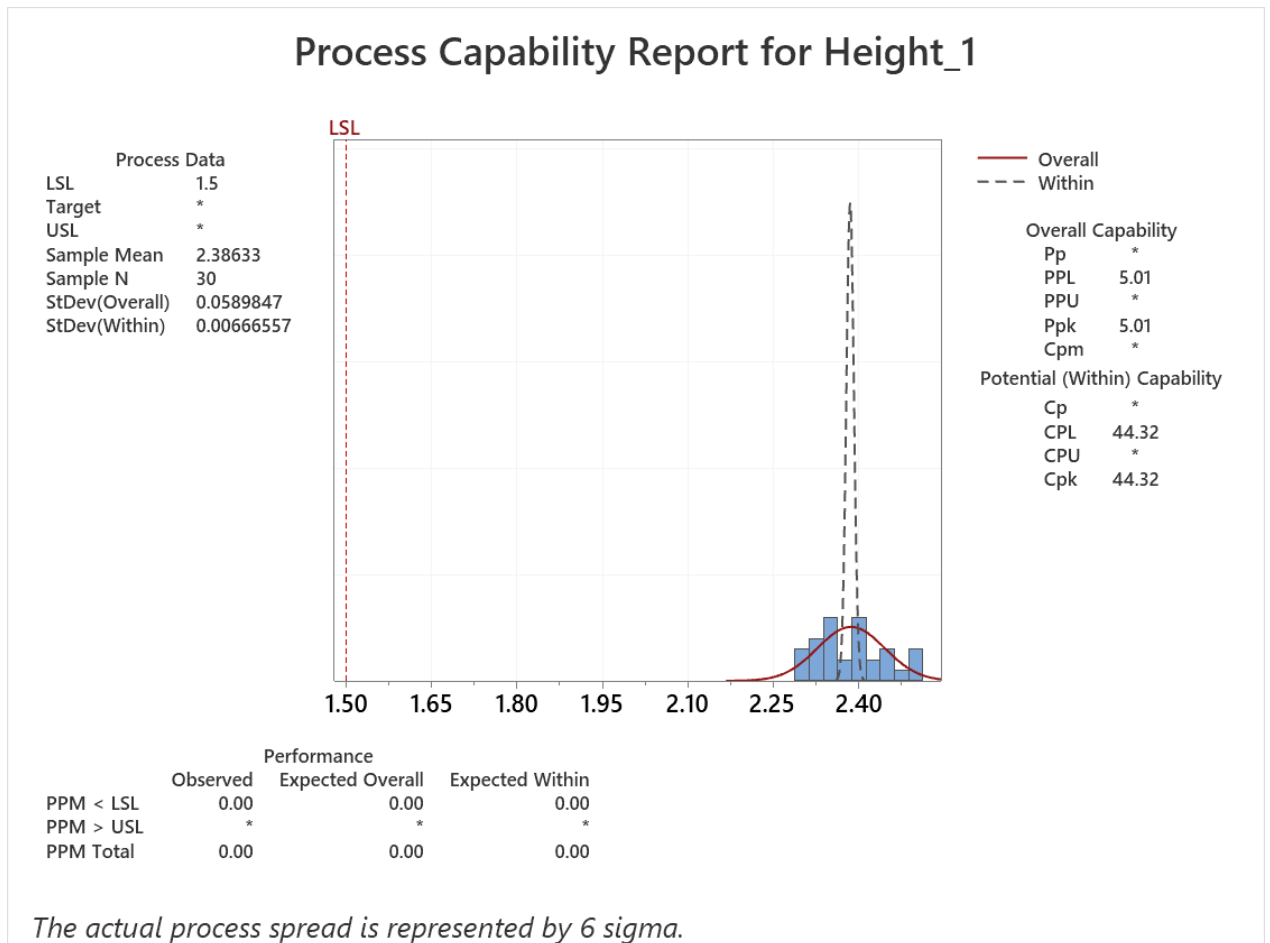


Figure 5.7

Inference :

The preliminary process capability index value for Height is > 1.33 and acceptable

- Preliminary process capability for Diameter

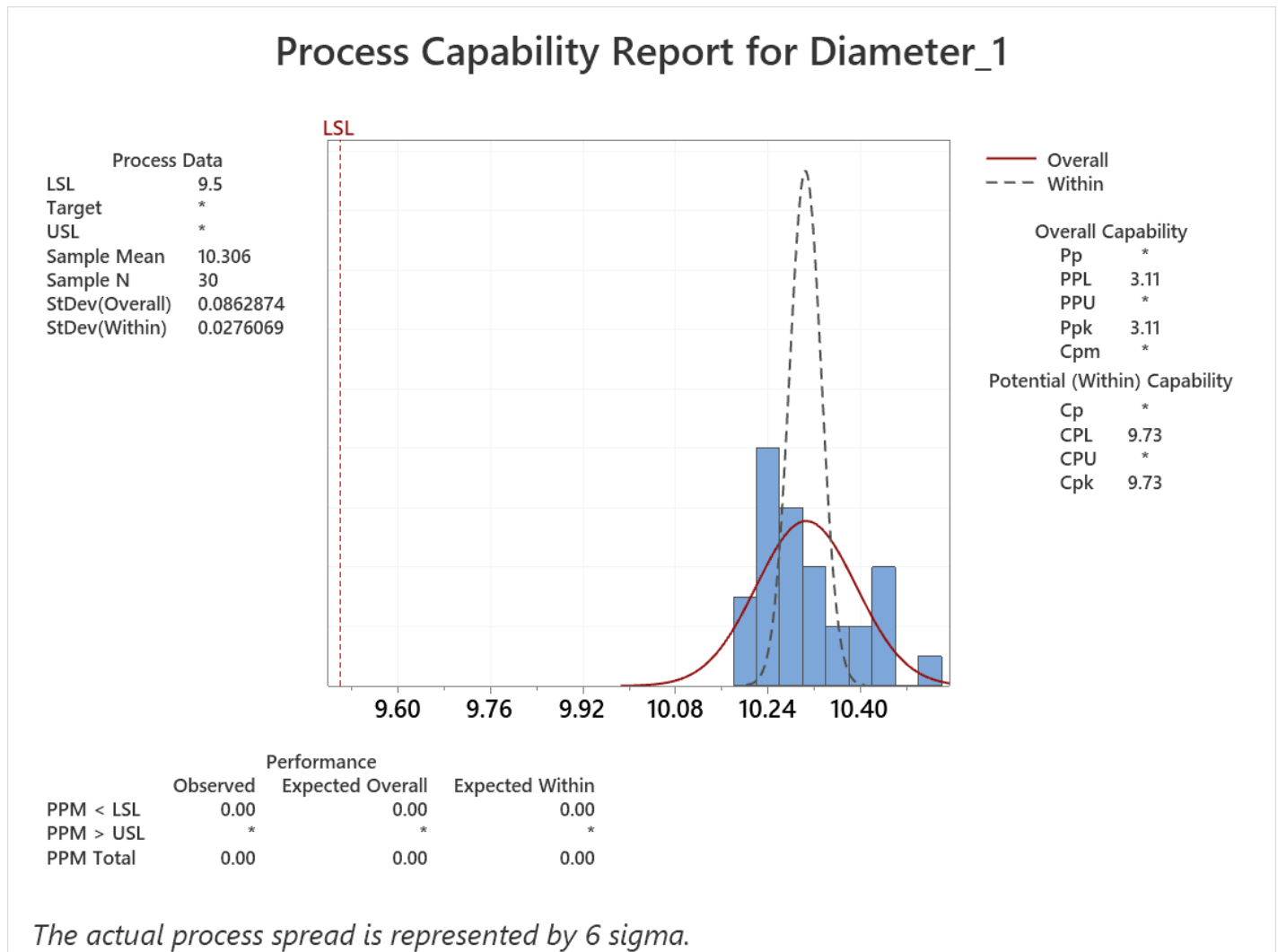


Figure 5.8

Inference:

The preliminary process capability index value for Diameter is > 1.33 and acceptable.

5.2 CONTROL PHASE

Process parameters were updated in SOP and parameters were addressed in Setup approval sheet.

SIX SIGMA TOOLS USED				
DEFINE	MEASURE	ANALYZE	IMPROVE	CONTROL
SIPOC	Calibration record	Full factorial	SPC chart	
Process flow		Main effect		SOP
Pareto chart		Interaction effect		Set up approval sheet

Table 5.15

5.3 CONCLUSION

Hence by using DOE Six sigma method new set of effective and efficient parameter was found out without compromising any quality factors and also learnt about the applications of DOE tool in six sigma methodology.

REFERENCE:

- Benny Tjahjono (August 2010): The purpose of the work presented in this paper is to capture the current state of Six Sigma as well as to document the current practices of Six Sigma through a systematic literature.
- Wincet (2009): There has been considerable number of papers published related to Six Sigma applications in manufacturing and service organizations.
- Adan valles (2017): This paper presents a Six Sigma project conducted at a semiconductor company dedicated to the manufacture of circuit cartridges for inkjet printers.
- Souraj salah (January 2009): Industries are continuously facing fierce competition and the challenge of meeting increasing demands for higher quality products at economic costs.
- Mahtab baha (July 2016): Rivet is one of the most significant methods of joining materials, used in various industries especially in Aviation industry.
- Sawangi (Meghe) (November 2014): The objective is to design and analyze the drilling cum riveting machine which reduces the operation as well as transportation time required for completing the job.
- H. Satbhai (Feb 2017): The successful implementation of any manufacturing sector is largely depended upon the quality & its productivity.
- Tushar A patil (Jan 2016): In Manufacturing aspect it is very important to know about all machining processes. Conventionally all these processes were performed manually by the workers but that was very tedious work.
- Six sigma green belt internal course material (2008), Brakes India ltd.
- Minitab software.

RIVETING PROCESS CHARACTERIZATION IN BRAKE LINED SHOE ASSEMBLY USING SIX SIGMA TOOL

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ABSTRACT: Brakes India is a leading Automobile Brake system manufacturer for four wheelers from passenger cars to heavy commercial trucks serving its customer in India & abroad. Brakes India adopts various tools like Total Productive Maintenance (TPM), Toyota Production System (TPS) in its business process to improve the productivity & fulfilling the customer needs. Now we started using Six sigma tools, so as per company objective & management direction we have identified Riveting process characterization for New Model Lined Shoe assembly.

We have taken the project of Riveting process (orbital machine) characterization in lined shoe assembly which is one of the key processes in Rear Brake assembly. In this project we have used the DMAIC approach to characterize the riveting parameters. In “Define” phase we have identified the Process parameter for Product requirements in riveting process (orbital machine). In “Measure” phase, the response (product requirements) & factor (process parameters) are identified and trial runs are Identified through Minitab Software and trials were conducted. In “Analyze” Phase, collected data has been analyzed and arrive the factors which contribute & which don’t contribute for response. In “Improve” phase, trials were conducted to validate the contributing factors with response. The optimized parameters are arrived & validated. In “Control” Phase, based on contributing factor, optimized parameters factor is standardized in SOP. which gives the desired response. The optimized parameters are updated in relevant documents. From the above project analysis using six sigma, the application of six sigma tools & DMAIC were well learnt & understood.

Keywords: DMAIC Approach, Define phase, Measure phase, Analyze phase, Improve phase, Control phase.

I. INTRODUCTION:

- 1.1 Six sigma: Six Sigma (6σ) is viewed as a systematic, scientific, statistical and smarter approach for management innovation which is quite suitable for use in a knowledge –based information society. The essence of six sigma is the integration of four elements (Customer, Process, Manpower & Strategy) to provide management innovation.
- 1.2 DMAIC Approach: Six sigma follows the 5-phase approach – DMAIC approach. DMAIC process (Define, Measure, Analyze, Improve & Control) is scientific approach moves step by step, which ensures problem is defined properly, Ensure Measurement system & method are good so that data captured are accurate without any errors. Then the problem is analyzed properly through various tools and root cause are identified. In Improve phase, corrective action is taken, the corrective actions are validated with response. Finally in Control phase, sustenance of counter measures is also ensured.
- 1.3 Terminology used in Six sigma:
 - BIG Y = Main Response for the Problem
 - SSV's = Factors (parameters) or Suspected sources of Variation (Causes) for the problem. They are also called as X's
 - Cause(s) = SSV's that are confirmed as cause(s) for the problem using the DOE tools, but are not controllable and need to be funneled further. They will become the intermediate Y's.

II. OBJECTIVES OF THE STUDY:

- To characterize the Lined Shoe riveting (Orbital) process using Six sigma tool method.

III. RESEARCH METHODOLOGY

1.1 Define Phase:

To characterize the process parameter of the Riveting process (orbital machine) without change in desired quality requirements.

1.2 Measure Phase:

Stage # 0 -To identify the design parameters and identify the '-' and '+' setting for each parameter.

IV. REVIEW OF LITERATURE:

Benny Tjahjono (August 2010): The purpose of the work presented in this paper is to capture the current state of Six Sigma as well as to document the current practices of Six Sigma through a systematic literature review. These include the interpretation of Six Sigma, tools and

techniques, implementation of Six Sigma, benefits, adoption, enablers and links to other disciplines.

Wincet (2009): There has been considerable number of papers published related to Six Sigma applications in manufacturing and service organizations. However, very few studies are done on reviewing the literature of Six Sigma in all the areas including manufacturing, construction, education, financial service, BPOs and healthcare etc.

Adan valles (2017): This paper presents a Six Sigma project conducted at a semiconductor company dedicated to the manufacture of circuit cartridges for inkjet printers. They are tested electrically in the final stage of the process measuring electrical characteristics to accept or reject them. Electrical failures accounted for about 50% of all defects. Therefore, it is crucial to establish the main problems, causes and actions to reduce the level of defects. With the implementation of Six Sigma, it was possible to determine the key factors, identify the optimum levels or tolerances and improvement opportunities.

Souraj salah (January 2009): Industries are continuously facing fierce competition and the challenge of meeting increasing demands for higher quality products at economic costs. The success of an organisation is directly related to how effective its implementation of continuous improvement (CI) is. For any manufacturing system, Total Quality Management (TQM) and Six Sigma are important CI methodologies. Finally, this research introduces how they fit together in order to develop a new structure for integrating them together which will provide an improved approach for CI.

Mahtab baha (July 2016): Rivet is one of the most significant methods of joining materials, used in various industries especially in Aviation industry. Rivets are used in permanent connections of sheets in the body of aircraft constructions. Failure of rivet joints depends directly on tension status of the joint. Various parameters such as riveting load, friction ratio, and tolerance effect directly on the stress and fatigue life of rivet joint. There are several different procedures for riveting, such as press riveting, pop riveting, explosion and radial frictional riveting, use in different industries. This research has studied the newest technology of riveting which known as rotational radial frictional riveting. The function of this machine is hyperbolic and this cause uniformity and minimum displacement in the molecular structure of the piece.

Sawangi (Meghe) (November 2014): The objective is to design and analyse the drilling cum riveting machine which reduces the operation as well as transportation time required for completing the job. Riveting operation is till now performed manually, but by using Orbital

Riveting Machine (ORM) it can be performs automatically. The concept is that the plate (raw material) having different size and thickness are drilled on drilling spindle first and then riveted on orbital riveting spindle. Both the operations perform on same machine having two separate spindles. The purpose of this machine is to replace manual hammering into automation, to increase productivity in operation also to reduce cost. To get accuracy in riveting the spindle is offset by 3 to 6 degrees, the upper part of rivet stud is expanding over plates without hammering. It is more beneficial to use in workshops, industries where drilling and riveting operations can perform simultaneously.

H. Satbhai (Feb 2017): The successful implementation of any manufacturing sector is largely depended upon the quality & its productivity. In traditional machining process for performing the different operation a separate machine required which becomes a time consuming also the inaccuracy in productivity due to involvement of human error which affects to productivity cannot be get improved at faster rate .the main purpose of this paper to develop special purpose machine for drilling and riveting machine which leads to improve the quality and productivity by minimizing the time period. in this process two or more operation can be performed simultaneously due to this cost of a material reduces.

Tushar A patil (Jan 2016): In Manufacturing aspect it is very important to know about all machining processes. Conventionally all these processes were performed manually by the workers but that was very tedious work. It is impossible to get higher production in such a case also there is chances of human error in the processes which affects the quality of the product. Today we have been suffering from lack of problem to achieve maximum productivity. it is impossible to get higher production by performing these processes separately on different machines it is time consuming as well as it is very difficult to maintain accuracy in the product. So, it is necessary to design and manufacture a machine which performs two or more operation on a single machine. The objective of paper is to design the drilling cum orbital riveting machine, which will help to increase production by minimizing time constrain.

V. ANALYSIS PHASE

5.1 Shainin DOE Trial 1

TRIAL – 01		
Factors	(-) Setting	(+) Setting
Set height	0.95 mm	0.3mm
Timer	16 sec	7 sec

TRIALS	(-) SETTING	(+) SETTING
1 ST Run	1.70	2.34
2 ND Run	1.78	2.63
3 RD Run	1.64	2.50

TRIAL – 01 RESPONSE – HEIGHT

TRIALS	(-) SETTING	(+) SETTING
1 ST Run	1.70	2.34
2 ND Run	1.78	2.63
3 RD Run	1.64	2.50
Median	1.70	2.50
Range	0.14	0.29
D	0.8	
d	0.215	
D/d	3.7209	

CONCLUSION:

Since D/d ratio is >3. The selected '+' setting parameters are ok and proceed for further steps.

52 Shainin DOE Trial 2

TRIAL – 02		
Factors	(-) Setting	(+) Setting
Set height	0.95 mm	0.3mm
Timer	16 sec	7 sec

TRIALS	(-) SETTING	(+) SETTING
1 ST Run	11.95	9.00
2 ND Run	12.01	8.70
3 RD Run	11.95	8.90

TRIAL – 02 RESPONSE – DIAMETER

TRIALS	(-) SETTING	(+) SETTING
1 ST Run	11.95	9.00
2 ND Run	12.01	8.70
3 RD Run	11.95	8.90
Median	11.95	8.90
Range	0.06	0.3
D	3.05	
d	0.18	
D/d	16.94	

CONCLUSION:

Since D/d ratio is >3. The selected '+' setting parameters are ok & proceed further steps.

53 Construction of Factorial Table

Stage # 1 – To construct factorial table and collect data for each combination in the factorial table and quantify the contributions. (Using Minitab software).

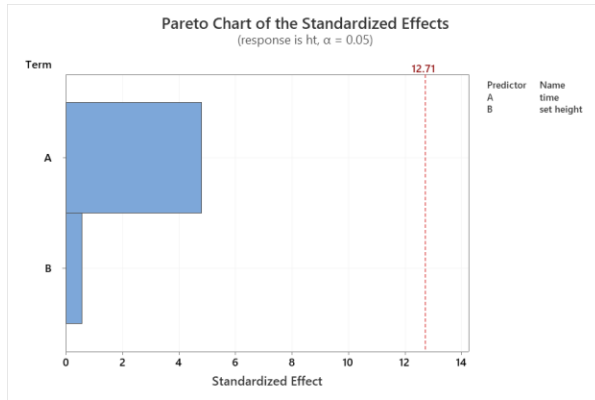
S.no	Timer (seconds)	Set height (mm)
1	7	0.9
2	16	0.3
3	7	0.3
4	16	0.9

S.no	Timer (seconds)	Set height (mm)	Y1 – diameter (mm)	Y2 – height(m)
1	7	0.9	9.26	2.57
2	16	0.3	11.94	1.89
3	7	0.3	8.9	2.50
4	16	0.9	11.95	1.70

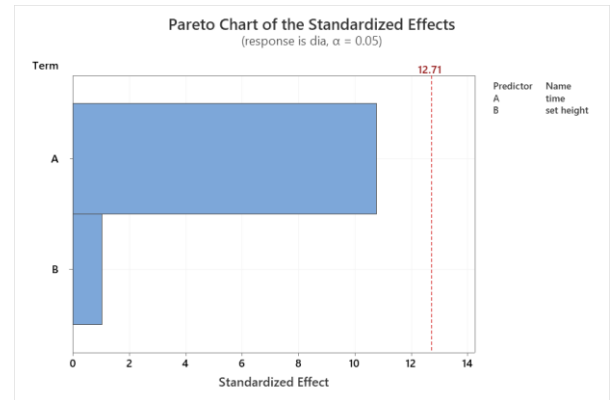
Using Minitab software, Analyzed each parameter significance to Response, Main effect, Interaction effect and Mathematical model for both Responses (Rivet Diameter and Rivet Height)

5.4 Pareto chart

Rivet height - Parameter contribution



Rivet Diameter – Parameter contribution

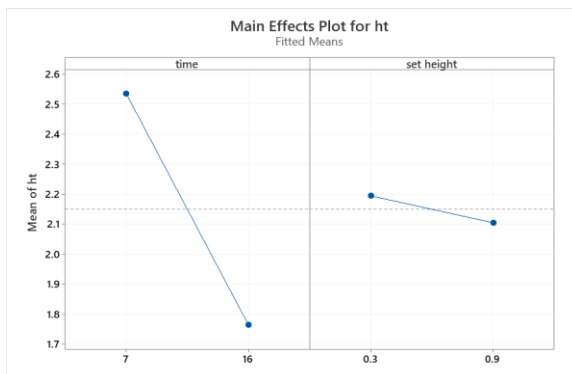


Inference

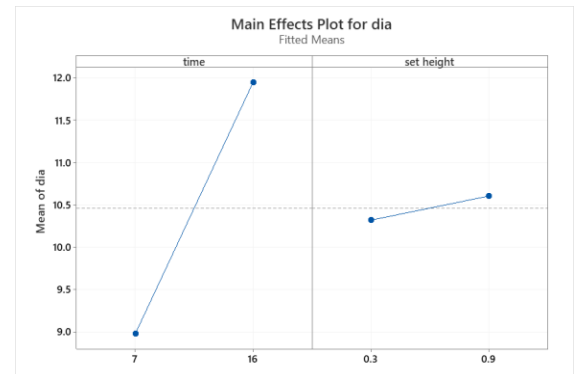
Time parameter is significantly influencing than set height.

5.4 Main effect plot

Rivet height - Parameter contribution



Rivet Diameter – Parameter contribution



Inference – Rivet Height

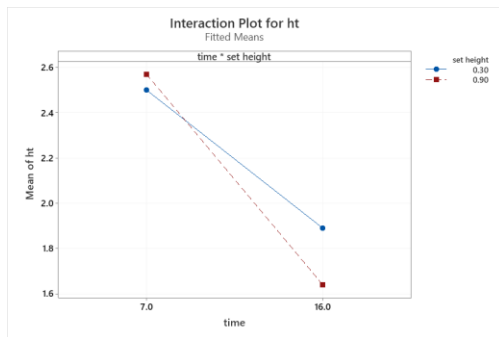
- Time and the Rivet height are inversely proportional. When the time increases the rivet height decreases
- Set height and Rivet height are inversely proportional. when the set height increases the rivet height decreases. Set height is marginally influencing response.

Inference – Rivet Diameter

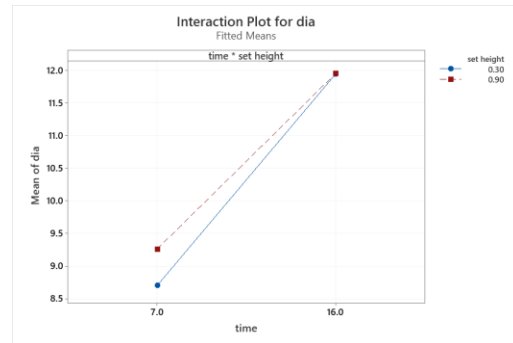
- When the time increases the rivet diameter decreases.
- when the set height increases the rivet diameter marginally decreases. Set height is marginally influencing response

5.5 Interaction Plot

Rivet height - Parameter contribution



Rivet Diameter - Parameter contribution



Inference

There is an interaction effect between the time and set height on both Rivet height and Rivet Diameter.

5.6 Math equation and Optimization

$$Y (\text{Optimal}) = \text{LSL} + 2.3 * d$$

Here LSL for Rivet height is 1.5 m (Product Design requirement) For Rivet height,

$$Y = 1.5 + 2.3 * (0.215)$$

$$Y (\text{Rivet Height}) = 1.99 \text{ mm.}$$

Here LSL for Rivet Diameter is 9.5 mm (Product design requirement) For Rivet diameter,

$$Y = 9.5 + 2.3 * (0.18)$$

$$Y = 9.5 + 2.3 * (0.18)$$

$$Y (\text{Rivet diameter}) = 9.914 \text{ mm}$$

5.7 Making math equation for optimization

$$Y (\text{OUTPUT}) =$$

Constant + Coefficient of A*A + Coefficient of B*B + Coefficient of A* Coefficient of B * A* B.

58 Estimated Coded Equation

A. Estimated Coefficients for height using data in uncoded units for Rivet Height

S, NO	TERM	COEFFICIENTS
1	Constant	2.83833
2	Set height	0.453704
3	Timer	-0.0533333
4	Set height *timer	-0.0481481
OUTPUTS DERIVED USING MS EXCEL WHAT IF ANALYSIS COMMAND FOR HEIGHT		

	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1	1.1	1.2
7	2.500229	2.511895	2.523562	2.535228	2.546894	2.558561	2.570227	2.581893	2.59356	2.605226
8	2.432485	2.439336	2.446188	2.453039	2.459891	2.466742	2.473594	2.480445	2.487297	2.494148
9	2.36474	2.366777	2.368814	2.37085	2.372887	2.374924	2.37696	2.378997	2.381034	2.383071
10	2.296996	2.294218	2.29144	2.288661	2.285883	2.283105	2.280327	2.277549	2.274771	2.271993
11	2.229251	2.221658	2.214065	2.206473	2.19888	2.191287	2.183694	2.176101	2.168508	2.160915
12	2.161507	2.149099	2.136691	2.124284	2.111876	2.099468	2.087061	2.074653	2.062245	2.049837
13	2.093762	2.07654	2.059317	2.042095	2.024872	2.00765	1.990427	1.973205	1.955982	1.93876
14	2.026018	2.003981	1.981943	1.959906	1.937869	1.915831	1.893794	1.871757	1.849719	1.827682
15	1.958274	1.931421	1.904569	1.877717	1.850865	1.824013	1.797161	1.770309	1.743456	1.716604
16	1.890529	1.858862	1.827195	1.795528	1.763861	1.732194	1.700527	1.66886	1.637193	1.605526

B. Estimated Coefficients for height using data in uncoded units for Rivet Height

S.NO	TERM	COEFFICIENTS
1	Constant	5.68611
2	Set height	1.6463
3	Timer	0.390556
4	Set height *timer	-0.101852
OUTPUTS DERIVED USING MS EXCEL WHAT IF ANALYSIS COMMAND FOR DIAMETER		

	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1	1.1	1.2
7	8.700003	8.793336	8.88667	8.980004	9.073337	9.166671	9.260004	9.353338	9.446672	9.540005
8	9.060003	9.143152	9.2263	9.309448	9.392597	9.475745	9.558894	9.642042	9.72519	9.808339
9	9.420004	9.492967	9.56593	9.638893	9.711856	9.78482	9.857783	9.930746	10.00371	10.07667
10	9.780004	9.842782	9.90556	9.968338	10.03112	10.09389	10.15667	10.21945	10.28223	10.34501
11	10.14	10.1926	10.24519	10.29778	10.35038	10.40297	10.45556	10.50815	10.56075	10.61334
12	10.5	10.54241	10.58482	10.62723	10.66964	10.71204	10.75445	10.79686	10.83927	10.88167
13	10.86001	10.89223	10.92445	10.95667	10.98889	11.02112	11.05334	11.08556	11.11778	11.15001
14	11.22001	11.24204	11.26408	11.28612	11.30815	11.33019	11.35223	11.37427	11.3963	11.41834
15	11.58001	11.59186	11.60371	11.61556	11.62741	11.63927	11.65112	11.66297	11.67482	11.68667
16	11.94001	11.94167	11.94334	11.94501	11.94667	11.94834	11.95001	11.95167	11.95334	11.95501

Chosen optimal setting

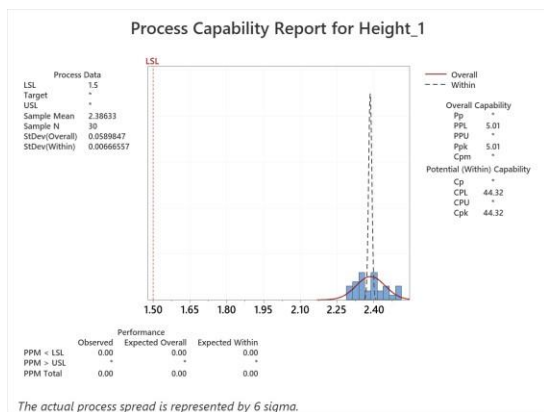
	INPUT (X)		OUTPUT (Y)	
S.NO	TIMER	SET HEIGHT	DIAMTER	HEIGHT
1	11	0.3	10.14	2.22

VI. IMPROVE PHASE

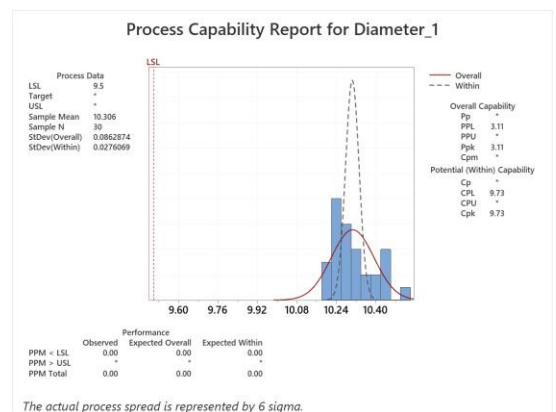
For confirming set parameters, Rivet diameter and Rivet height were checked trials were taken for 30 samples.

S.no	Height	Diameter
1	2.3	10.2
2	2.31	10.21
3	2.31	10.21
4	2.32	10.22
5	2.32	10.22
6	2.33	10.23
7	2.33	10.23
8	2.34	10.24
9	2.34	10.24
10	2.35	10.25
11	2.35	10.25
12	2.36	10.26
13	2.36	10.26
14	2.37	10.27
15	2.37	10.27
16	2.39	10.28
17	2.39	10.29
18	2.39	10.3
19	2.4	10.31
20	2.4	10.32
21	2.41	10.33
22	2.42	10.35
23	2.43	10.5
24	2.44	10.37
25	2.45	10.39
26	2.46	10.41
27	2.47	10.43
28	2.49	10.44
29	2.49	10.45
30	2.5	10.45

Preliminary process capability for height



Preliminary process capability for diameter



Inference:

The preliminary process capability index value for Height and Diamter is > 1.33 and acceptable

VII CONTROL PHASE

Process parameters were updated in SOP and parameters were addressed in Setup approval sheet.

SIX SIGMA TOOLS USED				
DEFINE	MEASURE	ANALYZE	IMPROVE	CONTROL
SIPOC	Calibration record	Full factorial	SPC chart	
Process flow		Main effect		SOP
Pareto chart		Interaction effect		Set up approval sheet

VIII CONCLUSION

Hence by using DOE Six sigma method new set of effective and efficient parameter was found out without compromising any quality factors and also learnt about the applications of DOE tool in six sigma methodology.

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