MANUFACTURING CYCLE TIME REDUCTION THROUGH SIX SIGMA METHODOLOGY

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ABSTRACT

We had completed our project on cycle time reduction through six sigma methology in Pragati Power Products, Naroda GIDC in which we had used DMAIC (Define-Measure-Analysis-Improve-Control) Approach to curb the cycle time.They produce many types of pulleys, shafts and berarings but we had selected TIMING Pulley because the demand of this pulley was much greater than other products.By using all tools of DMAIC Approach, We got the result by reducing approximate 30 minute from overall cycle time of timing pulley. First and for most we provide training to the no-trainee workers. Secondly, we reduce around 20 min on hobbinng machine by installing PLC indexing. Thirdly, we mitigated 0.30 sec/piece for flange finishing operation by doing finishing more than 1 Piece at a time by New designed Mandrel. Furthermore, we curtail around 5 min on hobbing machine by enlarging hole of lubrication tank. So, at the end we approximately reduce 30-35 min per cycle time so company can now get more profit than before.

Keyword: - *DMAIC Approach, Training, PLC indexing, Mandrel, Enlarge hole.*

1. INTRODUCTION

Six Sigma is a well-structured methodology that focuses on reducing the time and various defects occurring in the processes as well as in the products. Six Sigma methodology was originally developed by Motorola in 1980s and it targeted a difficult goal of **3.4 defects per million**. Six Sigma has been on an incredible run over 25 years, producing significant savings to the bottom line of many large and small organizations. Objectives of six sigma: Cycle time reduction, Reduce Variability, Reduce Waste, Reduce Cost, Improving Customer Satisfaction.

Steps in Six Sigma	**Main Activities**
DEFINE	Define the requirements and expectations of the customer.
MEASURE	Collect and compare data to determine issues and shortfalls
ANALYSIS	Analyze the causes of defects and sources of variation. Fishbone graph, FMEA Analysis. Determine the variations in the process.
IMPROVE	Develop creative alternatives and implement enhanced plan
CONTROL	Develop a strategy to monitor and control the improved proImplement the improvements of systems and structures

Table: 1

1.1 PROBLEM DEFINITION

We select **TIMING BELT PULLEY**. **The reason behind the selection of this product is that customers more demanded for this product when compare to other products.** After analyses the all operations of the timing belt pulley and last two months data, we observe that average cycle time 1 hr. and 34 min instead of 1 hr. and 24 min which is loss of productivity in making pulley which is indirectly affect the end customers and company profit. So if we retain this loss by reducing the cycle time then company can more profit at the end of month and in such a way that they will improve their business.

What is the specific problem affecting the success of our business?	**Maximum Cycle time of TIMING BELT PULLEY**
Who are the internal or external customer most affected by this project?	Internal Customer :- Manufacturing Department External Customer :- End Customer
Where is the problem occurring?	At manufacturing department
When the problem is first observed?	When we analyses the GEMBA.
How do you know this is a problem? What target is not met?	By observing all the operations of Timing Pulley. By this problem business has loss.
Approx. Financial Benefit of this	We can earn more profit by doing this project.
Problem Statement	Last two months data show that average cycle time 1 hrs. And 34 min instead of 1 hrs. And 24 min which is productivity loss in making pulley which is indirectly effect on our customer and profit.

Table: 2

Fig. 1 Timing belt pulley

2. DMAIC APPROACH

2.1 DEFINE PHASE

After observed the all operations of the timing belt pulley, we make a detailed flow process chart of timing belt pulley **for better understand the all operations which gives us a way to find the problem or error** which increases the manufacturing cycle time.

After that we made a project charter which is the most important document of our project. By seeing a project charter we can get the all idea about the whole project. In project charter all the information about the project is given and it is live till the end of the measure phase.

Project Charter

Project Name: Manufacturing Cycle Time Reduction Through Six Sigma

Problem Statement	Business Case & Benefits
Last two months data show that average cycle time 1 hr and 34 min instead of 1 hr and 21 min which is approx. 10% productivity loss in making pulley which is indirectly affect on our customer and profit.	If we reduce average cycle time from 1 hr and 34 min to 1 hr and 21 min so we can complete 2 pulley/day more ,that mean we can produce 44 more pulleys at the end of the month that shows company can profit approx. 10% more at the end of the month.

Goal Statement	Timeline		
The goal is to decrease 13 min from 1 hr and 34 min by 01/04/2018.	**Phase**	**Planned**	**Actual**
	Define:	10/09/2017	20/09/2017
	Measure:	15/10/2017	10/11/2017
	Analyze:	01/02/2018	12/02/2018
	Improve:	15/03/2018	24/03/2018
	Control:	30/03/2018	01/04/2018

Scope		Team Members	
Process Start:	Raw Material comes to the hexo machine	**Position**	**Person**
Process End:	Final Inspected Pulley	Team Leader	Modi Mihir
		Sponsor	Dr. Rakesh Patel
		Team Member	Panchal Hit
		Team Member	Patani Gaurang
		Team Member	Patel Miken

Fig -1: Project Charter

2.2 SIPOC

After completing a Project Charter we made a **SIPOC**, in SIPOC, **S** stands for **SUPPLIERS**, **I** stands for **INPUT, P** stands for **PROCESS**, **O** stands for **OUTPUT** and **C** stands for **CUSTOMERS.**

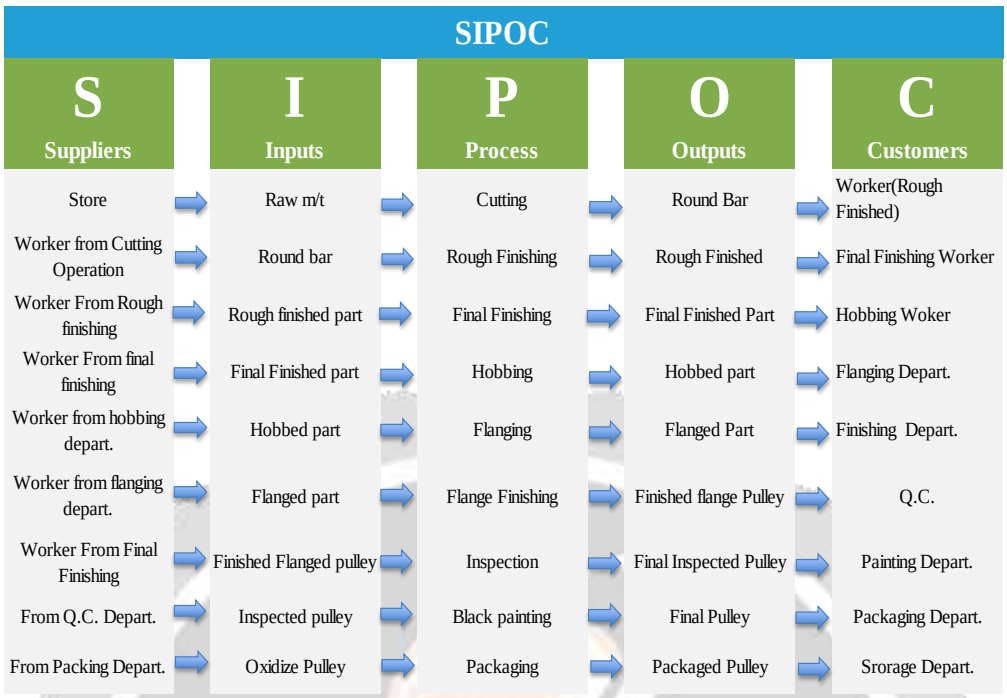

Fig.2 SIPOC

2.3 VOC (Voice of Customer)

Objectives of VOC are:

- Identifying critical product features
- Identifying improvement areas.
- Estimating minimal improvement necessary

Voice Of Customer		
Customer Comment (What Are They Saying?)	**Gathering More Understanding (Why Are They Saying it?)**	**Customer Requirement (What Do They Want?)**
Worker of rough finish operation doesn't have any complain about round bar which is cut by hexo machine operator	Nothing	He got what he wants
Worker who do final finish says that he can got more precise dimension of rough finnished part i.e. if O.D. is 70 mm then rough finished worker needs to cut 63 or 65 mm.	Due to more thickness of rough finished part he has to spent more time for final finish	He wants more precise dimensions
Worker who do hobbing process complaining that sometimes he got wrong bore	Due to the wrong bore he has to send back to the final finished part and enlarge bore with proper dimension	He wants proper dimensions of final finishing part
Worker who do flanging does not have any complain about hobbed part	Nothing	He got what he wants
Every Worker has a complain about lack of measuring instruments	Due to lack of measuring instruments, They has to find instrument while checking the parameters of pulley	They need proper number of measuring instrument and also at proper place

Fig. 3 VOC (Voice Of Customer)

3. MEASURE PHASE

3.1 Data Collection Plan

- The first section of Data Collection Plan pertain to "what data you want to collect"
- The remaining sections of the Plan will be covered later in this module.

Data Collection Plan								
Measure					Sampling Plan			
Input / Output	Measure	Data Type	Operational Definition	Measurement Method	Who	Type	How Many	When
Raw Material	Cutting Process	Minutes - Contionous	We will measuring cutting time from the raw material arrived to the hexo machine and then throughout the complete cutting process	Using Stopwatch	Gaurang	Process	6	02/09/2017
Round Bar	Rough Finishing Process	Minutes - Contionous	We will measuring rough finishing time when round bar comes from hexo machine to the lathe machine and unloading the rough finished	Using Stopwatch	Heet	Process	6	02/09/2017
Rough Finished Part	Final Finishing Process	Minutes - Contionous	We will measuring final finishing time when rough finished part is loaded to the lathe machine to unloading the final finished part	Using Stopwatch	Heet	Process	6	03/09/2017
Final Finished Part	Hobbing Process	Minutes - Contionous	We will measuring hobbing time when fina finished part is loaded to the unloading the hobbed part	Using Stopwatch	Heet	Process	6	08/09/2017
Hobbed Part	Flanging Process	Minutes - Contionous	We will measuring flanging time when hobbed part is getting flange	Using Stopwatch	Mihir	Process	6	09/09/2017
Pulley	Inspection	Minutes - Contionous	We will measuring inspection time from inspector inspect the all parameters of the pulley is either correct or not and give the decision.	Using Stopwatch	Heet	Process	6	09/09/2017
Inspected Pulley	Oxidization	Minutes - Contionous	We will measuring oxidization time throughout the whole pulley gets oxidize	Using Stopwatch	Gaurang	Process	6	10/09/2017
Oxidized Pulley	Packaging	Minutes - Contionous	We will measuring packaging time	Using Stopwatch	Miken	Process	6	10/09/2017

Fig. 4 DATA COLLECTION PLAN

3.2 Pulley Timing

Processes	Average Cycle time (min)	Operators
Cutting	4.20	1
Rough Finishing	26.48	1
Final Finishing	21.13	2
Hobbing	24.30	1
Flange Fitting	2.55	1
Flange Finishing	2.04	1
Inspection	10.20	1
Blackodizing	3.55	1
Packaging	1.02	2
Total	94.66 (1 hr. and 34 min)	11

Table: 3

3.3 Pareto Chart

- Shows 80/20 rules
- Helps focus efforts on problems, which cause most of the defects.

By this Pareto chart, we observe that we need to focus on mainly 3 operations hobbing, final finishing and rough finishing because these three operations have more time than other operations.

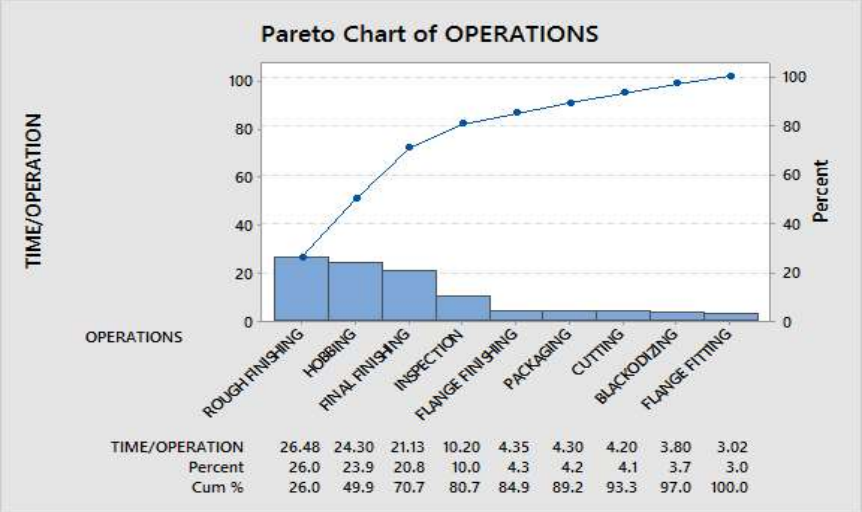

Chart 1 Pareto chart of OPERATIONS

4. ANALYSIS PHASE

4.1 Brain Storming

Brainstorming is a group creativity technique by which efforts are made to find a conclusion for a specific problem by gathering a list of ideas spontaneously contributed by its members.

Process for generating creative ideas and solutions through intensive and freewheeling group discussion. Every participant is encouraged to think aloud and suggest as many ideas as possible, no matter seemingly how outlandish or bizarre. **Analysis, discussion, or criticism of the ideas is allowed only when the brainstorming session is over and evaluation session begins.**

- **Result of Brainstorming:**

Fig. 5 Slips

- **All the equipment are not at proper place. So that confusion for select and pick up the equipment.**
- **In company, there is three hobbing machine and all of them are operate by only one worker so whenever the hobbing is completed, it has to wait for unload.**
- **Lack of Experience**
- When measuring the component with the help of simple vernier calipers occurs dimension defects.

- Sometimes workers doing time pass by using mobile or for eating a masala.
- **If one extra helper comes to the company in the morning and cleaned the floor & machine then workers don't need to waste their time to cleaning.**
- Tapping is done by hand.

4.2 Technical Issues & Solutions:-

1. At the hobbing machine, worker has to do indexing for new job and as we know that there are three hobbing machine in company and all are operated by only one worker so whenever worker does indexing, it takes 30-40 minutes depends on the job so that time production of machine stopped.

Sol. - To overcome this problem, we can use PLC indexing. Its initial cost is high but as time passes it will recover.

2. Some workers have less experience due to this if worker does rough finishing of pulley, he checks w/p usually for many time and few times per product it leads to high cycle time.

Sol. - For this problem, we can provide some small training period (i.e. 1 week to 10 days) under senior worker.

3. Machine has to stop at morning (when production start) for 15-20 min because in cold season lubrication cannot flow down as it get dense due to temp.

Sol. – To solve this problem, we can enlarge dia. of tank's lower hole from oil goes downward.

4. In company, they machining flange one by one that increase time very much.

Sol. - We suggest them to make a design of mandrel which used to do machining of 3-4 flange together.

4.3 Non-Technical Issues & Solutions:-

1. There is no place for measuring instruments or less measuring instruments so worker has to find measuring instrument for inline inspection. Due to this worker has to stop machine, find an instruments and come back and measures the W/P. It leads to high cycle time. (It seems small problem but it can raise 2-3 minute per product) and if worker has to go to other machine or other person for finding instrument, he also waste some small time by talking to person(It also seems small thing but at the end of the day it waste large time).

Sol. - We can solve this problem by putting table for instruments at each and every machine and give strictly instruction to workers that put instruments at on their table.

5. IMPROVE PHASE

- As getting solution in analysis phase, we have to implement that in field & check whether our solutions are liable or not.
- So, as we found that PLC indexing rather than manual indexing can reduce more cycle time so we suggest them to implement **integral PLC** in hobbing.
- Also we suggest them to **enlarge the diameter** of tank's outlet so in winter at the morning worker does not need to wait for 15-20 min.
- Another improvement we made was, we gave them idea to make a design of **mandrel** which can hold more than 1 or 2 flange on it so worker does not need to load and unload the pulley every time for only one flange and it will reduce cycle time.

5.1 Process Capability (BEFORE-AFTER COMPARISION)

- Compares the width of process variation to the width of Specifications or Requirements.
- The higher the Cpk, the better.

Rough Finishing:-
Before Improvement

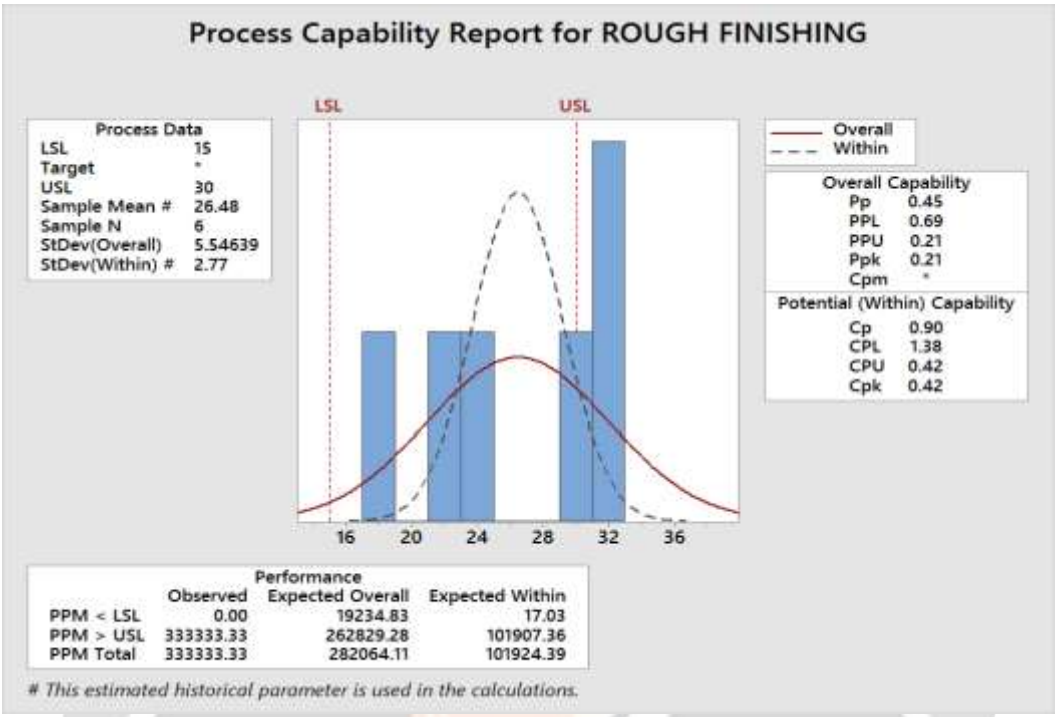

Fig. 6

After Improvement

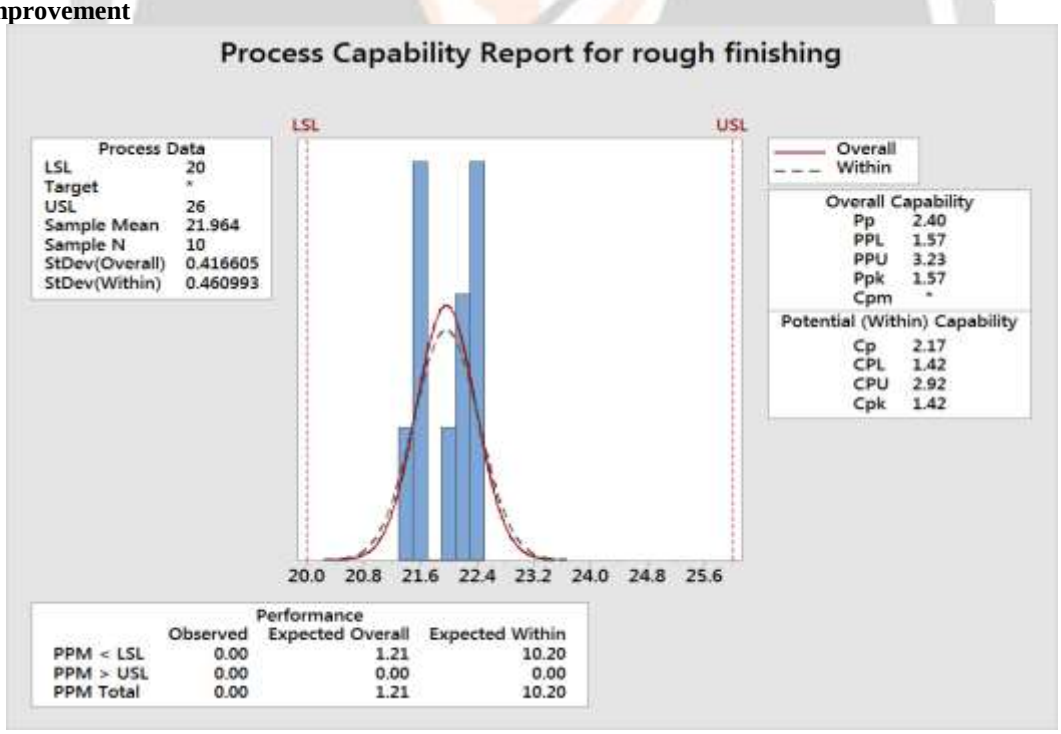

Fig. 7

Indexing Timing:-
Before Improvement

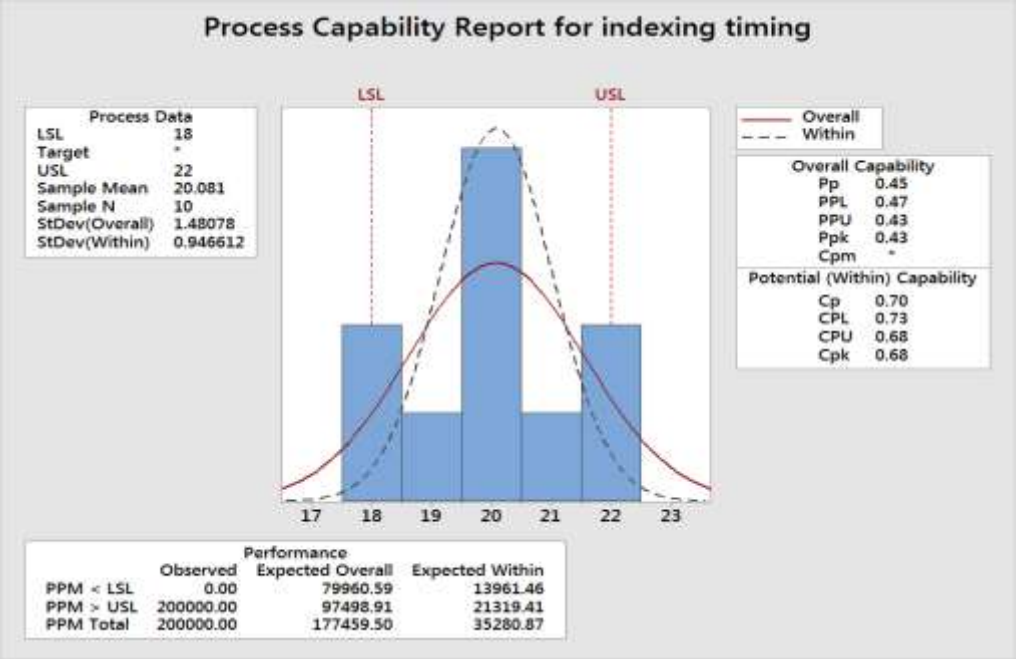

Fig.8

After Improvement

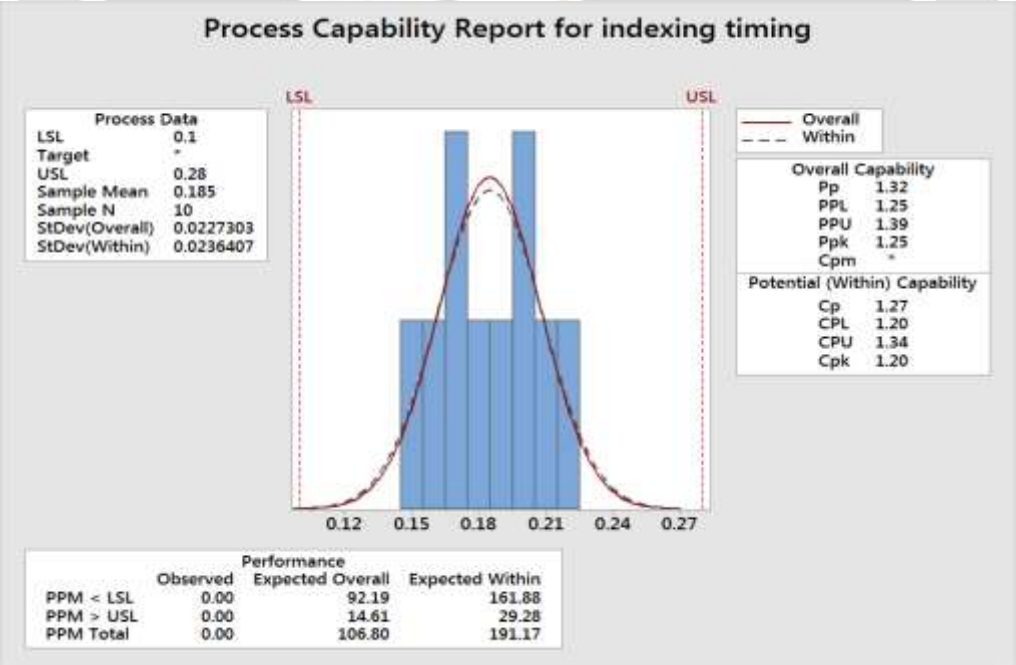

Fig.9

Lubrication Flow Time:-
Before Improvement

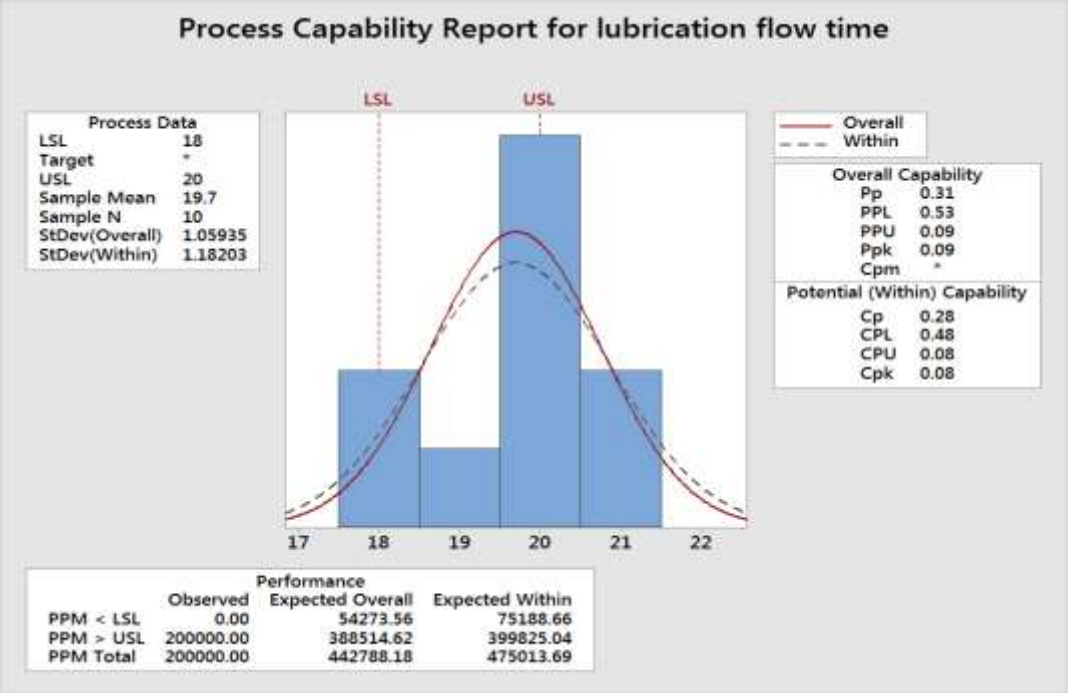

Fig. 10

After Improvement

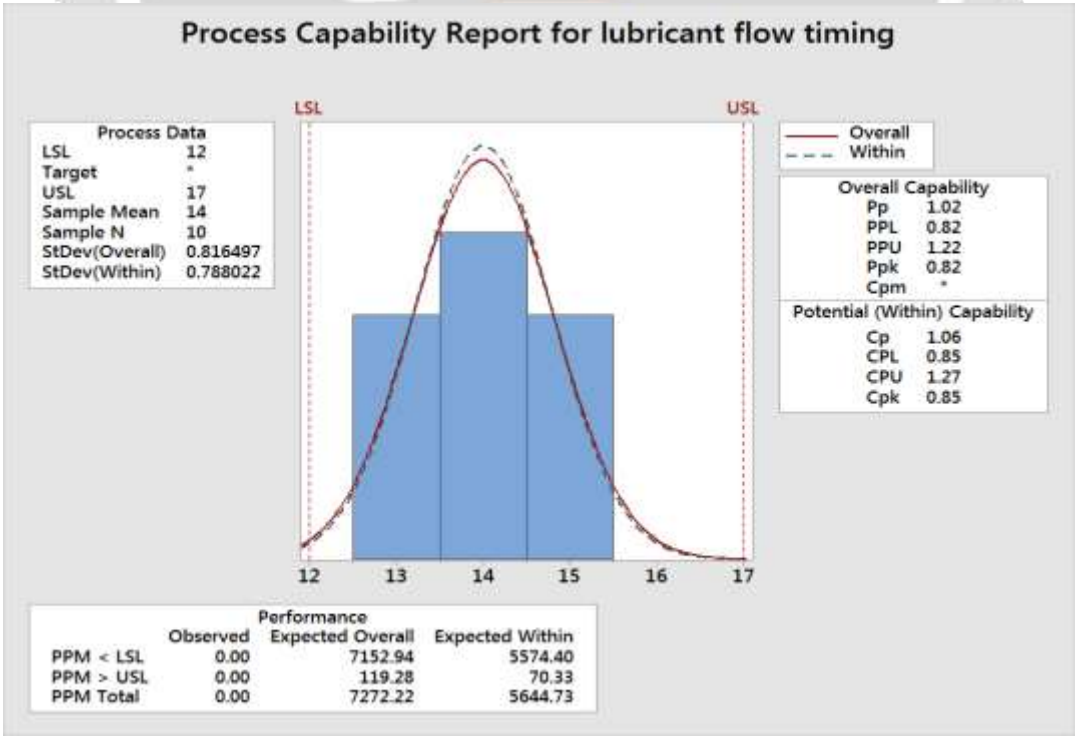

Fig. 11

Flange Finishing:-
Before Improvement

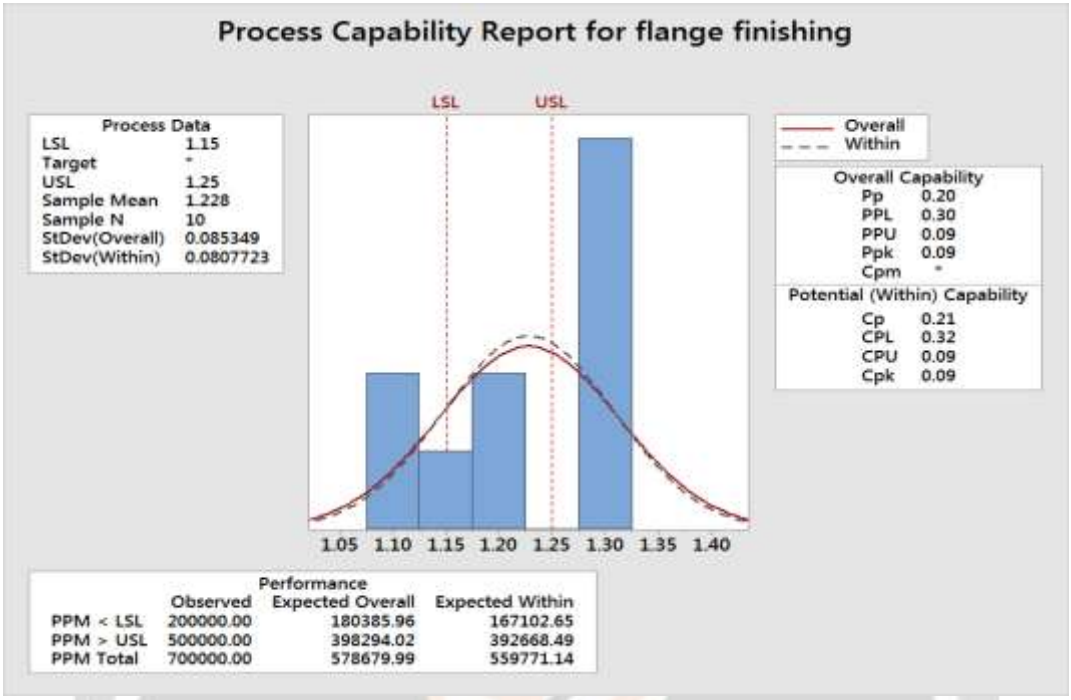

Fig. 12

After Improvement

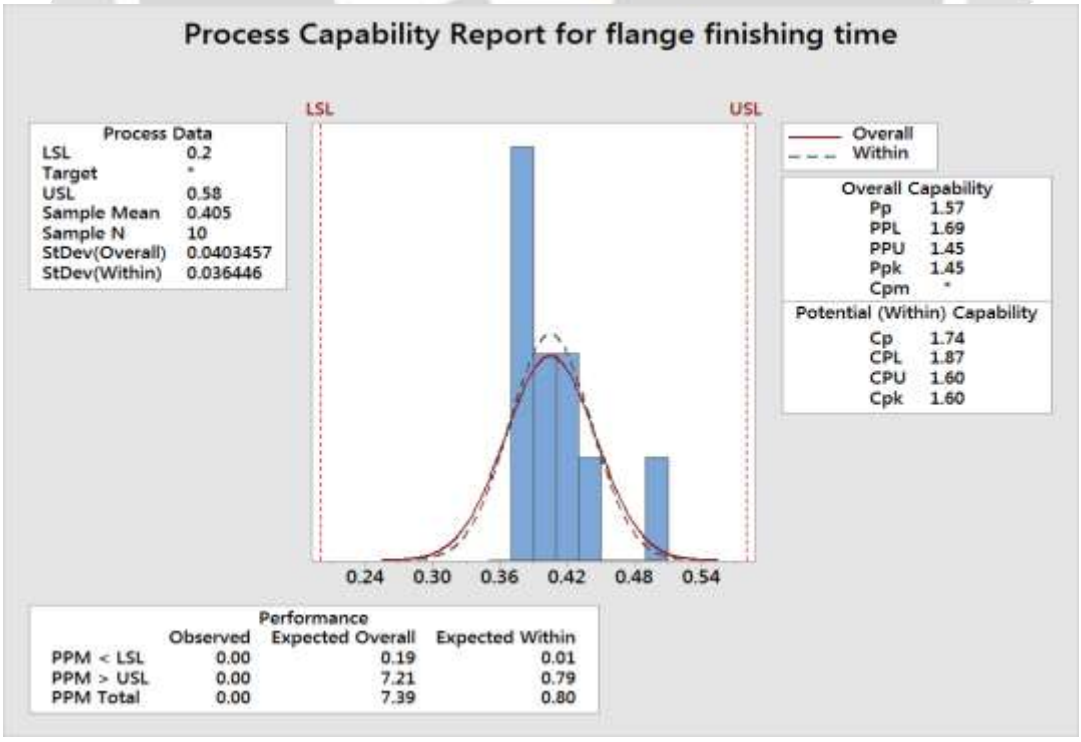

Fig. 13

5.2 New data of processes which are affect by our solution:

Processes	**Before Average Cycle time(min)**	**After Average Cycle time(min)**
Cutting	4.20	3.53
Rough Finishing	26.48	22.36
Final Finishing	21.13	21.35
Hobbing	24.30	24.30
Flange Fitting	2.55	2.16
Flange Finishing	1.23	00.41
Inspection	10.20	9.42
Blackodizing	3.55	3.24
Packaging	1.02	1.13
Total	**94.58(1 hr. and 34 min)**	**87.54(1 hr. and 27 min)**

Table: 4

Factors	**Before Average Cycle time (min)**	**After Average Cycle time (min)**
Indexing	20.09	00.19
Lubricant Flow	20	14
Total	**40.09 (30 min and 09 sec)**	**14.19 (14 min and 19 sec)**

Table: 5

You can see the big difference between before and after average cycle and that is 30 min we had reduced.

6. CONTROL PHASE

In control phase we made a Monitoring and Response Plan.

Monitoring Plan						Response Plan	
Name of the Measure	Input, Process or Output?	What is the Target?	Method of Data Capture	Checking Frequency	Person Responsible	Upper/Lower Trigger Point	Who Will Respond?
Cutting Time	Process	2 to 3 min	Stopwatch	Weekly	Worker	No more than 3 minute	Supervisor
Rough Finishing	Process	20 to 23 min	Stopwatch	Weekly	Worker	No more than 23 minute	Supervisor
Final Finishing	Process	20 to 23 min	Stopwatch	Weekly	Worker	No more than 23 minute	Supervisor
Hobbing	Process	25 to 30 min	Stopwatch	Weekly	Worker	No more than 30 minute	Supervisor
Flange Fitting	Process	2 to 3 min	Stopwatch	Weekly	Worker	No more than 3 minute	Supervisor
Flange Finishing	Process	In 1 min	Stopwatch	Weekly	Worker	No more than 1 minute	Supervisor
Inspection	Process	10 to 12 min	Stopwatch	Weekly	Worker	No more than 12 minute	Supervisor
Blackodizing	Process	3 to 4 min	Stopwatch	Weekly	Worker	No more than 4 minute	Supervisor
Packaging	Process	1 or 2 min	Stopwatch	Weekly	Worker	No more than 2 minute	Supervisor

Fig. 14

7. CONCLUSIONS

We had completed our project to reduce the cycle time of timing belt pulley by using six sigma methodology in which we used DMAIC approach and we had completed define, measure, analysis, improve and control phase.
After applying all the tools we got the conclusion:-

- By doing this project we conclude that we have reduced around 4min. in rough finishing operation by **providing a training** to **non-trainee** person.
- We reduced time around 30min. On hobbing machine by **installing PLC** for doing indexing every day.
- We reduced 0.30min./piece for flange finishing operation by doing finishing **more than 1 piece at a time** using mandrel.
- We reduced around 5min. On hobbing machine by **enlarge hole of lubrication tank.**

8. ACKNOWLEDGEMENT

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