ISSN 2229-5518

APPLICATION OF LEAN TOOLS (VSM, SMED, KAIZEN) IN MINIMIZING THE LEAD TIME IN GEAR MANUFACTURING PROCESS

KARTHICK.N[1], HARI PRASAD.V[2] , GOPI.S[3] , BALAJI.K[4]

[1] Assistant Professor, Department of Mechanical Engineering, Knowledge Institute of Technology, Tamil nadu, India.

[2]Student , Department of Mechanical Engineering, Knowledge Institute of Technology, Tamil nadu, India.

[3]Student, Department of Mechanical Engineering, Knowledge Institute of Technology, Tamil nadu, India.

[4]Student, Department of Mechanical Engineering, Knowledge Institute of Technology, Tamil nadu, India.

SYNOPSIS

Lean manufacturing is a process improvement methodology that focuses on eliminating non-value added activity, continuous improvement in the process, minimizing cycle time and lead time, reducing inventory level, lower the production cost, and increasing productivity

.

The project is carried out in **Rydon industries private limited,** Coimbatore. This industry produces variety of products such as sprocket, spur gear, helical gear and gear housing etc. In this project work spur gear manufacturing is taken for study. At first different manufacturing processes (cutting the bar stock, OD turning, center drilling followed by boring, CNC machining, gear hobbing, deburring, keyway slotting and gear grinding) are identified. Then Cycle time including machining and non machining time is calculated using simple **stop watch method** .Then takt time and lead time are calculated and value stream mapping has been plotted for the current state. From this bottle neck processes are found based on the cycle time above the takt time.

From the above, it is found the cutting, hobbing, drilling and slotting process are bottle neck processes. From the analysis it is found that the setup time of keyway slotting consumes more time. Using SMED concept single pallet is converted to two pallet. In cutting process continuous improvement technique Kaizen is used to change single piece cutting to two bar cutting at a time. With the implementation of these lean tools total lead time of the product can be reduced and the customer demand can be met. Finally the future state value stream map is drawn.

INTRODUCTION

1.1 LEAN MANUFACTURING

Lean Manufacturing, also called Lean Production, is a set of tools and methodologies that aims to improve the productivity, quality and reduce the cost through minimizing the non-value added time, cycle time, lead time. These aims are achieved by the implementation of various lean tools and concepts. The explanation of various lean tools and concept is given below

LEAN TOOLS AND CONCEPTS

- Visual management
- Quality at the Source
- Kaizan
- Leveling (HEIJUNKA)
- Kanban
- Single minute exchange of die (SMED)
- Five S's
- Total productive maintenance
- Standard Work
- Poka Yoke
- Preventative Maintenance

ISSN 2229-5518

- Changeover/setuptime reduction
- Batch Size Reduction
- Overall Equip ment Effectiveness (OEE)The above tools and concepts have been explained below in detail.

Visual Management

Visual Management systems enable factory workers to be well informed about production procedures, status and other important information for them to do their jobs as effectively as possible. Large visual displays are generally much more effective means of communication to workers on the factory floor than written reports and guidelines.

Fig 1.1: Visual management

Quality at the source

Quality at the Source, also called "Do It Right the First Time", means that quality should be built into the production process in such a way that defects are unlikely to occur in the first place – or insofar as they do occur, they will be immediately detected.

The Five S's

The Five S's are some rules for workplace organization which aim to organize each worker's work area for maximum efficiency.

1. **Sort** – Sort what is needed and what is not needed so that the things that are frequently needed are available nearby and as easy to find as possible. Things which are less often used or not needed should be relocated or discarded.
2. **Straighten** (or "Set in order") – Arrange essential things in order for easy access. The objective is to minimize the amount of motion required in order for workers to do their jobs.
3. **Scrub** (or "Shine") – Keep machines and work areas clean so as to eliminate problems associated with un-cleanliness. In some industries, airborne dust is among the causes of poor product surface or color contamination. To be more aware of dust, some companies paint their working places in light colors and use a high level of lighting.
4. **Stabilize** (or "Standardize") – Make the first 3 S's a routine practice by implementing clear procedures for sorting, straightening and scrubbing.
5. **Sustain** – Promote, communicate and train in the 5 S's to ensure that it is part of the company's corporate culture. This might include assigning a team to be responsible for supervising compliance with the 5 S's.

Fig 1.2 Five s

Preventative Maintenance

Preventative Maintenance is a series of routines, procedures and steps that are taken in order to try to identify and resolve potential problems before they happen. In Lean Manufacturing, there is a strong emphasis on preventative maintenance which is essential for minimizing machine downtime due to breakdowns and unavailability of spare parts.

Production levelling (heijunka)

Production leveling is a means of stabilizing production volume and variety by consolidating the total number of customer orders, and then spreading out their production in an even manner through-out the day. This is done to mitigate against the variation in customer demand that happens on a daily basis. The even spreading-out of production ensures a high order fulfillment rate because variety and volume requirements are catered for. Heijunka also ensures that the internal production is balanced, and that the established capacity is not over or under-utilized.

Changeover/setup time reduction

Lean Manufacturing aims to reduce unnecessary downtime due to machine setup or product changeovers since machine downtime is a significant source of unnecessary waste. This requires a culture of continuous improvement in which the company is continuously trying to find ways to reduce changeover and setup times.

Value Stream Mapping (VSM)

Value stream mapping is a lean-management method for analyzing the current state and designing a future state for the series of events that take a product or service from its beginning through to the customer. At Toyota, it is known as "material and information flow mapping".

Value stream mapping has supporting methods that are often used in Lean environments to analyze and design flows at the system level

Total Productive Maintenance (TPM)

Total Productive Maintenance (TPM) assigns basic preventative maintenance work including inspection, cleaning, lubricating, tightening and calibration to the production workers who operate the equipment. TPM clearly assigns responsibility to workers to proactively identify, monitor and correct the causes of problems leading to unnecessary machine downtime. By allocating this responsibility to the machine operators, maintenance problems are less likely to occur and therefore machine downtime can be reduced. This also requires the operators to frequently update to the maintenance team about the machine condition so that potential technical problems could be discovered on a timely basis and prevented.

Fig 1.3 Total productive maintenance (TPM)

As explained above several lean tools and concepts are available for the elimination of waste, reduction of lead time, cycle time, reducing inventory level and for increasing productivity. This project is focus on following points.

1.2 Focus and objectives

The main focus of the project is to reduce the lead time in a manufacturing process, by analyzing the cycle time for each of the process and identifying the critical process in the manufacturing line. Then identification of value added and non value added activities in process and to reduce non value added activities to increase the productivity in it.

- To increase the productivity of the industry so that the demands are met.
- To reduce the wastes leading to reduced expenditure.
- To eliminate the bottlenecks in the production line.
- To increase the efficiency of the process by reducing the non-value added activities.

The above given focus is carried in the project through the following objectives

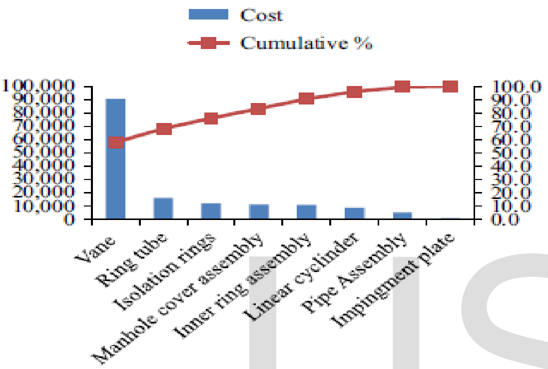
With the above focus the objective is being followed

- Study the process flow in the production line of a manufacturing.
- Estimate the cycle time for each manufacturing processes.
- Create the current state value stream map with the cycle time.
- Find out the bottleneck in the current state value stream map.
- Identifying the value added and non-value added activities for the product (bottleneck).
- Apply lean tools to minimize non value added activities.
- Create the future state value stream map and compare the benefits (Production time).

ISSN 2229-5518

LITRATURE REVIEW

M. Kemal Karasu et al (2013) discussed on the improvement of injection molding die changeover time reduction via Taguchi empowered SMED. The setup time of the mould before SMED implementation is about 30-40% of the total time. Setup time data for the mould is studied and all activities involved are been recorded through video recorder and listed to evaluate via ECRS (eliminate, combine, re-arrange and simplify). SMED concept is implemented and setup time has been reduced to 5 to 10%. [1]



Mohammed Ali Almomani et al (2013) proposed an approach for setup time reduction through Single Minute Exchange Die (SMED) and Multiple Criteria Decision-Making techniques (MCDM) in PVC pipes extruder process through the following steps.

- Phase 1: Mapping the current state map
- Phase 2: Classifying activities as external and internal setups
- Phase 3: Transferring internal to external activities, wherever it is possible
- Phase 4: Streamline all internal and external activities

In this work it is found that MCDM techniques are more effective in selecting the best setup time technology. [2]

K. Venkataraman et al (2014) implemented SMED concept in crankshaft manufacturing system. In this work following problems were identified more inventory between the workstations, more scrap, high cycle time and more number of workers. Earlier the flow of material between each station was in zig-zag manner as shown in the figure 2.1.

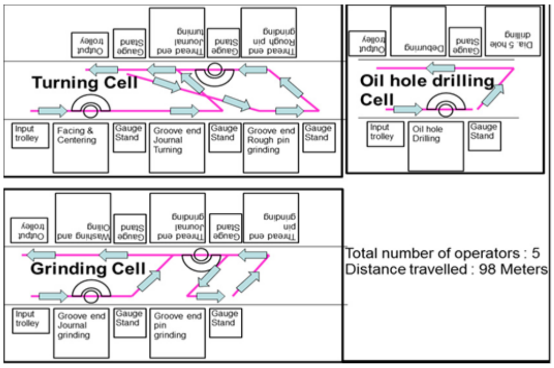


Fig 2.1: Manufacturing cell with a zig-zag flow of material

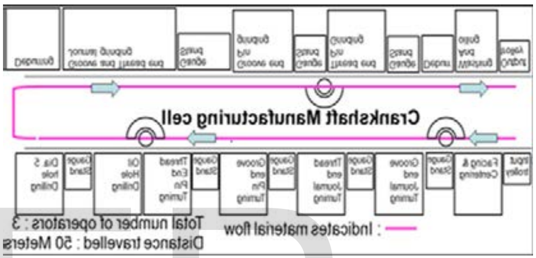


Fig 2.2: Manufacturing cell with single piece flow

After analysis the material flow is been converted to single piece flow in which single work piece moves at a time which reduces the inventory level, cycle time and reduces the number of worker. [3]

Fawaz A. Abdulmalek et al (2007) discussed the case study about implementing lean principles in steel mill. The value stream mapping has been prepared first to identify the bottle neck process involved in the steel mill. With this data push production system is been converted to pull production system by the implementation of lean tools like Just-in-time (JIT), Kanban, Total Preventive Maintenance (TPM), Total Quality Management (TQM) and Five'S. After that a detailed simulation model is been done using arena software to evaluate the potential gains. The results are been shown through future state map. [4]

Satish Tyagi et al (2015) focused on lean thinking concepts in order to improve and develop the product faster in gas turbine product. Value stream

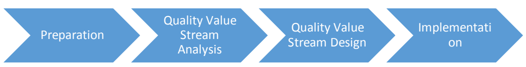
ISSN 2229-5518

mapping was used to explore the waste, inefficiencies and non-value added steps. It is found that most of the time is spent on waiting for information, decisions or processing over information or duplicate information, rework, rework due to early release of information. After value stream mapping Pareto diagram are used for prioritization purpose after identifying the major problems and ranking them. The figure 2.3 shows the Pareto analysis of the various processes. [5]

Fig 2.3: Pareto analysis of each process with cost involved

Benjamin Haefner et al (2014) adopted an innovative approach called Quality Value Stream Mapping (QVSM). QVSM is a procedure model, complementing classical Value Stream Mapping with specific quality related elements to systematically visualize, analyze and improve quality issues within a process chain. The presented method of QVSM consists of four phases: preparation, quality value stream analysis (QVSA), quality value stream design (QVSD) and implementation as given below fig. The developed method of Quality Value Stream Mapping is capable of systematically visualizing, analyzing and optimizing multistage manufacturing processes from a quality assurance viewpoint. The advantages of QVSM were demonstrated by means of an exemplary application of the method in an industrial case study. [6]

Steps for Implementing Quality Value Stream Mapping



Pierre E. C. Johansson et al (2013) focus on Standardized Work in Automotive Industry in Sweden. In this paper it describes the steps to implement the standard work and continuous improvement (KAIZEN) in automotive industries. In this competitive environment it is very difficult for the company to withstand, now days the market situation is cost needs to be minimized and quality should be increased so standardized work comes in to picture.

The steps shown in the figure is the steps for implementation of standard work in the industry by introducing the standard work productivity of the industry could be improved but there will be no flexibility in production. By implementing standardized work the production is increased by 60% [7]

R. Sundar et al (2014) discussed the lean manufacturing implementation techniques for any type of organizations. In order to implement the lean manufacturing successfully, the organisation had to focus on all aspects of lean element such as Value Stream Mapping (VSM), in which every activity including Value-Added activity (VA) and Non-Value-Added activity (NVA) are analyzed. Type of production flow is being analyzed and SMED concepts are implemented to reduce non-value added activities, conversion of push system to pull system in the production line. The implementation of Kanban, Production leveling and conversion of batch production to one piece flow required to convert the raw material into finished product. [8]

CYCLE TIME STUDY FOR EACH PROCESS IN GEAR MANUFACTURING

As indicated earlier the main aim of the project is to reduce the lead time in a gear manufacturing process. The project is taken in the ***Rydon Industries private*** limited in Coimbatore. The main products manufactured in the company are spur gears, helical gears, automobile sprockets, chain couplings and gear couplings. From the above products manufactured in the industry spur gear is choose as product and the study is made on it. To reduce the lead time in gear manufacturing process the following steps are followed.

1. To study about plant layout of the industry.
2. To know various processes involved in the manufacturing of gear.
3. Estimation of cycle time study for each process in gear manufacturing.

4. Determination of lead time and takt time of gear manufacturing process.
5. Analysis on the current method to meet the demand.
6. Creation of current state value stream map.

3.1 Plant layout of the industry

Plant layout of the industry shows the location of the machine and the various sections in the plant with the dimensions. The study is made on plant layout and been drawn as shown in the figure 3.1 with this layout it is known that where the machines are located located in each sections and the pathways ways in the plant. The machines which are available in the plant are bang saw cutting machine, centre lathe, drilling machine, CNC turning centre, gear hobbing machine, broaching machine, and slotting machine. The sections involve inventory storage, cutting section, lathe section, drilling section, CNC section, gear hobbing section, slotting section, office, inventory storage, and quality control section.

3.2 Process involved in gear manufacturing with process layout

In this work spur gear manufacturing is taken for study. To draw the process layout we should know the various process and machine involved in the manufacturing of spur gear. In process layout, the work stations and machinery are not arranged according to a particular production sequence. Instead, there is an assembly of similar operations or similar machinery in each department (for example, a drilling department, a paint department, etc). The various process involved in manufacture of spur gear with machines are listed in the table 3.1 as shown below.

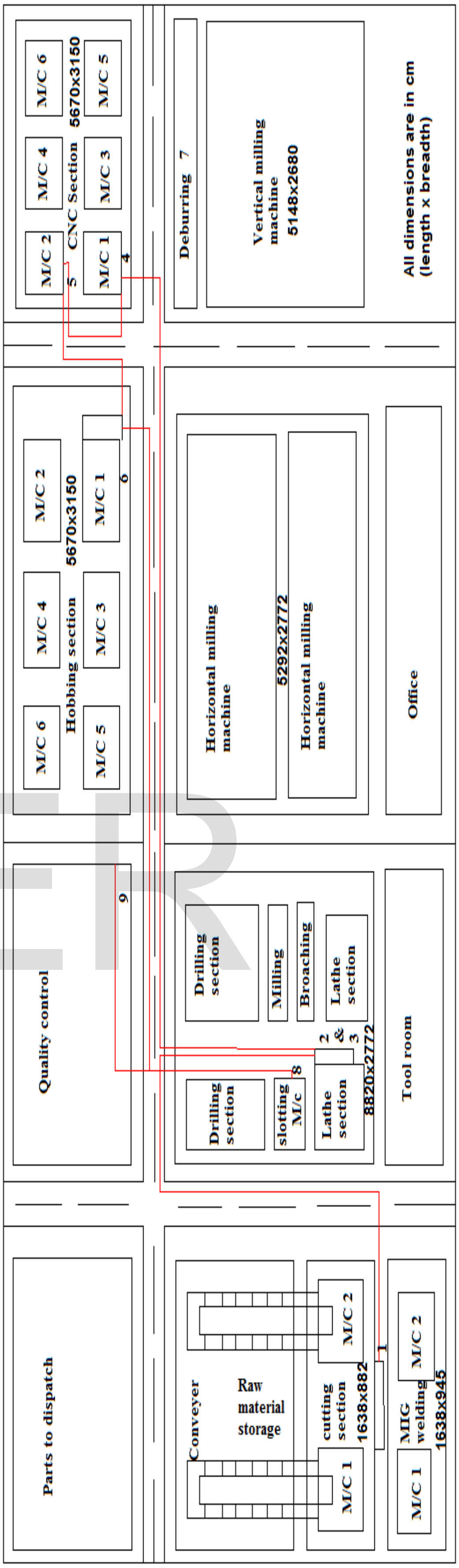


Table 3.1: Sequence of process involved in gear manufacturing with the machine

S. No	Sequence of process	Machine used
1	Cutting process	Bang saw cutting machine
2	Outer diameter turning	Center lathe
3	Drilling	Center lathe
4	Boring	CNC turning center
5	Gear hobbing	Hobbing machine
6	Deburring	Manual
7	Slotting of keyway	Slotting machine
8	Deburring	Manual
9	Heat treatment	Out sourcing
10	Dispatching	Manual

Fig 3.2: Process sequence in spur gear manufacturing pr

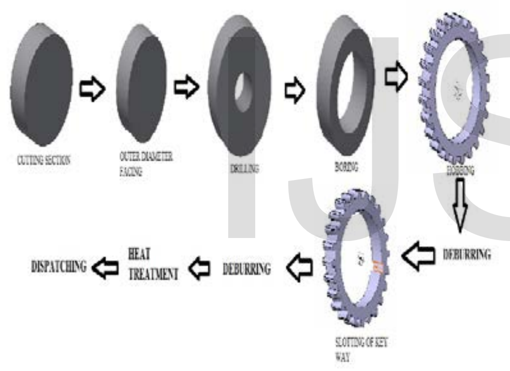


Fig 3.3: Process layout of gear manufacturing

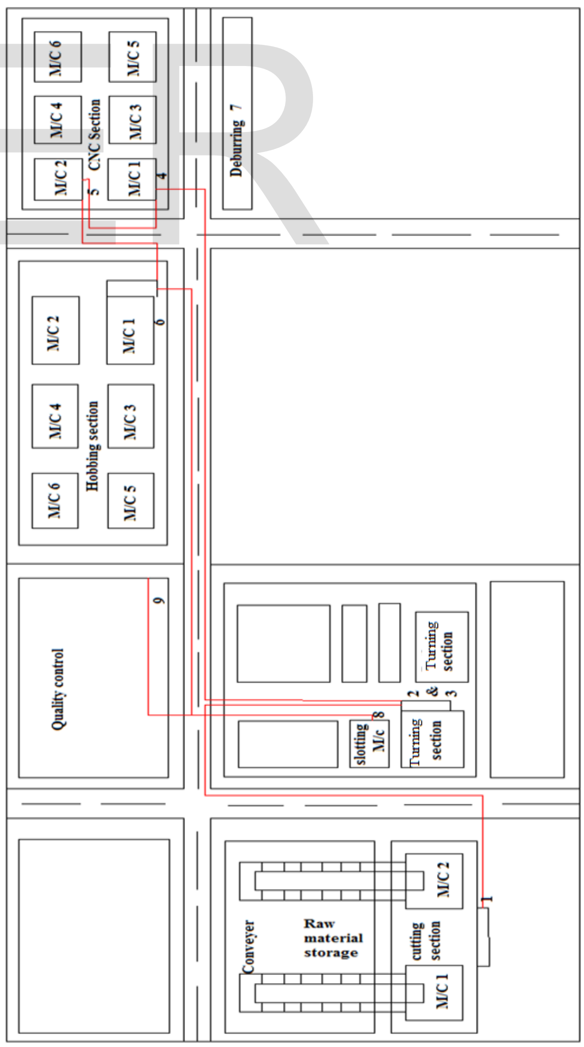
With the above study made about the process involved in gear manufacturing and the machine required for the machining, the process layout is draw as shown in fig 3.3. Numbers in the layout indicate the sequence of the operation involved in gear machining process with material movement.

3.3 Estimation of cycle time of each process

To calculate the lead time of the product, it is required to calculate the cycle time of each process sequence from start to finish.

Time study is a work measurement technique for recording the time of performing a certain specific job or its element carried out under specific condition and for analyzing the data so as to obtain the time necessary for an operator to carry out at a defined rate of performance. Time study is a method of direct observation it can be done in any method. To make the time study of each process **stop watch method** is used here. The observer watches the job and records data as the job is being performed over a number of cycles.

Measurement of working time via time study technique was done for all the processes involved in the



production of spur gear. A normal procedure in the time Study activity initiated with preliminary time study to determine and calculate the number of observations or the required sample size. The trials of the cycle time with average are shown in fig 3.2.

Table 3.2: Cycle time for each process in gear manufacturing

S. No	Process	Cycle time (min)			
		TRIAL I	TRIAL II	TRIAL III	AVERAGE
1	Cutting	3.9	3.65	3.85	3.8
2	Outer diameter turning	2.49	2.55	2.49	2.51
3	Drilling	3.25	3.18	3.2	3.21
4	CNC process I	2.35	2.41	2.41	2.39
5	CNC process II	2.83	2.81	2.79	2.81
6	Hobbing	4.78	4.83	4.88	4.83
7	Deburring	1.05	1.10	1.07	1.08
8	Slotting of key way	3.45	3.50	3.52	3.49
9	Deburring	2.23	2.17	2.23	2.21

From the above study of the cycle time of each process in a gear manufacturing the avearage time taken for each process is ploted in a graph as shown below.

Total available time	Non-Working time
Hours per shift = 12	Lunch break = 60 min
Shift per day = 2	No of lunch break per day = 2
	Tea break = 15 min
	Number of tea break per shift = 2
Total available time = **24 h** = **1440 min**	Total non-working hours = **180 min**
Total working hours = 21 h	Total available working time = [(**24X60**) – **180**)] = **1260 min** = **21 h/day**

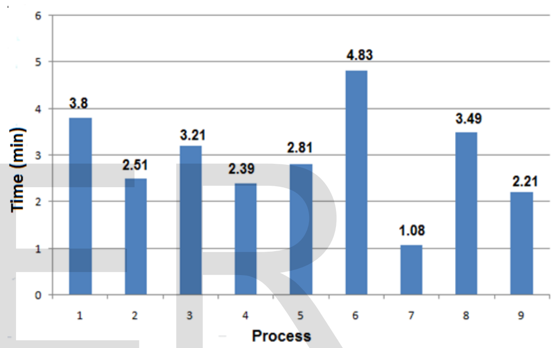


Fig 3.4: Cycle time of each process in gear manufacturing

3.4 Lead Time of the product

Lead time of the product is the total time required to manufacturing an item, including order preparation time, queue time, setup time, run time, move time, inspection time, and put-away time. Current lead time for production of 480 components per day is 27.6min as calculated below with the cycle time of each process in gear machining whereas 1.27min is the allowance provided for transportation.

Current Lead time	3.8+2.51+3.21+2.39+2.81+4.83+1.08+3.49+2.21= **26.24 min**

The customer's actual demand is 540 components per day the corresponding lead time for component is 20.9 min. So lead time has to be reduced from 27.6 min to 20.9 min to meet the customer's demand.

3.5 Takt Time of the product

To calculate takt time of the product it is necessary to know about the working and non-working hours in the plant. The following data's are being collected as mentioned in the table 3.3.

Table 3.3: Total working and non-working hours per day

Take time is the average unit production time needed to meet customer demand. Takt Time is calculated by dividing the available production time (per day) by customer demand (per day).The data pertaining to the working hours and customer demand was provided by the plant supervisor. The above data in table 3.3 are used to calculate takt time.

1. Current production rate =480 components/day
2. Expected production rate = 540 component/day

Takt time =

$$\frac{(\text{No of working hours X No of shifts X minutes}) - (\text{Break time X No of breaks})}{\text{Products produced}}$$

Calculation of takt time

Current takt time (480 gears/day) =

$$\frac{(\text{No of working hours X No of shifts X minutes}) - (\text{Break time X No of breaks})}{\text{Products produced}}$$

$$= \frac{((12X2X60)-(90X2))}{480}$$

= **2.63 min**

= **158 s**

Takt Goal (540 gears/day) =

$$\frac{(\text{No of working hours X No of shifts X minutes}) - (\text{Break time X No of breaks})}{\text{Products Demand}}$$

$$= \frac{((12X2X60)-(90X2))}{540}$$

= **2.33 min**

= **140 s**

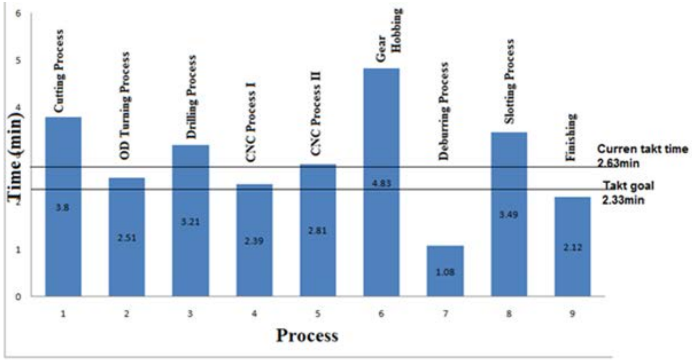


Fig 3.5: Current takt time and takt goal in cycle time chart

From the above figure 3.8 it is known that certain process are below the takt time however the demands are met using extra machines as discussed below

Current method to meet the demand

To meet the current demand of 480 components per day number of machine are employed in the work the graph given below shows the working hours of each machine per day to meet the demand in this cutting, drilling, and hobbing machine require the support of another extra one machine to produce the total product. The data's are being collected from the study of working hours of each machine involved in the manufacturing of gear.

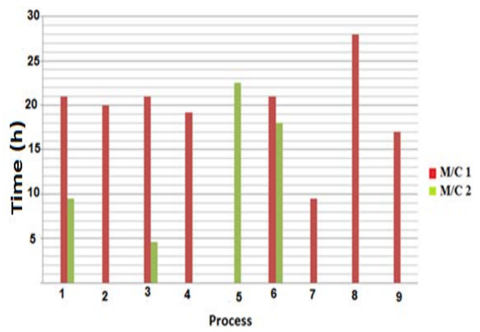


Fig 3.6: Current working hours per day of each machine to meet demand

Components produced by each machine to meet demand

With the above known working hours per day of each machine we can calculate the number of components produced by each machine per day this calculated using the below formula and figure 3.6 shows the components produced by each machine.

No of components per day =

$$\frac{\text{No of working hours of machine per day X min}}{\text{Cycle time of the machine}}$$

Example for calculation

$$\text{Process 1(machine1)} = \frac{21 \text{ X } 60}{3.8}$$

$$= \mathbf{331}$$

components per day

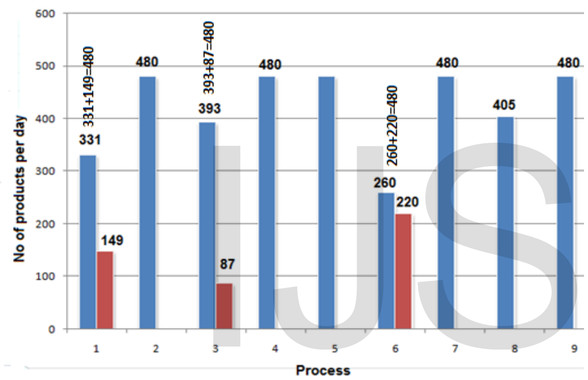


Fig 3.7: Number of components produced by each machine

Machining (value added activities) and non-machining (value added activities) for each process

Cycle time of each process in the gear manufacturing is known with this we can separate value added and non valued added in each process.

Machining time (Value-added activities) are activities which transform the materials into the exact product that the customer requires.

Non-machining time (Non value-added activities) are activities which aren't required for transforming the materials into the product that the customer wants. Anything which is non-value-added may be defined as waste.

In order to reduce the cycle time of the process we have to reduce non value added activities time in the process this can be done by the complete study about the loading and unloading time ie setup time in the process. The graph shows the value added and non value added time of each process.

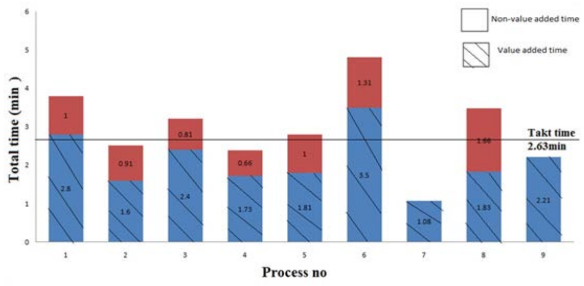
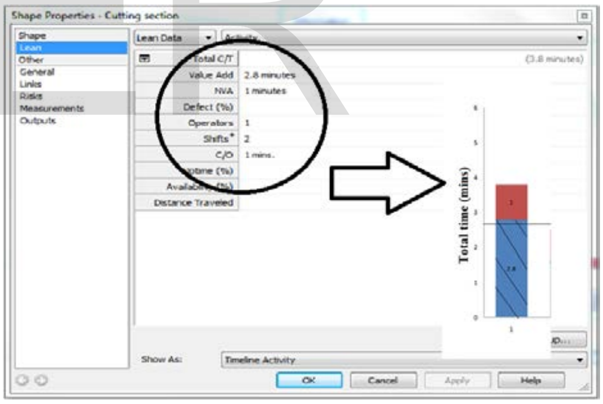


Fig 3.8: Machining time (value added) and non-machining (non value added time) in each process

Thus from this we know the current production rate and separation of time in each process. Then we have to calculate takt time of the product to find the



bottleneck process.

3.6 VALUE STREAM MAPPING

It is a process modelling and analysis tool available to help organizations understand and improve business. ***iGrafx Flow Charter*** facilitates creating graphical representations of processes allowing people to easily comprehend business information. It can be used to create.

- **Process Maps / Flowcharts, Value Stream Maps Cause & Effect Diagrams / Ishikawa Diagrams, FMEA Spreadsheets**

ISSN 2229-5518

To create a ***current state map***, our team collected the data and information by walking the flow and interviewing the operators who perform the individual task. The drawing of the VSM mapping was carried out using the software iGrafx Flow charter 2013.The following information were fed to the software to create the current state map

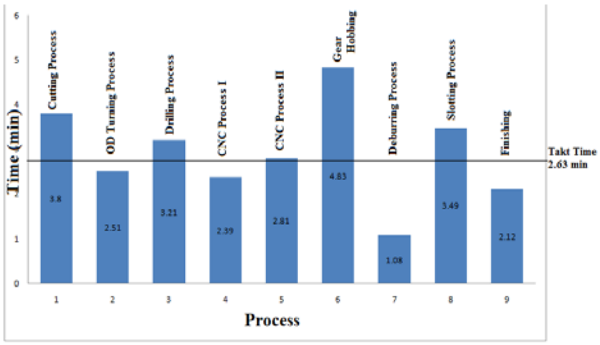
- The Takt time data
- The Process steps
- Process time (Cycle time and Waiting time)
- Supplier with Material flows
- Information and Physical flows

Figure 3.9 represents the current state map. At the bottom of the current state map is the timeline summative indicator. It represents value added time and non-value added time as given below

Fig 3.9 Snapshot of take time data entry in iGrafx software

Fig 3. 10: Snapshot of iGrafx software of cycle time in gear manufacturing process

Fig 3.11: Current state map



After creation of current state value stream mapping work balance sheet for the **process is generated as shown in below figure**

Bottleneck literally refers to the top narrow part of a bottle. In engineering, it refers to a phenomenon where the performance or capacity of an entire system is limited by a single or small number of components or resources

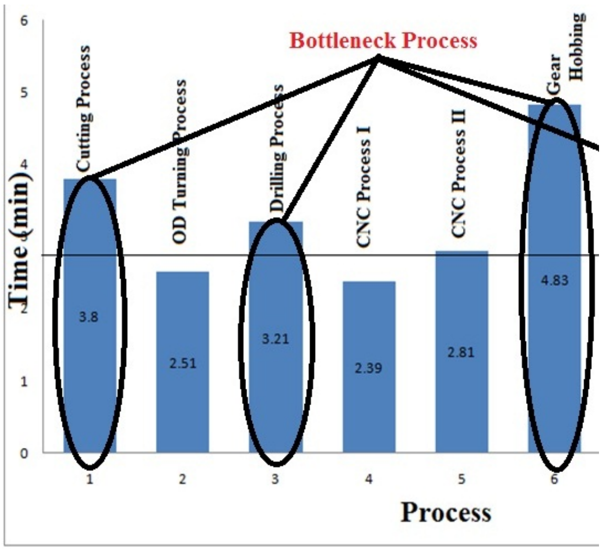


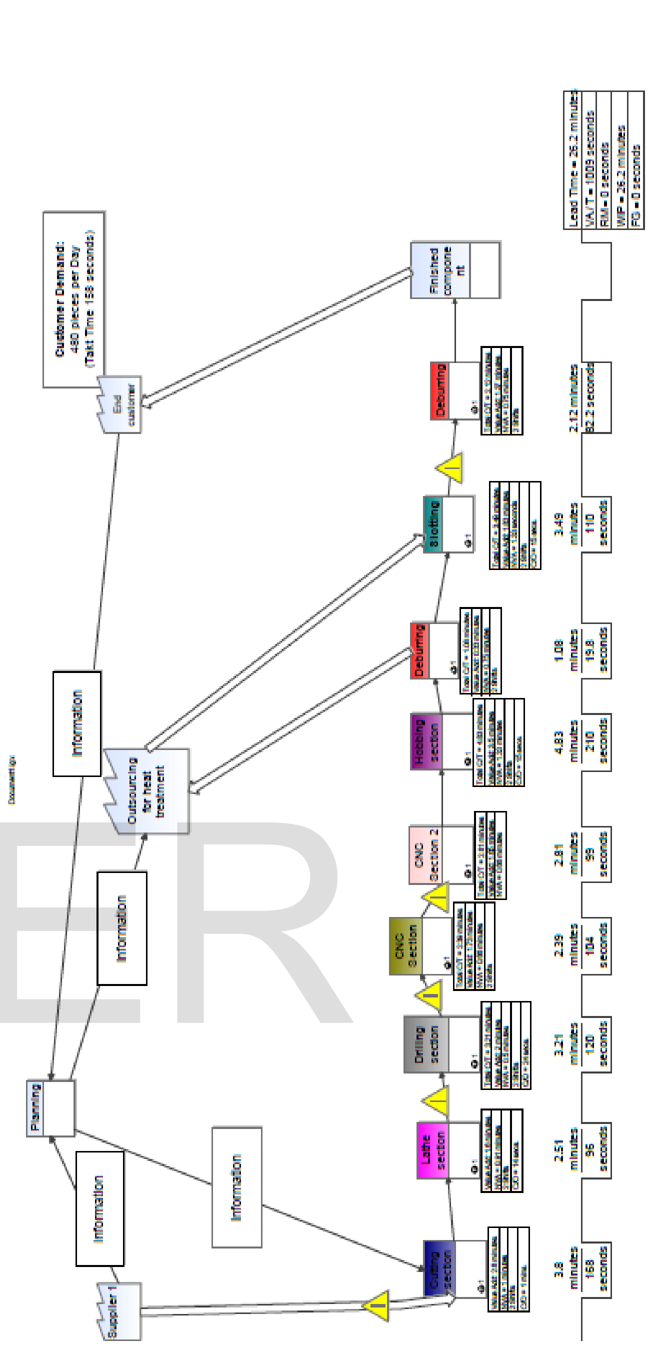
Fig 3.13: Bottleneck process in gear machining

Observation

- Various processes in gear manufacturing process are studied with the process layout.
- Cycle time (stop watch)of each process were being studied with the value added and non value added in each process
- Current methods of machine usage involved in production of components were understood.
- Current state value stream mapping is prepared for the project
- Bottleneck processes were identified

IMPLEMENTATION OF SINGLE MINUTE EXCHANGE OF DIE (SMED) CONCEPT IN SLOTTING PROCESS

As mentioned earlier the aim of the project is to reduce the lead time in the gear manufacturing process, and to increase the productivity. To reduce the lead time, cycle time of process has to be reduce, for this bottleneck process has to be known, from that process cycle time can be reduce by minimizing the non-machining time in the process by the implementation of lean tools like SMED, Kaizen, and value stream mapping. Detail description of the bottleneck process and lean tool implementation is followed below.



4.1 Bottleneck process in gear machining

The bottleneck processes in gear manufacturing process are shown in below figure 4.1. Bottleneck literally refers to the top narrow part of a bottle. In engineering, it refers to a phenomenon where the performance or capacity of an entire system is limited by a single or small number of components or resources.

ISSN 2229-5518

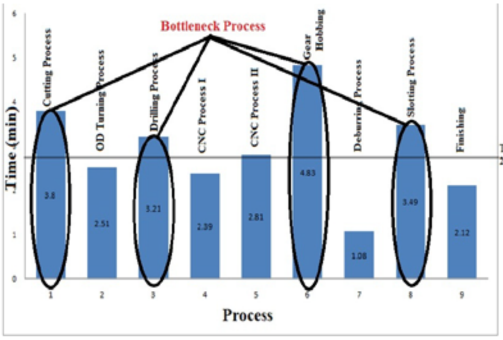


Fig 4.1: Bottleneck process in gear machining process

From the above figure 4.1 it is noted that there are four bottleneck processes. They are

1. Cutting process
2. Drilling process
3. Gear hobbing process
4. Slotting process

The machining (value added activities) and non-machining time (non-value added activities) are shown in the graph in 3rd chapter in figure 3.7

Table 4.1: Machining (value added activities) and non-machining (non-value added activities) time for bottleneck process

S. No	Bottleneck process	Machining time (min)	Non-machining time (min)
1	**Slotting**	**1.83**	**1.66 = 99 s**
2	Gear hobbing	3.5	1.31 = 78.6 s
3	Cutting process	2.8	1 = 60 s
4	Drilling process	2.4	0.81 = 48 s

Inference

- From the above table it is clear that non machining time of slotting process takes 40% of the total time so cycle time of the process increases.
- In order to reduce the non machining time we have to reduce setup time ie both loading and unloading time it is done by optimizing the slotting fixture.

4.2 Detail study of setup time (non-machining time) of gear in slotting machine

Procedure for mounding of gear

Over slotting machine table three jaws chuck is placed which is fixed with the table by means of clamps. On the chuck fixture plate is clamped to the jaws of chuck which is held stationary. Over the plate gear are to be mounted and clamped by means of strap clamp and bolts, support block is placed at the end for support of clamps as shown in figure 4.1.

In this slotting fixture single work piece is clamped at a time here strap clamps are removed and clamped every time by means of bolt and nut so the setup time for clamping of the work piece is about 3.49 min. In this method about 40% of time is taken as non-value added activities so we have aimed to design a slotting fixture using SMED concept.

Slotting machine

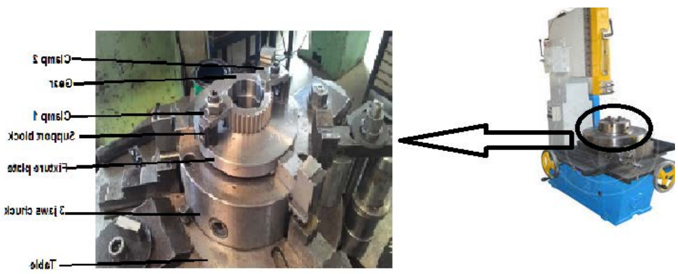


Fig 4.2: Close up view of mounting of the gear

Sub elements of non-value added time for setup time

Table 4.2: Activities of present slotting fixture

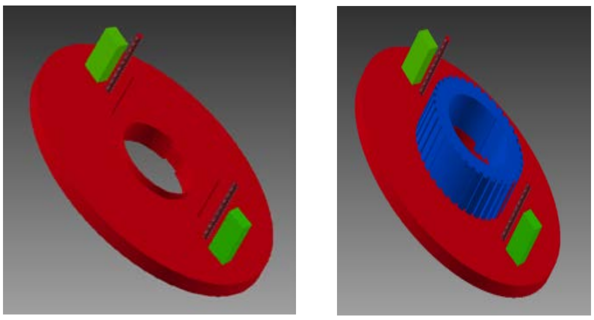
Task no	Activities	Time (s)
1	Positioning the gear on fixture plate	9
2	Fixing the strap clamp 1	11
3	Loose fastening the nut 1	10
4	Fixing the strap clamp 2	13
5	Loose fastening the nut 2	10
6	Tight fastening	15
7	Adjusting the table to the tool position	31
	Total	**99 s**

From this table we can know that activities of placing the strap clamp and fixing it take time of 58 s nearly 1 min which can be avoided more over adjustment of the table also takes 30s which is also avoidable. The each activity is explained in detail with the figures given below.

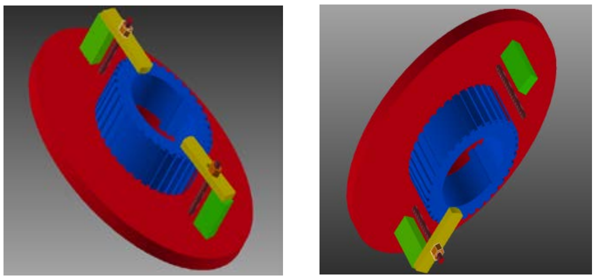
The Software used slotting fixture design is

Autodesk Inventor 2014 – It is a 3D CAD software offers an easy-to-use set of tools for 3D mechanical design, documentation and product simulation.

Step by step procedure for mounting the gear using CAD model



(a) **(b)**



(c) **(d)**

Fig 4.3: 3D model of each activity of present slotting fixture

(a) Fixture plate of fixture (b) Placing of gear in the fixture plate
(c) Fixing of clamp 1 with nut (d) Fixing of clamp 2 with nut

The assembly drawing of the slotting fixture is shown in the figure 4.4 with the indication of the parts with it.

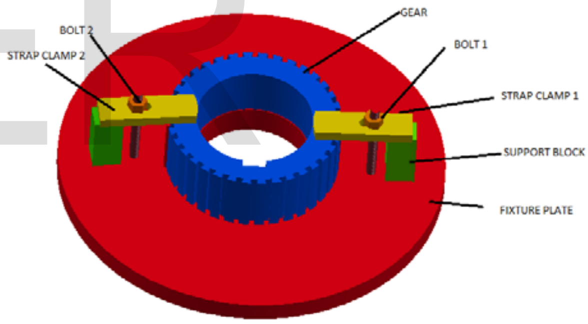


Fig 4.4: CAD model for present slotting fixture

4.3 Application of single minute exchange die (SMED) concept to reduce setup time

In this slotting fixture every time the clamp has to be removed and place so it takes much time in fixing of gear positioning of gear with the tool also take more time and effort so it can be reduce by the implementation of lean tools like SMED, changeover time reduction and much more in this project we implement SMED concept. **Single- minute exchange die (SMED)** is the term used to represent the Single Minute Exchange of Die or setup time that can be counted in a single digit of minutes. SMED is often used interchangeably with quick changeover. SMED and quick changeover or the practice

ISSN 2229-5518

of reducing the time it takes to change a line or machine from running one product to the next.

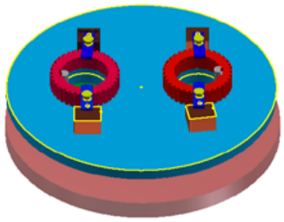


Fig 4.5a: 3D view of the proposed slotting fixture

S.NO	ACTIVITIES	TIME (s)
Offline station		
1	Placing the gear on the fixture plate	15
2	Rotating the strap clamp 1	5
3	Locking with the pin1	5
4	Rotating the strap clamp 2	5
5	Locking with the pin 2	5
Online station		
6	Rotating the table to 180*	30
7	Positioning of the tool head	10
Total		75 s

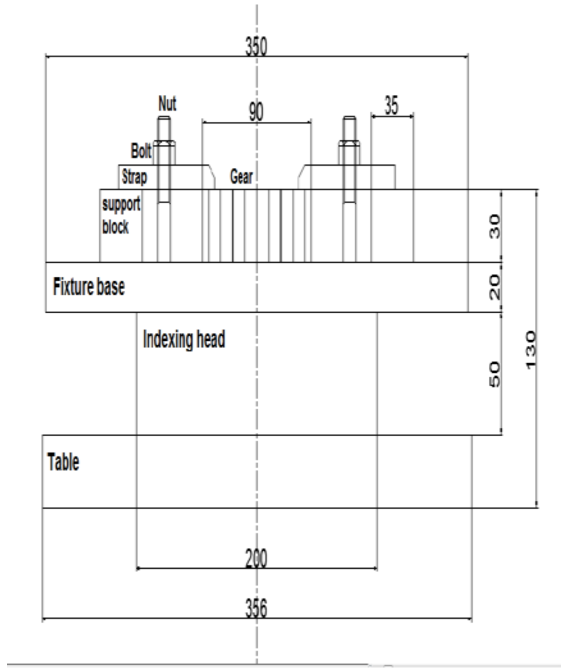


Fig 4.5b: Orthografic view of proposed slotting fixture

The description of the component and part drawing of the proposed design of the fixture is attached in annexure 2 page no 34.

Procedure

The design is made to hold two gears simultaneously the step by step procedure is given below.

- There are two projections in the fixture plate in order to hold two gears at a time.
- There is a strap clamp with retraction spring which is used to tighten the gear.
- There is a support block which is used to hold the strap clamp with the help of pivot in the support block.
- Table is mounted on the indexing head so it is easy to index at each time.

Detail of the activities with time is explained in table with necessary figure 4.6.

Table 4.3: Activities in proposed slotting fixture

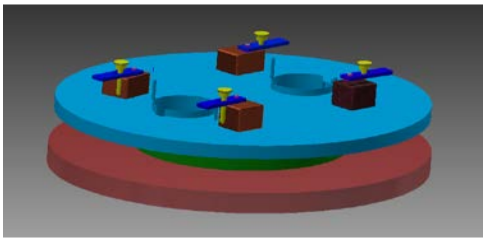
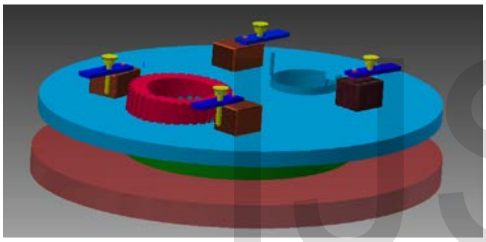
Materials for slotting fixture design

Table 4.4: Material for slotting fixture

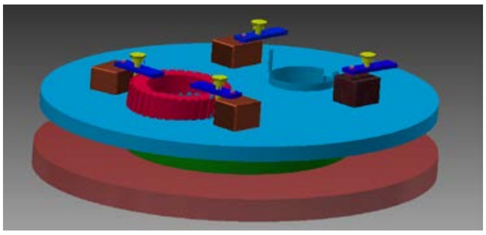
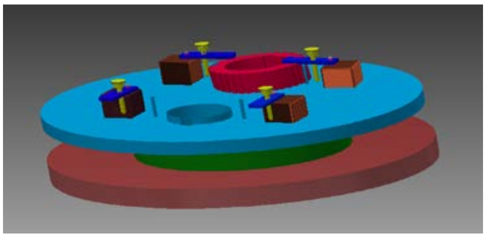
ISSN 2229-5518

S. No	Part	Material
1	Fixture plate	Cast iron
2	Strap clamp	Cast iron
3	Retracting pin and nut	Mild steel
4	Support block	Cast iron
5	Component	Mild steel (C-45)

The each activity is explained in detail with the figures 4.6 given below.

(a) , (b)

(c) (d)

Fig 4.6: 3D model of each activity of proposed slotting fixture

(a) Fixture plate over indexing head

(b) Placing of gear in the fixture plate

(c) Locking of gear 1 with lock pin

(d) Indexing the table to 180°

Results

Table 4.5: Comparison between present fixture and proposed fixture

	Present slotting fixture		**Proposed slotting fixture**	
S. No	**Activities**	**Time (s)**	**Activities**	**Time (s)**
1	Positioning of the gear on the fixture plate	20	Placing the gear on the fixture plate	15
2	Fixing the strap clamp 1	11	Rotating the strap clamp 1	5
3	Loose fastening the nut 1	10	Locking with the pin1	5
4	Fixing the strap clamp 2	13	Rotating the strap clamp 2	5
5	Loose fastening the nut 2	10	Locking with the pin 2	5
6	Tight fastening	15	Rotating the table to 180°	30
7	Adjusting the table to the tool position	20	Positioning the tool head	10
	Total	**99**	Total	**75**

Outcome of result

- Earlier the setup time of the gear in the fixture takes about 1.66 min it has to be reduced so to that extra running hours of the machine can be avoided and demands can be met.

- After the study about the existing activities involved in fixing the gear in fixture implementation of SMED concept is done.
- With the implementation of SMED concept the setup time has been reduced to 0.5 min which stops the extra running of machine.
- The below graph shows the reduction in cycle time with the implementation of SMED concept with takt time in it.

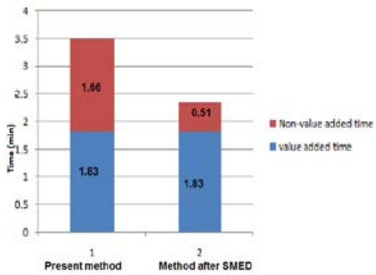


Fig 4.7: Time Comparison between present and proposed method for slotting fixture

IMPLEMENTATION OF KAIZEN CONCEPT IN CUTTING PROCESS

Fig 5.1: Bang saw cutting machine

Sawing machine is a device used for cutting up bars of material or for cutting out shapes in plates of raw material. The cutting tools of sawing machines may be thin metallic disks with teeth on their edges, thin metal blades or flexible bands with teeth on one edge.

5.1 Present method of cutting bar stock

In the present method of cutting bar stock only one workpiece is being cut at a time in the cutting machine the diameter of the work piece is dia 90mm. The time taken for cutting one wokpiece is 3.8 min. During the process the speed of the blade is 25 rpm .The fixture has two jaws to clamp the workpiece the two jaws are moveable to hold the work piece. So that at each time workpiece can be easily loaded and unloaded by moving jaws.

Fig 5.2: Cutting single bar stock

5.2 Implemented method of cutting bar stock

In this type we made two work pieces to cut at a time in the cutting machine. As the specification of the machine is to hold maximum work piece dia of 180 mm. So after making the study we come to know that two work pieces can be clamped in the fixture, so that two work pieces are being cut at the time of 4.2 min with the speed of the blade as 22 rpm.

Fig 5.3: Cutting two bar stocks

Result

Table 5.1: Comparison between current method and implemented method

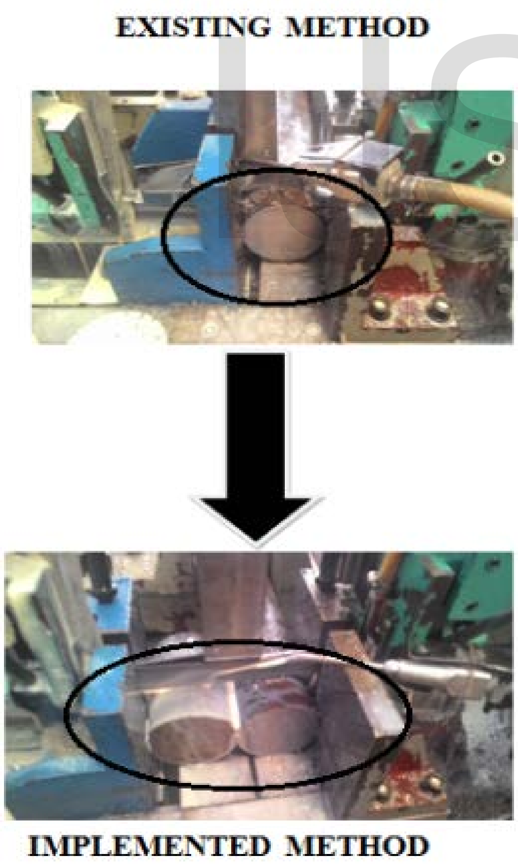
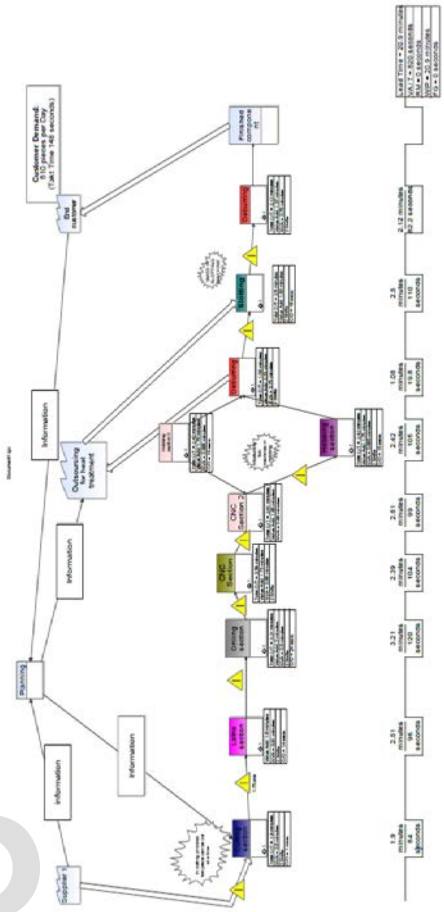
Existing method	Future method
Cycle time = 3.8 min	Cycle time = $\frac{4.2}{2}$ = 2.1 min
Single componen t is cut at a time	Double component is cut at a time 

Fig 5.4: Present method to implemented method

Outcome of study

- First one workpiece was been cut in the bang saw cutting machine after the study two workpiece were made to cut.
- With this implementation for the same cutting time two workpiece were cut. Figure 5.5 shows the time reduction in the cutting of single workpiece.



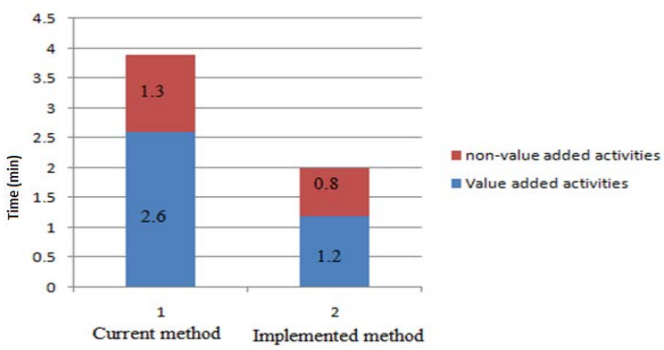


Fig 5.5: Graph between present method and implemented method

5.3 Future state value stream map

The current state map picturises the existing practices which on analysis would reveal the waste elimination opportunities. After gathering the information of the current state value stream mapping future state map is being developed for production of 540 components per day.

Fig 5.6: Future state VSM

Work balance sheet generated from future state map

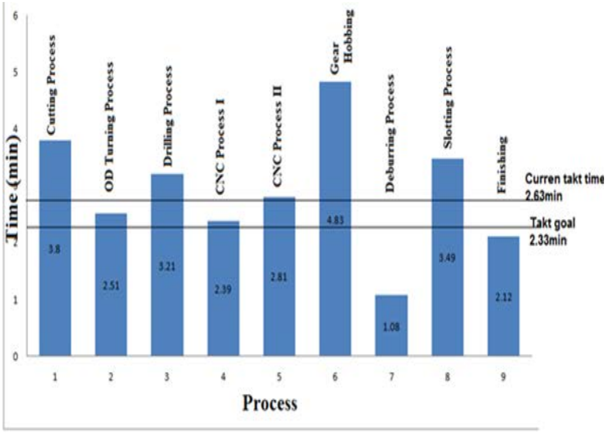


Fig 5.7: Work balance sheet for future state map

Comparison between current state value stream mapping to future state value stream mapping

Lead time = 26.2 min
VA/T = 1009 s
WIP = 26.2 min

Fig 5.8: Comparison of current state and future state VSM

CONCLUSION

Lean principles and methods were studied and utilized in this project to increase the productivity of the industry under study. The various processes in the **Rydon industries private** Limited Industry was analyzed. Current state value stream mapping is being drawn using iGrafx software. In the current state value stream mapping using work balance sheet it is identified that there are there process which is being identified as bottleneck process are **Cutting process, Drilling process, Hobbing process, Slotting process**

One of the major problems more setup time was identified and then study about the current fixture design. Literature survey related to **single minute exchange of dies (SMED)** was carried out. Current fixture design that about 40% of the total time is non-value added activities so SMED concept was introduced to reduce the setup time.

Next bottleneck operation is cutting section here **KAIZEN (Continuous improvement)** is being implemented to utilize the effectiveness of the machine properly. Initially only one work piece is being cut at time but the cutting process has been enhanced that two raw materials can be cut at a time by implementing kaizen. The time for cutting process is drastically reduced from 3.8 min to 2.1 min.

Next bottleneck operation is hobbing process. In this process the problem is more inventory inorder to reduce the inventory one more machine is being introduced in the shop floor due to this production also increases simultaneously

Lead time = 20.9 min
VA\T = 820 s
WIP = 20.9 min

Finally future state map was drawn after giving the solution to all the bottleneck operations in the the lead time is drastically reduced from **26.2 min to 20.9 min** therefore the production rate has been increased from 480 products/day to 510 products/day. Thus the production in the company has been enhanced.

References

[1] R. Shah, A. Chandrasekaran and K. Linderman, "In pursuit of implementationpatterns: The context of Lean and Six Sigma", International Journal ofProduction Research, voI.- 46, no.- 23, pp. 6679-6699,2008.

[2] Mader and D.P., "Lean Six Sigma's Evolution". Quality Progress, vol.- 41,no.-l, pp. 40- 48,2008.

[3] Brett, C. and P. Queen., "Streamlining Enterprise Records Management withLean Six Sigma", Information Management Journal, vol.-39, iss.-6, pp. 58-62,Nov. / Dec. 2005.

[4] Byrne, G. Lubowe, D. Blitz and A., "Using a Lean Six Sigma approach todrive innovation", Journal of Strategy and Leadership, vol.-35, no.-2, pp. 5-10, 2007.