Increasing the Production Capacity of N112 Carburator

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Abstract:- Keihin Fie. Pvt Ltd is a Japanese Multi-National having its product range in Engine Parts, and is leading manufacturer for nearly all Two Wheeler Manufacturers in India. The company has started its modern plants at Chakan MIDC, Pune and Bawal, Haryana to produce precise carburetors and air suction valves and hence cater the demand of Indian two-wheeler and three-wheeler automobiles.

Keihin carburetors, engine management system and other components provide quick response and high performance in motorcycle and recreational vehicles. In today's competitive world, it is vital to constantly improve, be it a manufacturing or service industry. Quality with quantity is a main characteristic which helps a company stay in the competition. Technology has taken leaps of development lately and this has brought about an increase in the customer demands.

The main aim is to study the current capacity, analyze it to find areas of improvement and make an improvement proposal to meet the forecasted increase in demand of N112 Carburetor of TVS Apache. This report presents the current performance of outputs and capacity of the plant calculated using continuous data collected in shop floor. In each workstation the processing time is different and the longest time consumption workstation will be identified as a bottleneck workstation. The identified bottleneck station will be analyzed to reduce the processing time which increases production rate.

***Keywords**:- productivity improvement, time study analysis, DMAIC-Define, Measure, Analyse, Improve, Control.*

I. INTRODUCTION

A. Problem Statement

Keihin Fie manufactures 3000 parts per month of N112 Carburetor model but due to increasing demand of customer, TVS, the Target from March 18 has been raised to 25000 parts per month. Company aims to manufacture 28000 parts per month considering rejections & balance stock.

The company aims at improving their output and productivity to achieve their yearly target by eliminating some causes and production time that affect profit for company. In flow line production the product moves to one workstation due to time restriction. Once it gets stuck due to accumulation in certain workstation, it exceeds the cycle time in that station. Faster station is limited by slowest station thus decreasing the rate of productivity. In order to cater the demand, productivity improvement techniques are needed to be used to identify the bottleneck process in production line and minimize or eliminate them to achieve the set target of the company.

B. About Part

TVS is a major customer of Keihin Fie. N112 carburetor used in TVS Apache RTR 200 is the part under current study. The part comprises of around 200 Child Parts, All of which are supplied by different suppliers.

Fig 1:- TVS Apache RTR 200

C. Manufacturing Processes of N112

There are majorly four manufacturing processes

- *Die casting*

Die casting is a metal casting process in which the molten metal is forced under high pressure into a mold cavity. The mold cavity is created using two hardened tool steel dies which have been machined into shape and work similarly to an injection mold during the process. Manufacturing of parts using die casting is comparatively simple, involving only four major steps, which keeps the incremental cost per item low. It is especially suited for a large quantity of small- to medium-sized castings, which is why die casting produces more castings than any other casting process. Die castings should have a very good surface finish (by casting standards) and dimensional uniformity.

Keihin-Fie uses Multi mold casting, with four jobs per cycle. Material used for the production of carburetor is

Aluminum 4043. There are three Special Purpose Machines for die casting each producing.

After Casting there is a Deburring Process and a Quick Quality Check.

- *Machining*

Machining is any of various processes in which a piece of raw material is cut into a desired final shape and size by a controlled material-removal process. In today's modern world much machining is carried out by computer numerical control (CNC), in which computers control the movements and operations of the mills, lathes, other cutting machines, etc. The Machine Shop of the Company majorly uses VMCs Boring Machines and Gang Drilling Machines.

Following Operations are performed

- *Milling:*- Milling machining process uses rotary cutters to remove material from a work piece by feeding in a direction and at an angle with the axis of the tool.

- *Drilling:*- Drilling is a cutting process in which a drill bit is used to cut a hole of circular cross-section in solid materials. The drill bit is normally a rotary cutting tool, and frequently multipoint.

- *Tapping:*- Tapping is the process of cutting threads from the inner side of the components like inside a hole so that a cap screw or bolt can be threaded into the hole.

- *Reaming:*- A reamer is a type of rotary cutting tool used in metal working. The process of enlarging the hole is called reaming.

- *Boring:*- In boring a hole which has already been drilled or cast with the help of a single-point cutting tool is enlarged, such as in boring a gun barrel or an engine cylinder.

- *Facing:*- In machining, facing is the act of cutting a face, which is a planar surface, onto the work piece.

- *Chemical Processing*

Due to high Fuel Contact the mother body is chemically treated to prevent oxidization. The Parts are dipped in Oxidizing Chemicals and allowed to react.

- *Assembly*

An assembly line is progressive assembly in which parts (usually interchangeable parts) are added as the semi-finished assembly moves from workstation to workstation where the parts are added in sequence until the final assembly is produced.

There are 200 outsourced child parts which are semi automatically assembled on assembly line.

II. LITERATURE SURVEY

A. Productivity Improvement

Productivity improvement is one of the core strategies towards manufacturing excellence and it also is necessary to achieve good financial and operational performance. It enhances customer satisfaction and reduce time and cost to develop, produce and deliver products and service. Productivity has a positive and significant relationship to performance measurement for process utilization, process output, product costs, and work-in process inventory levels and on-time delivery. Refinement can be done by minimizing, eliminating, correcting of unsuccessful processing, simplifying processes, optimizing system, maximizing productivity, reducing cost, improving quality or responsiveness, reducing set-up time and cycle time, etc.

B. Capacity Management & Improvement

The Capacity management is responsible for all kinds of operations' capacity. It is generally responsible for matching the long-term capacity of a process to the demand for its products. It does this through capacity planning, which describes more specific methods for achieving this match.

C. Principles of Production Line

Production line has seven principles which are as follows:

- The principle of least distance: work stations should be located to the minimum distance to each other.
- The principle of constant flow: materials must flow continuously and with fixed rate.
- The principle of the division of labour between the staff of the line: circulation and division of labour between individuals.
- The principle of concurrency of the operations: in a production line all people should be working (on the first, last and all parts of the line).
- The principle of entirety of the operations: the entire set must be considered as a unit and with an overall goal.
- The principle of least time: finding the minimum time among the times.

Famous DMAIC technique is the methodology chosen to carry out to increase the production of N112 carburetor manufacturing. It also includes following considerations:

- From the direct continuous observation data collected the capacity has been calculated.
- Identification of bottleneck process.
- Analyzing bottleneck process.
- Reducing cycle time.
- Reducing TAKT time.
- Calculating overall machine efficiency.
- Reducing tool change over time.

This study technique is used to improve work process in company and the objectives towards accomplished with this study is to identify problems in the production work process and improve it in terms of production time, number of processes and production rate by proposing an efficient work process to company. This study uses systematic observations, flow process a stop watch time study as the methodology.

III. CASE STUDY BY USING DMAIC THEORY

A. Dmaic Model

One of the Six Sigma's distinctive approaches to process and quality improvement is DMAIC. The DMAIC model mentions five interdependent stages which are define, measure, analyze, improve and control that helps organizations to solve problems sequentially, statistically and improve their processes. Dale et al. defines the DMAIC phases as follows:

- *Define* – This stage within the DMAIC process involves defining the team's role; project scope and boundary; customer requirements and expectations and the goals of selected projects.
- *Measure* – This stage involves selecting the measurement factors which are to be optimized and provides a structure to evaluate current performance and assess, compare and monitor subsequent improvements and their capability.
- *Analyze* – This stage centers in determining the root cause of problems (defects), understanding why defects have taken place as well as comparing and prioritizing opportunities for advance betterment.
- *Improve* – This step focuses on the use of practical experimentation and statistical methods to get the possible improvements and hence reduce the amount of quality problems or defects.
- *Control* – The purpose of this step is to sustain the gains. Monitor the improvements to ensure continued and sustainable success. Create a control plan. Update records as required.

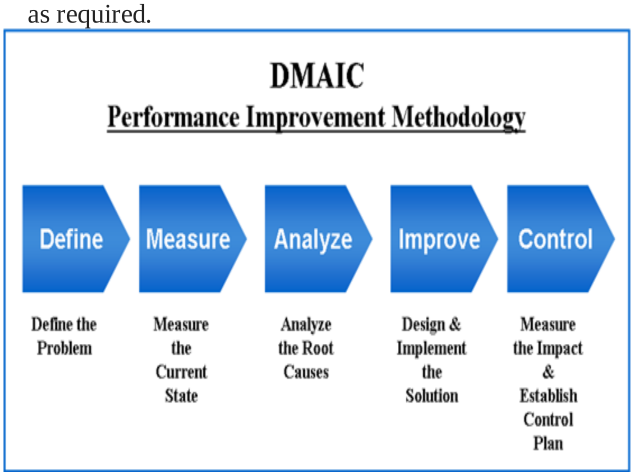


Fig 2:- DMAIC Methodology

B. Define Phase

Problem Statement:

Capacity of N112 model of carburetor is lower than Requirement for next year.

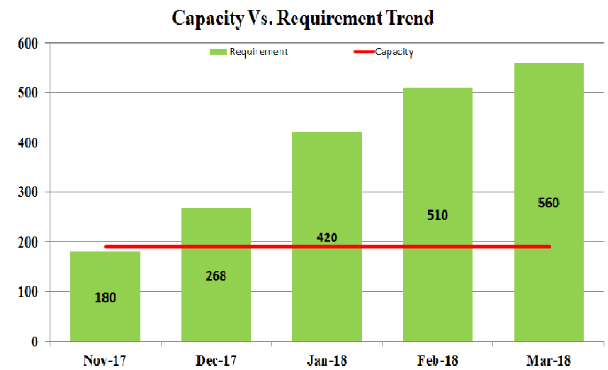


Fig 3:- Capacity Vs Requirement

Goal Statement

To increase the capacity of N112 model from 3000ppm to 28000 ppm.

C. Measure Phase

The "measure" phase of the DMAIC problem solving methodology consists of establishing reliable metrics to help monitoring progress towards the goal, which in this research consisted of reducing the amount of quality flaws in the rubber gloves manufacturing process. Particularly, in this project the "measure" phase meant the definition and selection of effective metrics to clarify the major defects which needed to be reduced. Also, a collection plan was adopted for the data to be gathered efficiently.

- *Process Wise Cycle Times*

To analyze process wise cycle times, 10 cycle times were measured for each process for each shift. The chart for average cycle time vs. the process is shown in Fig.

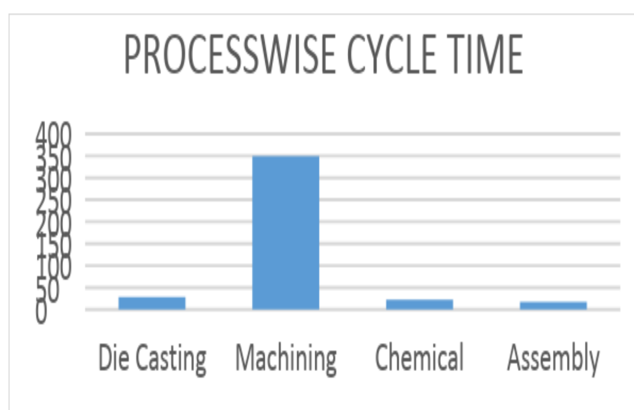


Fig 4:- Process wise Cycle Times

It clearly indicates that machining majorly contributes to overall cycle time and needs to be optimized.

- *Machine Wise Cycle Times:*

There are various machines used for boring, Drilling and Machining operations. Cycle Times were measured for all the machines for each machine. Following is the Column chart for same.

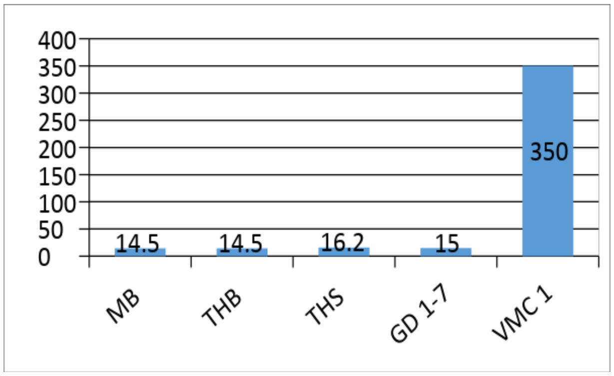


Fig 5:- Machine wise Cycle Times

The Chart Clearly indicates that VMC is the Bottleneck process in Machine Shop.

- *Operation Wise Cycle Time:*

There are three stages in VMC machining process and a operation wise measurement was taken. Following are the cycle times for each stage:

PROCESS	CYCLE TIME IN SEC.
ACV drilling	10
ACV tapping	15
ACV p Drilling	9
ACV Reaming	8
TH wire tapping	14
By st G 1 drilling	9
By st G 2 drilling	9
ACV air jet drilling	9
VPB boring	21
L/UL	4

Table 1. – Operation wise C.T

PROCESS	CYCLE TIME IN SEC.
Top drilling	10
Top tapping	14
SAJ drilling	10
SAJ reaming	9
By st Reaming	14
By st Grooving	8
BY st Centring	7
By st p drilling	10
By st tapping	10
L/UL	4

Table 2. – Operation wise C.T

PROCESS	CYCLE TIME IN SEC.
SJ drilling	9
SJ tapping	10
NJ tapping	10
SG 1 drilling	9
SG 2 drilling	9
ET drilling	10
BP reaming	12
AV drilling	8
FCB tapping	16
PS operations	28
Fuel p drilling	9
Th sensor tapping	12
L/UL	4

Table 3. – Operation wise C.T.

- *Operation Wise Rpm And Feed Rate*

OPERATION NAME	RPM	FEED RATE
ACV drilling	3500	0.2
ACV tapping	900	0.7
ACV P drilling	4000	0.18
ACV reaming	2400	0.22
TH wire tapping	900	0.8
By st. G1 drilling	3200	0.2
By st. G2 drilling	3200	0.2
ACV air jet drilling	3600	0.18
VPB boring	5000	0.15

Table 4. – RPM & Feed Rate

OPERATION NAME	RPM	FEED RATE
Top drilling	2800	0.25
Top tapping	900	0.7
SAJ drilling	3600	0.2
SAJ reaming	2500	0.24
By st. reaming	1800	0.18
By st grooving	2400	0.25
By st. centring	3200	0.35
By st. p drilling	3800	0.24
By st. tapping	600	1

Table 5. – RPM & Feed Rate

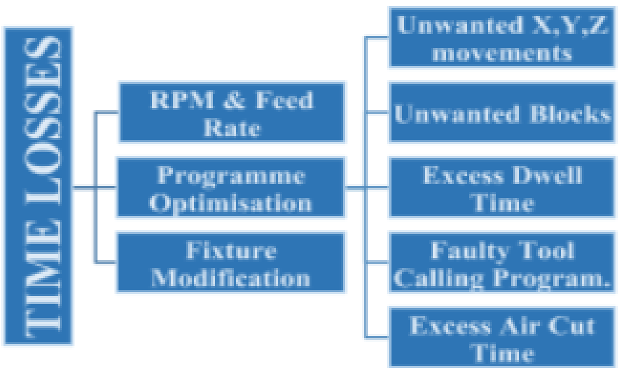
OPERATION NAME	RPM	FEED RATE
SJ drilling	3250	0.18
SJ tapping	900	0.8
NJ tapping	750	0.75
SG 1 drilling	3200	0.21
SG 2 drilling	3200	0.21
ET drilling	2800	0.2
BP reaming	1600	0.1
AV drilling	3500	0.26
FCB tapping	900	0.7
PS operations	4000	0.2
Fuel p drilling	3850	0.22
Th sensor tapping	900	0.8

Table 6. – RPM & Feed Rate

D. Analysis

After collecting and measuring data, it was certain that VMC Machining was the Bottle neck Process of Whole Manufacturing Process. It was necessary to analyze the Causes of this. The Team Conducted a Brain Storming Session and Resulting Fishbone Diagram.

After noting the key causes a inspection and observation of raised causes was conducted and following conclusion was drawn of the whole Analysis.



E. Improve

To reduce the cycle times following methods were adopted,

1. RPM & Feed Rate Optimization: Check if RPM can be increased , Check if feed can be increased.

2. Programme Optimization: Reduce unwanted X,Y,Z axis movement , Identify losses in programming , Review the air cut time of each operation & set as per requirement, Reduce excel dwell time , Set tool calling sequence , Reduce unwanted fixture movements.

3. Fixture Optimization: Review stroke usage , Study for possible modification.

- *Rpm Change*

While Implementation of this trials The RMPs of the Cutting Tools were increased for Drilling and Tapping Operations and quality was monitored. The Feed rate was optimized to compensate Heating issues. Following Table shows results after RPM change.

Operation Nam	Hole Diameter (mm)	Before		After	
		RPM	Feed	RPM	Feed
By st g drilling 1	Dia. 2.4 $^{\pm0.03}$	3200	0.18	5200	0.17
BY st g drilling 2	Dia. 2.2 $^{\pm0.10}$	3200	0.22	5200	0.22
ACV drilling	Dia. 3.3 $^{\pm0.05}$	4000	0.16	4650	0.17
FCB drilling	Dia. 3.3 $^{\pm0.05}$	2850	0.21	4650	0.20
SAJ drilling	Dia. 2.4 $^{\pm0.10}$	3600	0.25	5200	0.22
ACV air in dril	Dia. 2.9 x 3.4	3200	0.18	4800	0.16

RPM & Feed Rate Chart for Drilling

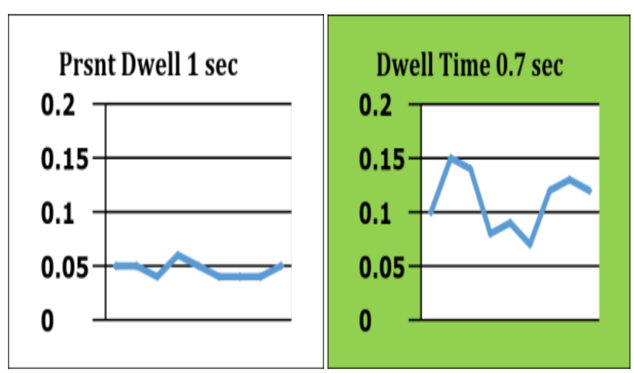
Similarly the RPM rate was increased for the Tapping operation. These trial methods concluded that the RPM increase was within the tolerance limit and hence the remark was change in RPM thus reducing the cycle time.

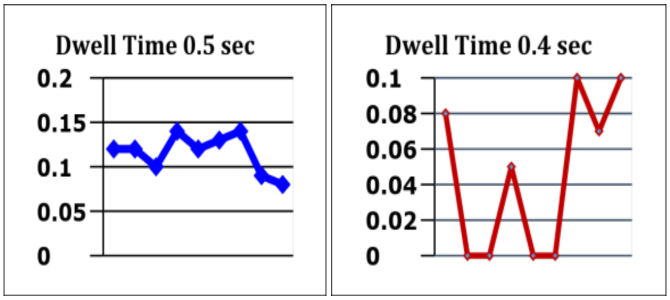
- *Tool Life Confirmation*

Tool Life was measured to validate the new RPM Values and Feed Rates which were found to be less affected. But increase in RPM led to faulty tapping and resulting in tightening of gauge in the tapped hole. Hence set at old RPM.

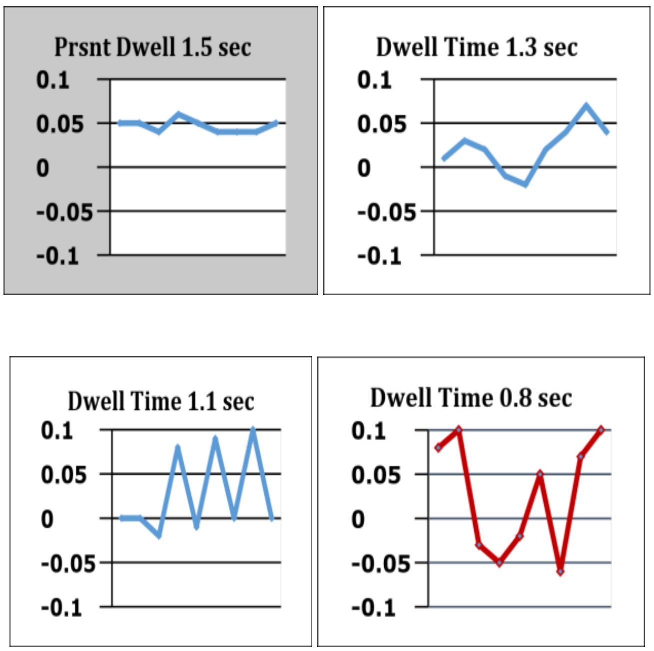
- *Reducing Dwell Time*

Dwell times of tools were changed and trials were taken following are the run charts for each operation.

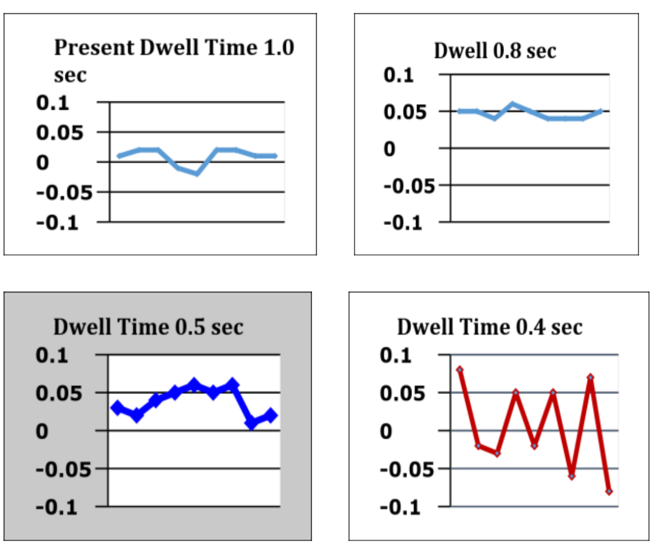




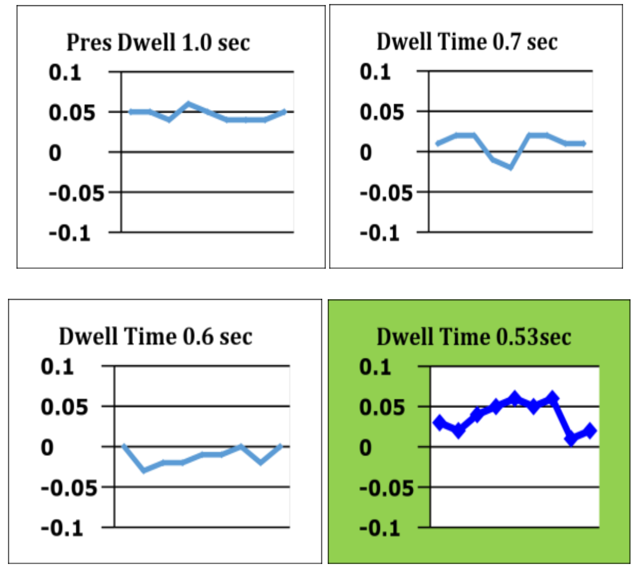
VPB Fine Boring



BY Pass Reaming



By Standard Reaming



By Standard Reaming

* *Dwell Time Optimization Result Table.*

After various trials dwell time for the operations that affected the quality they were kept unchanged. Around 3 sec of Cycle Time was reduced by this method. Eg. Dwell time for BP Reaming wasn't changed.

* *Revision In Tool Calling Program*

The initial tool calling program was of following processes.

1. Tool post arrives at Tool change position.
2. Desired Tool Aligns itself by rotating the Magazine.
3. Tool gets Changed.
4. Tool resumes machining.

The program was revised such that it combines first two processes and lot of time was saved.

* *Standard Fixtures For Vmc*

The space between the Tail Stock and Rotary of the fixture mounting assembly was changed. The space from 350mm was changed to 750mm.

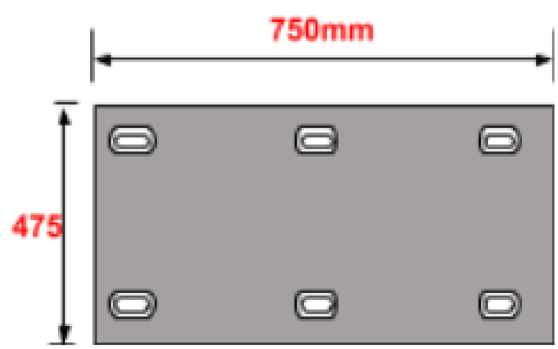


Fig 6:- Before
1050mm

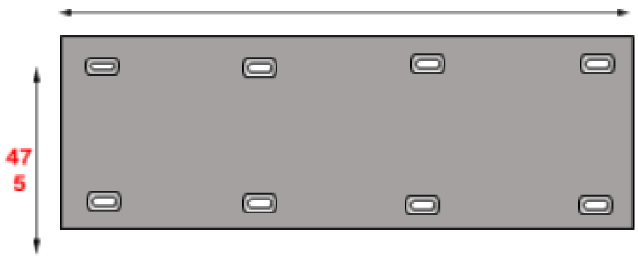


Fig 7:- After

- *Loss Time Analysis & Countermeasure*

Activity on VMC	Machining time in %
Air cut time	8.19
Fixture & Spindle movement time while tool change.	10.70
Actual tool change time	19.79
Material cutting time	35.79
Dwell time	3.51
Spindle return time	12.01
Body to body fixture movement	10.01

In order to overcome these losses Tail Stock and Rotary table mountings were changed as shown.

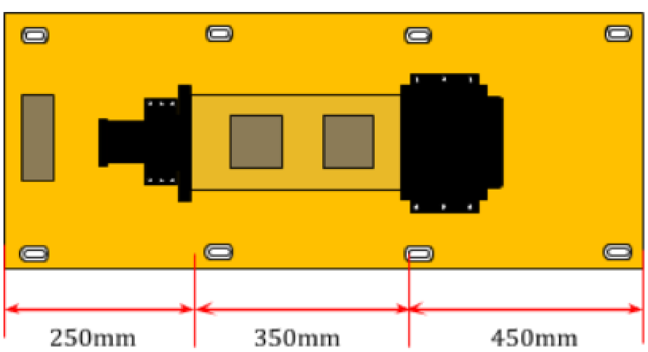


Fig 8:- Before

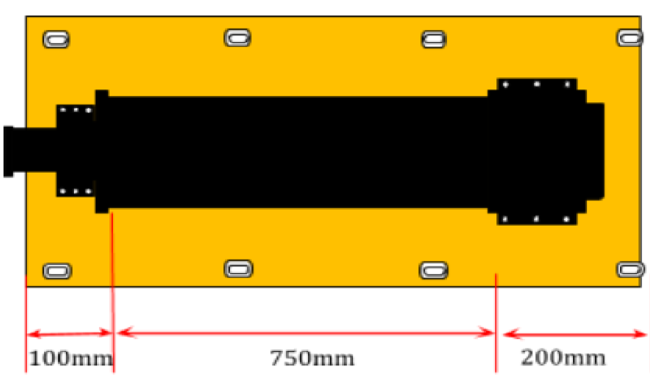


Fig 9:- After

This increase in the number of fixtures helped in reducing the time of parts processed in the VMC machine. Along with the clubbing and reshuffling of the operations such as AV drilling and TH tapping on VMC 3 which were performed on VMC 1 and VMC 2 respectively reduced the VMC 3 cycle time.

IV. RESULT

The above study and measures taken helped reduced the cycle time from 330sec to 122sec.The increase in capacity of parts produced per day has hyped from 202 to 521.This ultimately increased the output per person from 40.06 to 54.7 parts.

But to reach the targeted capacity VMC machines need to be modified to their best optimum capacity.

V. FINAL IMPROVEMENT

Final modification in the VMC bed fixtures was done as follows:

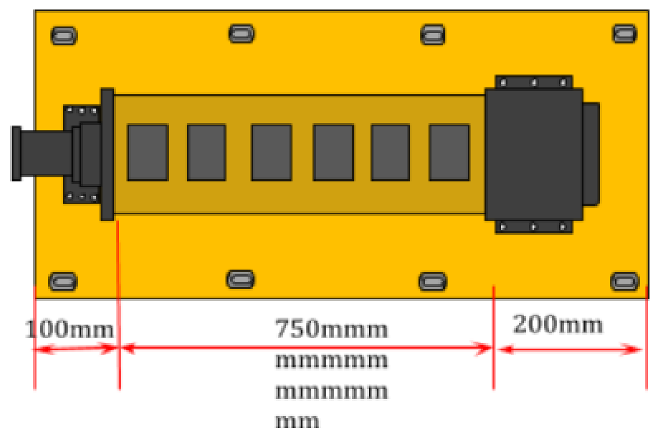


Fig 10:- Before

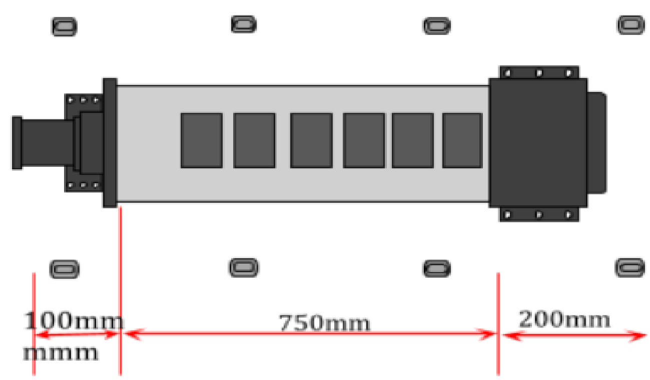


Fig 11:- After

VI. RESULT & CONCLUSION

The result thus satisfies the projected values(460) of the parts produced on VMC machine with 7 fixtures mounted on it. This paper has even focused on achieving the objectives such as:

- Understanding the processes of industrial manufacturing.
- Control the manufacturing processes.
- Continuously improve processes.
- Assessment of performance
- To determine a manufacturing process ability to sustain in the long run.

These objectives ultimately helped in increasing the productivity without investing much in cost and manpower which led the company increase its business.

On the basis of time study analysis the following conclusions can be inferred:

- The time cycle required for the part in the machine shop was 330sec. After optimizing the processes and VMC modulation the new calculated is 106sec.
- Due to the efficiency increase the manpower per day rate increased from 5 to 12.

This project paper identified how simple methods can be used to improve work and work process in the industry. The project identifies the current methods used using the DMAIC theory and how long the component takes to get manufactured. By making simple changes to the process, it could reduce the time taken by each component to speed up the production line.

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