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Increasing an Overall Equipment Effectiveness Visibility and Analyzing in a Manufacturing Industry

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ABSTRACT

This paper tries to evaluate the OEE of machines in a valve manufacturing and identifies the main loss elements of the process. An application had been created for continuous data collection. OEE data on machine performance is an initial key point to understand the equipment losses and establish improvement to eliminate them. The results are compared with world class level. Result of the research demonstrates that although the OEE coefficient of the investigated process is not meeting the world class level, however with the continuous improvement, performance of the machine can be acceptable.

Keywords: lean manufacturing, overall equipment effectiveness, spread sheet

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INTRODUCTION

OEE is an effective tool to benchmark, analyze, and improve your production process. The OEE tool gives you the ability to measure your machines for productivity improvements. OEE not only measures these inefficiencies but groups them into three categories to help you analyze the machine and have a better understanding of the manufacturing process.

Here is a list of common concerns of many manufacturing companies:

- Reducing Bottlenecks – Increase Throughput
- Implementing Machine Operator Training
- Reducing Machine Setup Time
- Improving Machine Reliability – Implement Preventive Maintenance
- Maximizing Optimal Run Rates and Capacity
- Eliminating Down Time – Provide Down Time Reason Codes.

Putting this tool in place to address these concerns and improve the manufacturing process can be very time consuming and costly. To reduce that cost, Overall Equipment Effectiveness (OEE) Spread sheet has been designed that is used to help with this process. The spread sheet allows the whole plant to be involved in the process of improving OEE. From the machine operator, production manager to the plant manager, this production monitoring information can help everyone to come to a solution. The bottom line for all employees should be to reduce production losses and build profitable products. The spread sheet provides production managers and machine operators with the necessary real time information to make crucial decisions about the effectiveness of the production process.

Need for Analysis

The company is facing a low production rate and high lead time in comparison to its competitors. Estimation shows that industry is having Work In Progress Inventory (WIP) of 7 days and Rework of 10%.

Objectives

The aim of this project is to a spread sheet of OEE in valve manufacturing industry. Since OEE implementation can take much higher implementation time. That's why the scope of this project is to achieve Milestones in path of OEE implementation:

- To create a spread sheet for overall equipment effectiveness analysis to increase the visibility of OEE within 1 minute.
- To reduce minor stoppages and work in progress to 5% from its present value.
- To reduce the part rejection to 2%.

LITERATURE SURVEY

The OEE improvement was tried in different environment and with different factors taken. But most of them give priority for quality, on time delivery and organizational ability. The different tools and techniques used by researchers to implement OEE are Kanban, SMED, DMAIC, Markov process, Gravity flow rank method, Hypothesis testing, Interview method and Software development.

The OEE implementation is closely related with performance of machine but the researchers paid very less attention on how much time they are taking for OEE analysis.

RESEARCH METHODOLOGY

The methodology started with problem identification i.e. low OEE in our case. After identification, product model need to sort out for carrying our study. In the case company, after selecting part model, current performance of those machines are tabulated and evaluated against its deciding factors for determining key product. The current status provides a way of thinking to improve in future.

The brainstorming session was conducted for ideas generation in context of OEE visibility and then sorted out based on rankings. The proposal was implemented along with CIR plan and plotted in graphs for each strategy. The complete cycle of methodology is plotted in Figures 1 and 2, respectively. [7–15]

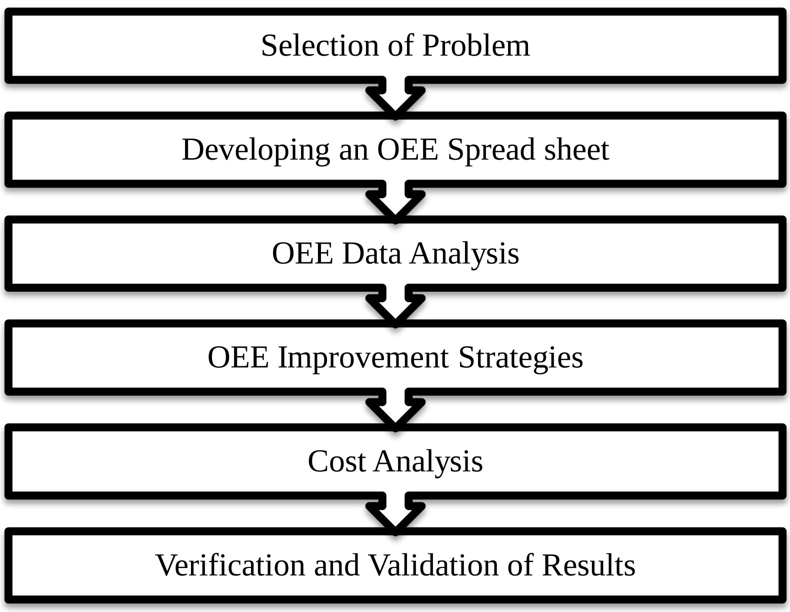

Fig. 1. *Flow diagram of research methodology.*

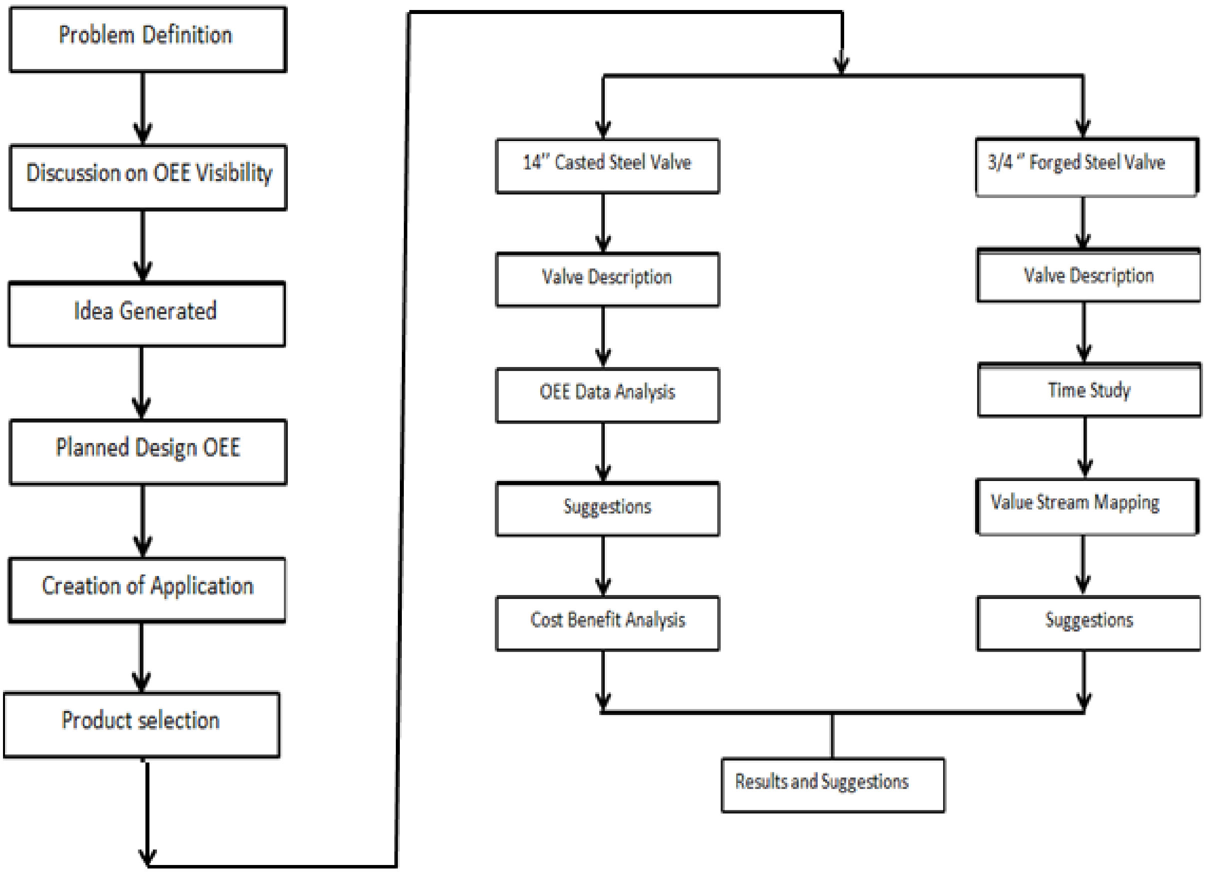

Fig. 2. *Detailed methodology.*

Developing an OEE Spread Sheet

The OEE implementation needs a model part on which methodology applies and evaluated to track improvement. The selection is based on following strategies which is shown in Figure 3.

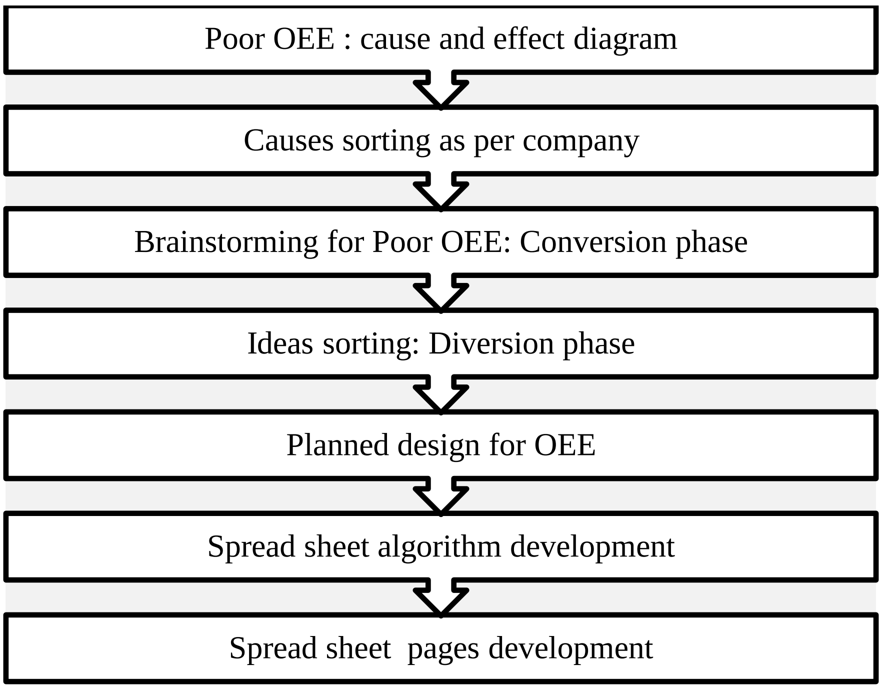

Fig. 3. *Methodology for OEE Spread sheet.*

Poor OEE: Cause and Effect Diagram

The implementation starts with identification of Cause and Effect since as a manufacturer we need to satisfy him mostly. The data is taken from production department and main causes are identified which is shown in Figure 4.

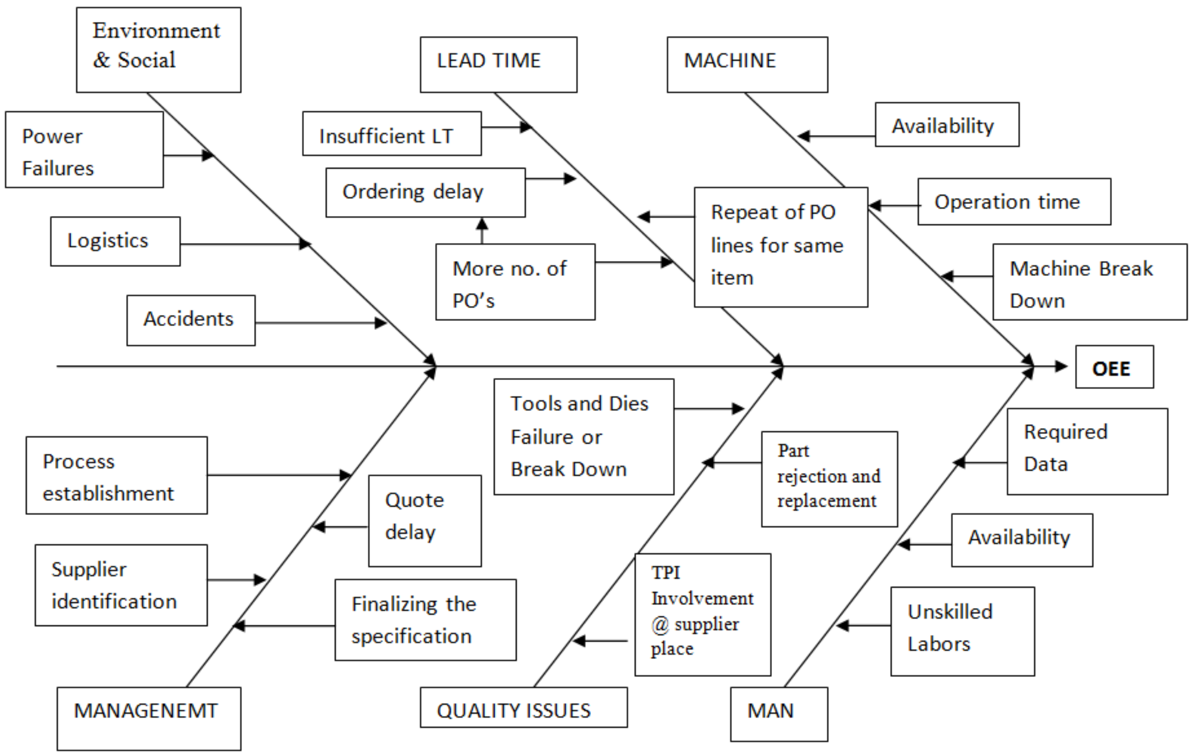

Fig. 4. *Poor OEE cause and effect diagram.*

Main Causes for Poor OEE Visibility

Main causes are for poor OEE visibility is identified by conducting brain storming session, having all department managers and assistant managers and solution had been formed as improper data, Data collecting time, Insufficient data, More types of losses or unnoticed, Retrieving of Previous data is difficult and Maintaining of data is in Paper.

Brainstorming-Diversion Phase for Poor OEE Visibility

As a diversion phase ideas where generated by the groups for the improvement of OEE visibility and fallowing solutions where finalized as Spread sheet based OEE software, Excel based OEE software, Computer installation, Paper method, OEE Software

Conversion Phase in Brainstorming

As a conversion phase brainstorming is carried and ranking is given for the solutions and best solutions is formed. Ranking is given based on the following parameters, potential cost benefit (1 – very low saving, 4 – minor saving; 7 – major saving; 10 – very high saving), cost of development (1 – very high cost; 4 – major cost; 7 – affordable cost; 10 – minimum cost), time required for implementation (1 – very long time; 4 – high time; 7 – less time; 10 – very short time), probability of removal (1 – no chance; 4 – low chance; 7 – high chance; 10 – excellent chance), state of art (technology used) (1 – very high technology; 4 – imported from other countries; 7 – locally available; 10 – off the shelf) and ranking is given as shown below in Table 1.

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Table 1. *Ranking method (conversion phase).*

Proposals	Potential cost Benefit	Cost of development	Time required for implementation	Probability of implementation	State of art	Total Score
Application based OEE software	6	6	7	9	9	37
Excel based OEE software	6	7	5	7	6	31
Computer installation	6	7	4	7	6	30
Paper method	3	4	5	6	5	23
OEE Software	6	1	3	7	3	20

Idea Finalized

As a result of the brain storming session, we came to an idea of creating an overall equipment effectiveness (OEE) spread sheet which will help to improve machine performance and utilization and database will be used to analyze the OEE at regular interval (month, week, day).

Planned Design for OEE

A design is developed before creating the spread sheet.

Based on this plan whole OEE system will be operating which is shown in Table 2.

Table 2. *OEE design.*

No. of days over	1	
No. of days Remaining	25	
	SHIFT-1	
	Time	Qty
Worked time/day	460	
8a- Line scheduled cleaning	15	
8b- Line scheduled p.m		
8c- Line scheduled meeting		
8d- Line development work time		
8e- Line planned stop (No req.)		
8 - Total Line shut down losses	15	
Loaded time	445	
Over all cell effectiveness	97%	
Line operating time	420	
Pitch time	30.00	
Line actual pitch time	35.00	
Qty.to be produced		15
Plan for the day(PPC)		15
Actual produced		12
Quantity lost / day		3

1 - Equipment failure	15	1
2 - Setup & Adjust.		0
3 - Tool & Jig change - Scheduled	10	0
4 - Start-up		0
5 - Minor stoppage		0
6 - Speed loss		0
7 - Defect loss	30	1
9a-Awaiting instruction		
9b-Awaiting material(from previous cell)		
9c-Awaiting material (from vendor)		
9d-Awaiting men		
9e-Want of Spares / hand tools		
9f-Air pressure loss		
9g-Power failure		
9h-A/c failure		
9i-Accident		
9 - Total Management loss	0	0
12 - Logistics loss		0
3a-Tool & jig change loss-due to tool		
3b-Tool & jig change loss-due to fixture		
13b-M&A loss-because of M/C		
13d-M&A loss-standard		
13 - Measure & Adjustment loss total	0	0
10 - Operating motion loss	60	2
11 - Line organasation loss		
Total Qty. lost due to losses		3

OEE Spread Sheet

A spread sheet had been created using Visual Studios (.net) as front end and a SQL data base as back end and results will be converted to Microsoft Excel Format for the easy use. It is shown below in Figures 5–8.

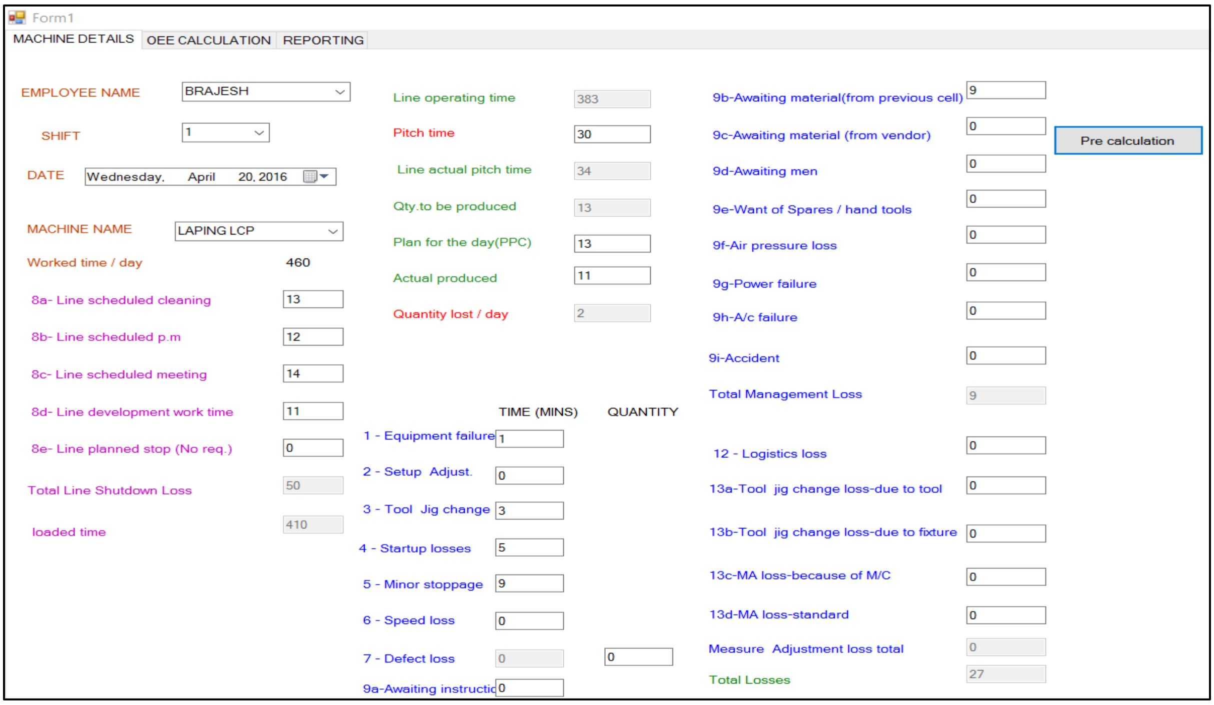


Fig. 5. *Spread sheet front page.*

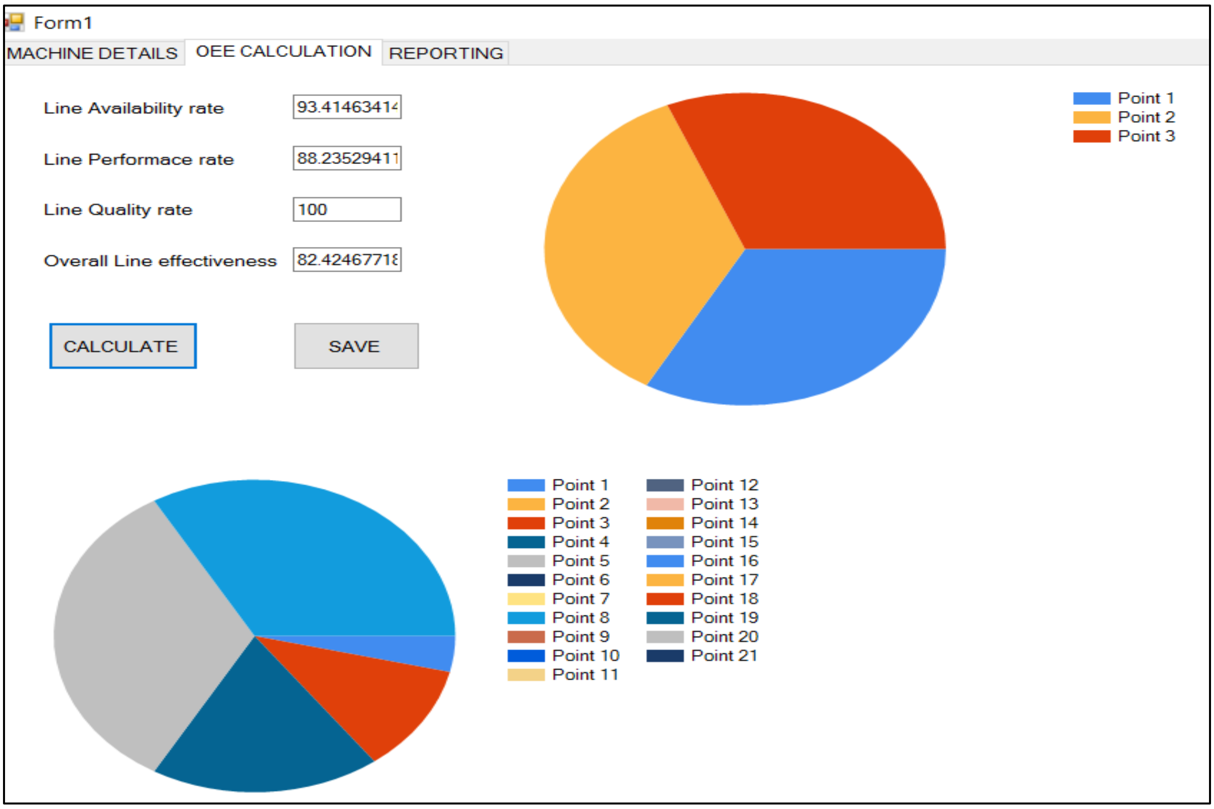
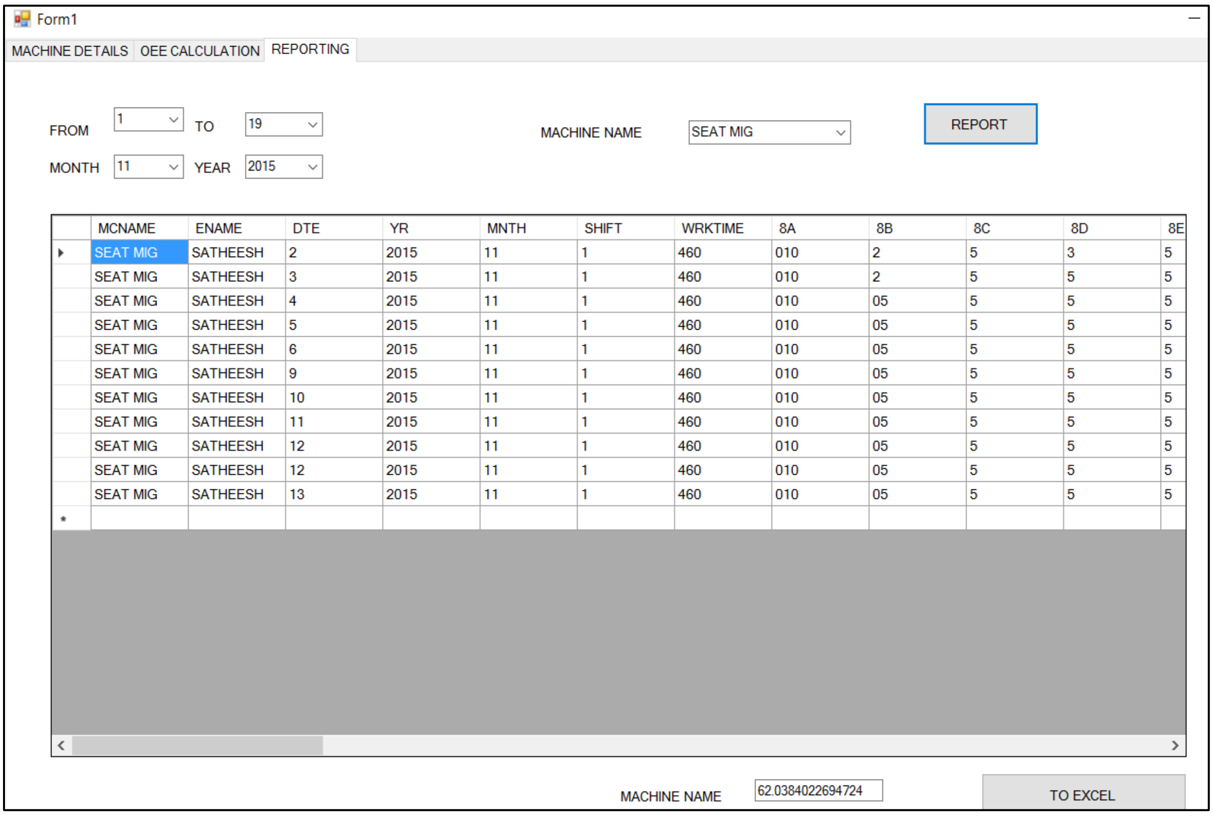


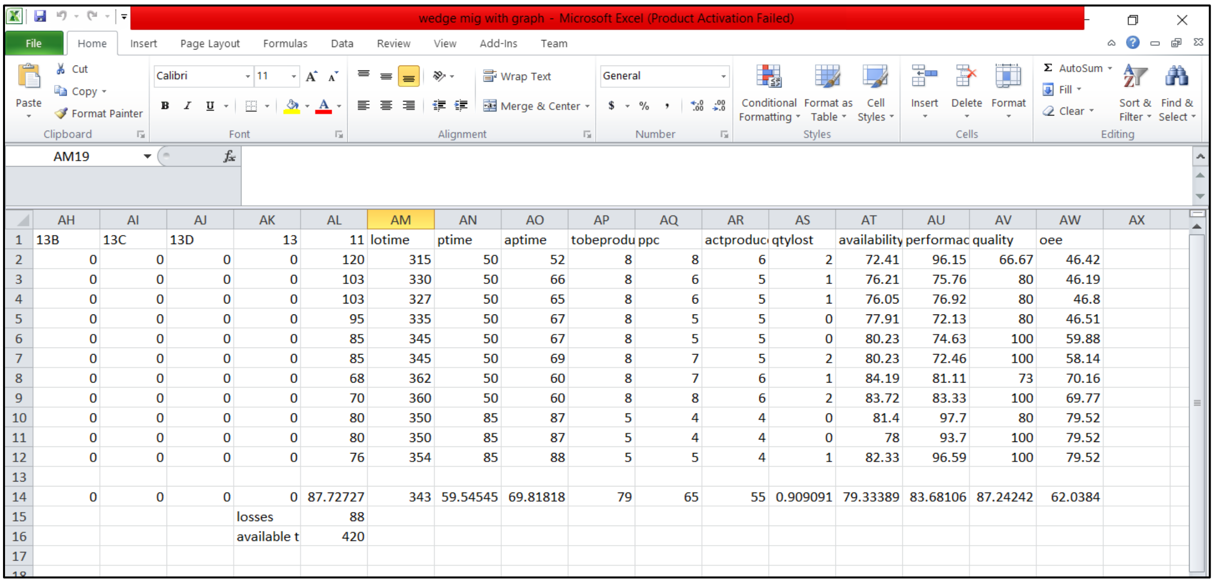
Fig. 6. *Spread sheet result page.*



MCNAME	ENAME	DTE	YR	MNTH	SHIFT	WRKTIME	8A	8B	8C	8D	8E
SEAT MIG	SATHEESH	2	2015	11	1	460	010	2	5	3	5
SEAT MIG	SATHEESH	3	2015	11	1	460	010	2	5	5	5
SEAT MIG	SATHEESH	4	2015	11	1	460	010	05	5	5	5
SEAT MIG	SATHEESH	5	2015	11	1	460	010	05	5	5	5
SEAT MIG	SATHEESH	6	2015	11	1	460	010	05	5	5	5
SEAT MIG	SATHEESH	9	2015	11	1	460	010	05	5	5	5
SEAT MIG	SATHEESH	10	2015	11	1	460	010	05	5	5	5
SEAT MIG	SATHEESH	11	2015	11	1	460	010	05	5	5	5
SEAT MIG	SATHEESH	12	2015	11	1	460	010	05	5	5	5
SEAT MIG	SATHEESH	12	2015	11	1	460	010	05	5	5	5
SEAT MIG	SATHEESH	13	2015	11	1	460	010	05	5	5	5

Fig. 7. *Spread sheet data source page.*

This spread sheet consists of all the data that are required for OEE analysis and data can be retrieved as shown in Figure 7 and can be converted into Microsoft excel as shown below in Figure 8.



	AH	AI	AJ	AK	AL	AM	AN	AO	AP	AQ	AR	AS	AT	AU	AV	AW	AX
1	13B	13C	13D	13	11	lotime	ptime	aptime	tobeprodu	ppc	actproduc	qtylost	availability	performac	quality	oee	
2	0	0	0	0	120	315	50	52	8	8	6	2	72.41	96.15	66.67	46.42	
3	0	0	0	0	103	330	50	66	8	6	5	1	76.21	75.76	80	46.19	
4	0	0	0	0	103	327	50	65	8	6	5	1	76.05	76.92	80	46.8	
5	0	0	0	0	95	335	50	67	8	5	5	0	77.91	72.13	80	46.51	
6	0	0	0	0	85	345	50	67	8	5	5	0	80.23	74.63	100	59.88	
7	0	0	0	0	85	345	50	69	8	7	5	2	80.23	72.46	100	58.14	
8	0	0	0	0	68	362	50	60	8	7	6	1	84.19	81.11	73	70.16	
9	0	0	0	0	70	360	50	60	8	8	6	2	83.72	83.33	100	69.77	
10	0	0	0	0	80	350	85	87	5	4	4	0	81.4	97.7	80	79.52	
11	0	0	0	0	80	350	85	87	5	4	4	0	78	93.7	100	79.52	
12	0	0	0	0	76	354	85	88	5	5	4	1	82.33	96.59	100	79.52	
13																	
14	0	0	0	0	87.72727	343	59.54545	69.81818	79	65	55	0.909091	79.33389	83.68106	87.24242	62.0384	
15				losses	88												
16				available t	420												
17																	

Fig. 8. *Converted into MS excel.*

OEE Data Analysis

OEE data are generated using OEE spread sheet. And results are analyzed by the fallowing steps. Critical Product is selected and data are analyzed. And proposal is given based on the cost benefit analyze which is shown in Figure 9.

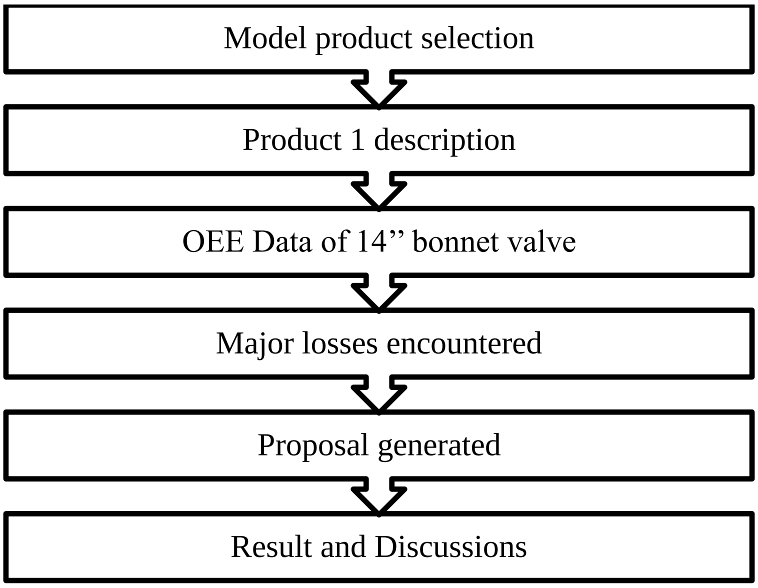


Fig. 9. *Flow diagram for OEE data analysis.*

Model Product Selection

Critical product is selected based on the following points, Two types of valves are produced 1.Forged steel and 2.Casted Steel, and Eighteen sizes of valves are produced, 3/8 – 3 Forged Steel, 4 – 24 Casted Steel. Two products are selected for better analysis 1.720 Types of valves are manufactured in Casted and forged Steel), 3/4 inch bonnetless valves (28% of overall Forged Steel Valves), 14 inch Casted Valves (36 % of overall Casted Steel Valves).

Product 1 (14” Valve)

To calculate the machine OEE process of valve is drawn and OEE data for every machine is taken for two week. From that data Welding Machine is having Less OEE when compared to other machines, which leads to fall on overall OEE.

Valve Description

Velan pressure seal flexible wedge gate valves (Figure 11) are ideal for high pressure steam (main steam isolation), liquid (feed water isolation), catalytic reformers, hydrocrackers and other tough services. Velan’s proven pressure seal design. Velan flexible wedge offers superior tightness of seats and freedom from sticking. Wedge guiding minimizes seat rubbing and scuffing resulting in long cycle life. Designed to ASME B16.34. Body made of superior strength forgings and optional cast steel. Velan stem seal offers tight seal with little to no maintenance over long periods of time. Optional live-loading of packing, non-rotating stem.

OEE Data of 14’’ Valve

OEE of welding machine is generated and graphs are shown in the Figure 10 for the same. Availability = 79%, performance = 83%, quality = 87%, OEE = 62%.

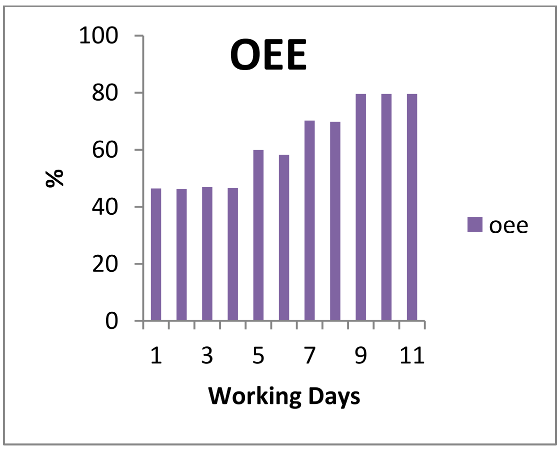


Fig. 10. *OEE graph.*

Fig. 11. 14'' Bonnet valve.

Graphs were drawn for the major losses occurred in the machine in Figures 11–14, respectively which consists of losses like stoppages occurred in machine (Figure 11), management losses like availability of man, tools, power, etc. (Figure 12), time taken more than the allowed time to setting up the work piece (Figure 13), and machine speed losses due to improper alignment and unskilled labor (Figure 14) where explained.

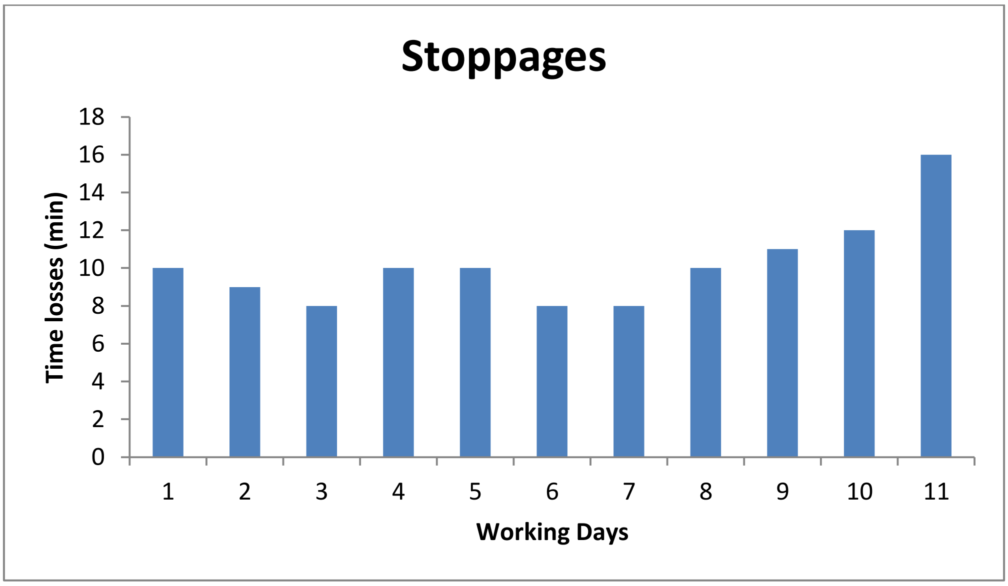


***Fig. 12.** Minor stoppages per day.*

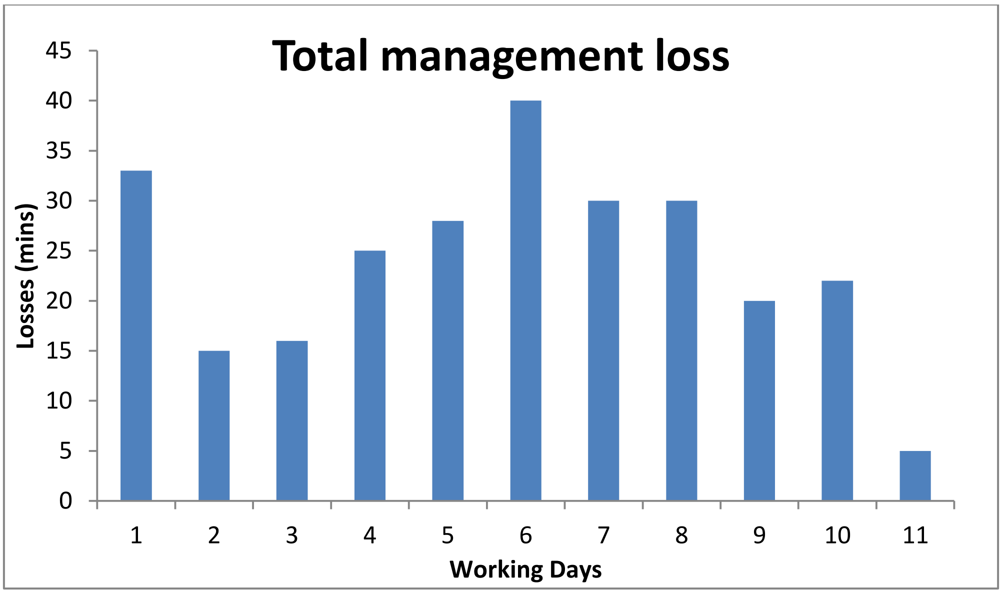


***Fig. 13.** Management losses per day.*

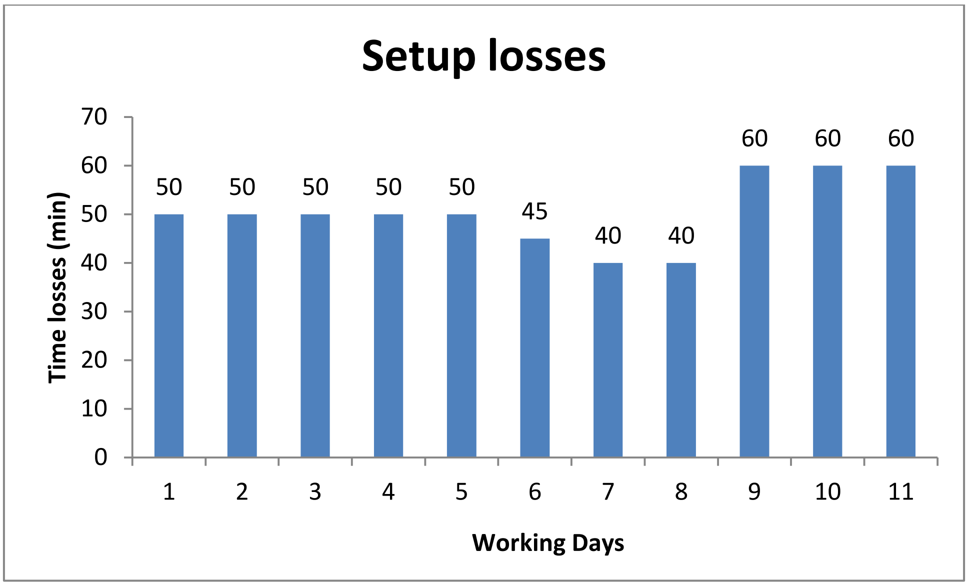


Fig. 14. *Setup time per day*.

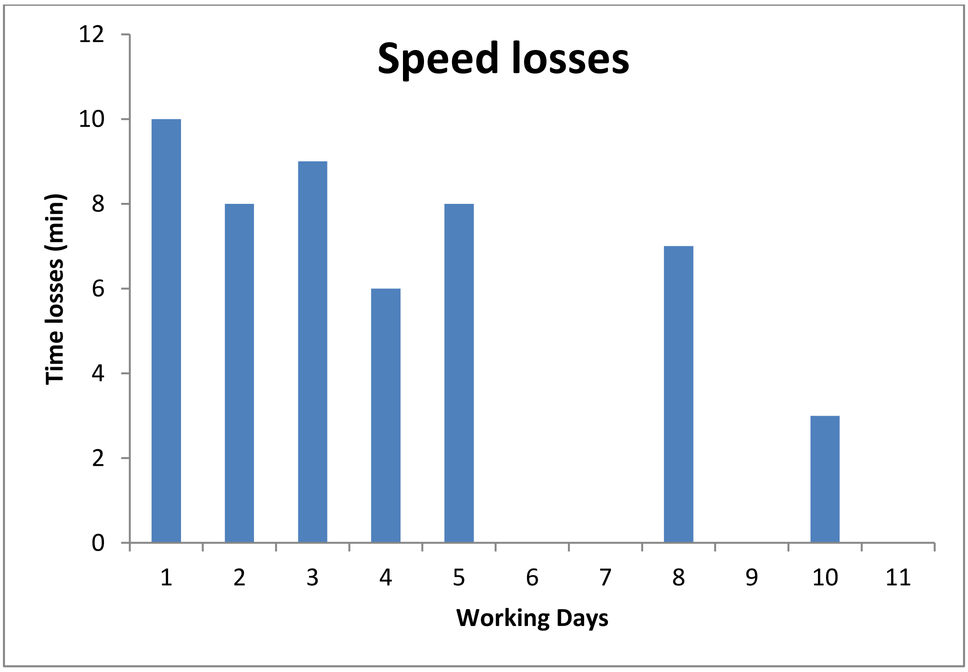


Fig. 15. *Speed losses per day*.

Proposals Generated

Instead of manual welding, it can be done in special purpose machine which is available in the industry itself (Figure 15). It can help in reducing the need of skilled welder due to which more management losses are occurred,

In reducing increased quality and surface finish of welding. Setup time is only 6 minutes and processing time is 25 minutes (Figure 16).

COST BENEFIT ANALYSIS OF PROPOSAL

Manual Welding Process/Shift

Welding rods = 1600 INR
Labor required= 2 * 500
Maintenance = 25 mins
Produced 1 piece = 1 h
Rejects / reworks = 20%
Working cost = 380 INR
Numbers can be produced = 8

Robotic Arm Welding/Shift
Welding rods = 3800 INR
Labor required= 1 * 390
Maintenance = 20 minutes
Produced 1 piece = 20 minutes
Rejects/reworks = 1%
Working cost = 2880 INR
Numbers can be Produced = 16

Cost analysis

- Spent cost = manual welding = 2100 + 1000 + 380 = 3480 INR
  (3480 + (3480 * 0.2)/8) = 522 INR/Piece
- Spent cost = robotic arm welding = 5000 + 390 + 2080 = INR rupees
  (7470 + (7470 * 0.01)/16 = 471 INR

Fig. 16. *Manual and robotic arm welding.*

Model Product 2 Process

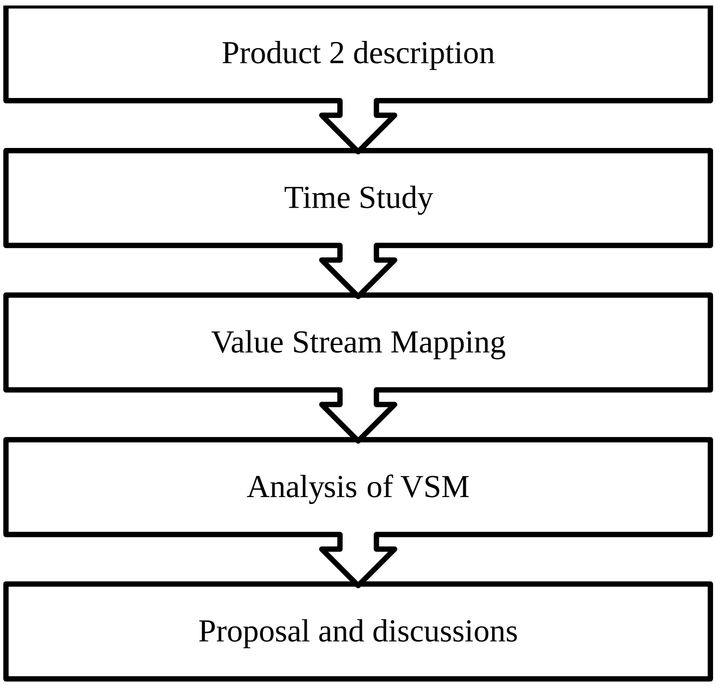


Fig. 17. *Model 2 process flow.*

3/4'' Bonnetless Valve
One-piece, forged, bonnet less globe valves (Figure 16) have been proven in critical, tough service spread sheets around the world for over 30 years. This includes high pressure drop, steam blow down,

steam injection, fast acting isolation, 6000 psi (414 bar) gas and super-heated steam at 1100°F (593°C). They offer to the user an outstanding, long-lasting, high performance valve for high-pressure and tough spread sheets (Figure 18).

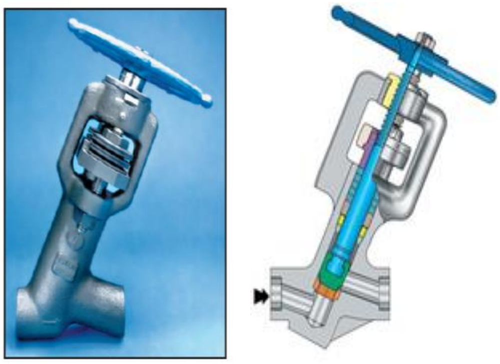


Fig. 18. *3/4" bonnetless valve.*

Reason for Choosing 3/4 Inch Bonnetless Valve

3/4 Inch bonnetless valve is selected based on the total production in Table 3 (Figure 19).

Table 3. *Valve production.*

3/4 Inch valve/year production				
Year	**Units**	**Total production**	**Rework**	**% of rework**
2013	7645	27,106	918	12.00
2014	2539	12,589	351	13.82
2015	7534	30,219	781	10.03

Time Calculation and Value Stream Mapping

Time calculation had been done for 3/4″ bonnetless valve with operator rating 0.8 and value stream is drawn for the same (Table 4).

Table 4. *Time calculation.*

3/4" Bonnet Less Valve timing per unit in minutes							
Process	operators	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Avg
Disc machining(turning)	2	15	15	16	14	15	15
Body machining (vmc)	1	40	40	40	40	40	40
(Hmc)	1	50	50	50	50	50	50
Seat weld (Robot)	1	5	5	5	5	5	5
Seat testing (robot)	1	1.5	1.5	1.5	1.5	1.5	1.5
Parkerizing (phosphating)	2	56	56	56	56	56	56
Assembly 1	2	6	7	8	6	7	6.8
Assembly 2	2	5	6	5	5	7	5.6
Testing	1	5	6	4	7	6	5.6
Inspection	1	2	2	1	2	1	1.6
Packing	2	30	30	25	25	27	27.4
Dispatch	3	25	23	24	30	25	25.4
Total Average Time		20.04	20.13	19.63	20.13	20.04	19.99

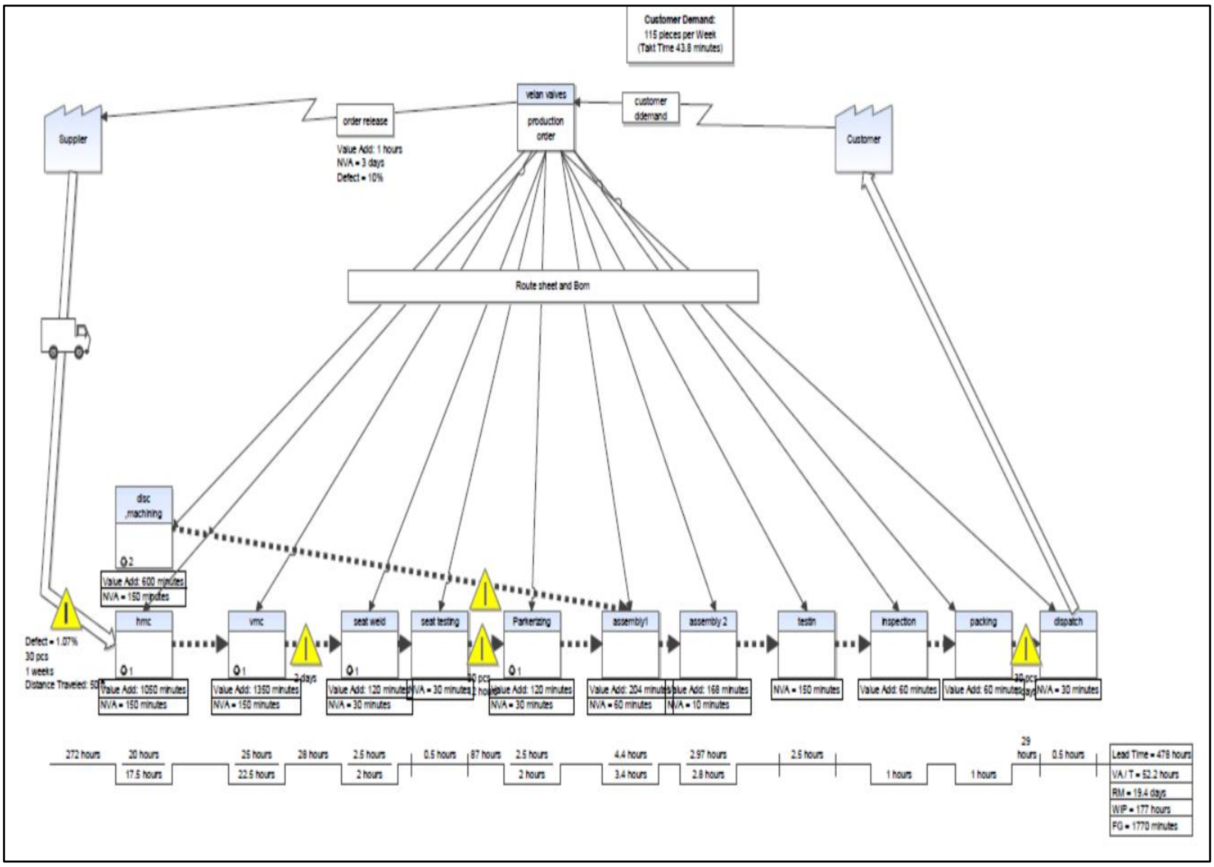


Fig. 19. *Current state mapping of 3/4" valve manufacturing.*

Analyzing of Current State

Identification of Non-value Adding Activities

- By applying value stream mapping to practice (Figure 19), I realized the benefits the tool brought to my work. I identified embedded waste, which had been neglected before in the working process.
- The actual value added time is 52.2 h and the lead time is 464 h. It is clear that the ratio of value added time to lead time is very less. There is an Inventory of 7 days between Turning, Parkerizing and Assembly.
- More bottlenecks are there in the process

Identification of Maximum Lead Time

- The more lead time is found in vertical machining (40 min/unit) and horizontal machining centers (50 min/min) need to be reduced by any means to improve the productivity.[6,7]

Takt Time

The lead time in many machines are very higher than the takt time of the product which is shown in figure. Lead time should be reduced to achieve takt time for customer timely delivery.

Proposals for Reducing Reworks

- Bottle necks can be reduced by providing multi machines at horizontal and vertical machining center
- More reworks are occurred in WIP which is before Parkerizing. It can be moved after Parkerizing. To avoid rusting of machined parts
- It also helps in reducing the reworking time of the products

RESULT AND DISCUSSIONS

- OEE visibility has been increased from 23 to 1.5 minutes
- Rework had been reduced to 2% by changing work in process
- OEE had been improved from 62% to 88% by implementing this above processes which is shown in Figure 20.

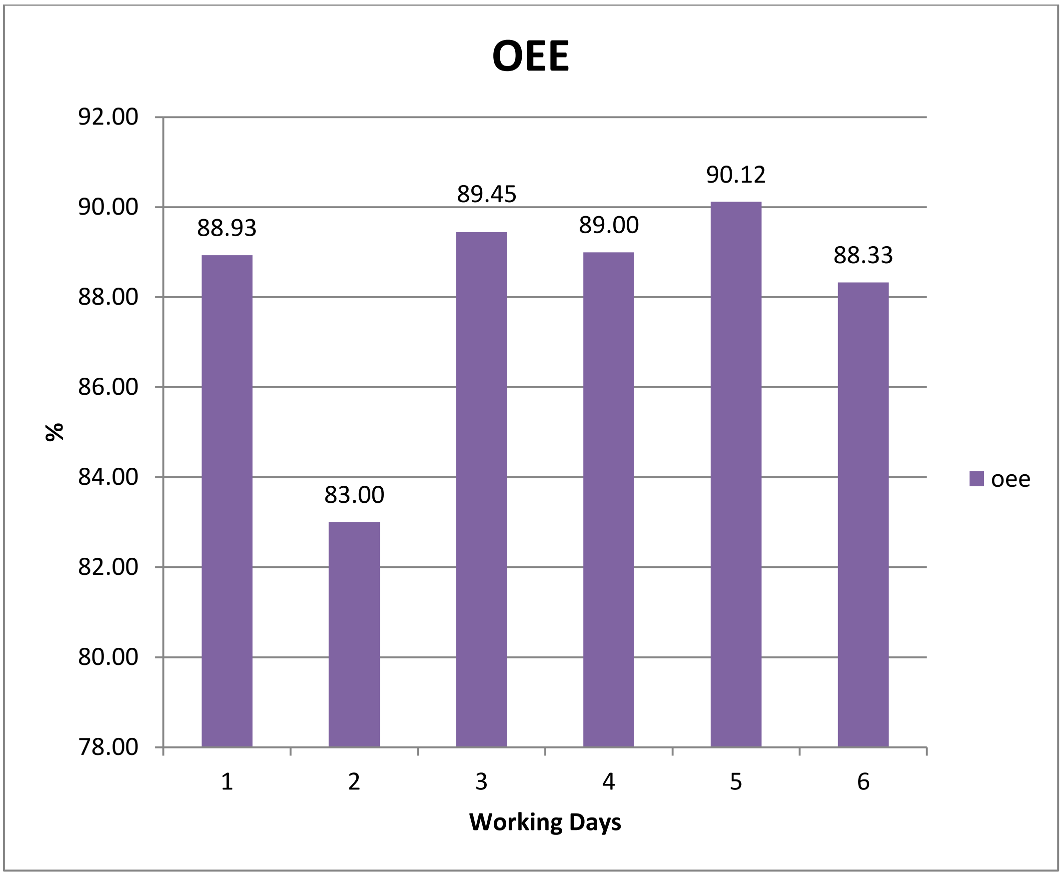


***Fig. 20.** OEE of proposed model.*

CONCLUSION

Identification of losses is a main problem in a manufacturing industry. OEE will help in monitoring the machine and thus machine utilization can be improved. It also helps in identify the losses occurring in industry and it can be reduced through lean techniques. Identification of losses is a main problem in a manufacturing industry.

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