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OEE (Overall Equipment Effectiveness) Improvement of Qsk-23 Housing Flywheel Line by Implementing Lean Manufacturing

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Abstract - *"OEE Improvement of Qsk-23 Housing Flywheel Line by Implementing Lean Manufacturing" paper describes the importance of lean manufacturing. We need to reduce the wastages in QSK-23 housing flywheel production line by implementing lean manufacturing.OEE represents the statistics of the current performance condition of the company. Lean manufacturing is one of the solution for elimination of wastages from all aspects from an organization's operations, where waste is observed as loss of resources and time that does not lead directly to creating the product which customer is willing to pay for the product. In many industrial processes, such type of non-value added activity can comprise more than 90 percent of a factory's total. This project is about reducing these wastages from the particular industry, by listing out wastages and giving the guidelines to reduce them by using lean manufacturing tools and estimating them profit in terms of cost.*

***Key Words*:** **QSK-23 Housing Flywheel, Lean Manufacturing, Non-Value Added Activity, OEE**

1. INTRODUCTION

Today's customer needs a good quality product with low price and less time. This is not possible with using conventional methods for manufacturing. This is possible with only using modern techniques and machines as per the requirement of the process. Overall Equipment Effectiveness is the standard tool for measuring manufacturing productivity. It identifies and displays the percentage of manufacturing time that is truly productive. An OEE score of 100% means we are manufacturing only Good Parts, as fast as possible, with no Stop Time. In the language of OEE that means 100% Quality, 100% Performance (as fast as possible), and 100% Availability (no Stop Time).

2. LITERATURE REVIEW

2.1 Overall Equipment Effectiveness

OEE (Overall Equipment Effectiveness) is the standard tool for measuring manufacturing productivity. It identifies and displays the percentage of manufacturing time that is truly productive. An OEE score of 100% means we are manufacturing only Good Parts, as fast as possible, with no Stop Time.

2.2 Why is OEE important?

OEE (Overall Equipment Effectiveness) is a universally accepted method for measuring the improvement potential of a production process which displays the results in terms of percentage. Measuring makes it easier to improve, and improving productivity is the core objective of Lean Manufacturing by eliminating wastages.

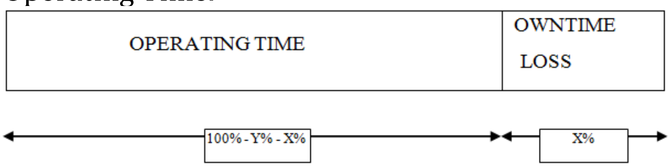
2.3 OEE Bench Marks

An OEE score of 100% is perfect production which means we are manufacturing only good parts, as fast as possible, with no stop time. An OEE score of 85% is considered as world class for manufacturing industry. For many industries, it is a suitable long-term goal. An OEE score of 60% is fairly typical for the manufacturers, but indicates there is scope room for improvement. An OEE score of 40% is not at all uncommon for manufacturing companies and improve their manufacturing performance.

2.4 PREFERRED CALCULATION

OEE=Availability x Performance x Quality

1. Availability takes into account Down Time Loss, which includes any Events that stop planned production for an appreciable length of time. Examples include equipment failures, material shortages, and changeover time. Changeover time is included in OEE analysis, since it is a form of down time. While it may not be possible to eliminate changeover time, in most cases it can be reduced. The remaining available time is called Operating Time.



Availability =(Operating Time / Planned Production Time)x100

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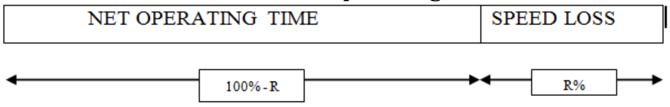
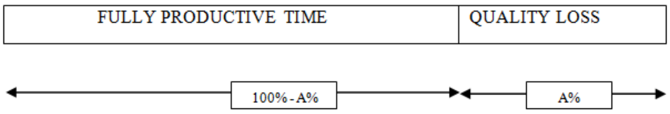
2. Performance takes into consideration Speed Loss, which that cause the process to operate at less than the maximum possible speed under running condition. Examples includes machine wear, substandard materials, misfeeds, and operator inefficiency. There meaning available time is called Net Operating Time.



Performance= (operating time/planned production time)

3. **Quality** takes into account Quality Loss, which accounts for produced pieces that do not meet quality standards, pieces that require rework. There mining time is called Fully Productive time. Our goal is to maximize Fully Productive time.



Quality = (Good pieces/total pieces)

2.5 Lean Manufacturing

The core idea of lean manufacturing is eliminating waste from the manufacturing process. Waste is defined as any activity that does not add value from the customer's point of view. Almost 60% of production activities in a typical manufacturing operation are waste – they add no value at all for the customer. Every industry has an opportunity to improve, using lean manufacturing techniques and other manufacturing best practices. Lean manufacturing techniques enables us to deliver higher quality products at significantly lower costs.

3. Problem Definition & Objectives

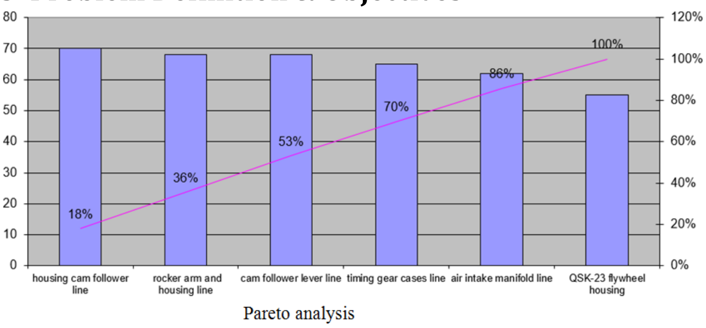


Fig -1: Pareto analysis

According to Pareto Analysis of all production lines of industry we came to conclusion that the OEE of QSK 23 housing flywheel line is less than all other production lines. So we set the target to increase its OEE by using lean manufacturing tools.

3.1 Selection of the Project

1. Industrial visit to the GMT Company.
2. Discussion regarding the products manufactured in company and the project prone areas with the chairman of the company.
3. GMT Company is manufacturing and machining a product QSK-23 FLYWHEEL HOUSING which is supplied to Cummins India Ltd.
4. The machines involve in this production line is 1 HMC AND 1 VTM.
5. The OEE of that production line is less than desirable level by Pareto Analysis and this affects the overall OEE of the company adversely.
6. The project sponsored is about observing the whole process with the wastages from lean point of view from the delivery of the product from foundry till packaging of the product.
7. The majority of the waste in housing line will be reduced which henceforth will increase the availability and productivity of the equipment and quality of the product.
8. Calculating the current OEE of the machining line, generating OEE, applying lean manufacturing tools if current OEE is less than the required OEE.
9. It will result in increasing OEE of the particular manufacturing line.

4. Actual Work Carried and Experimentation.

4.1 PRODUCT INFORMATION

Fig -2: After machining part (rareview)

Fig -3: After machining part (frontview)

4.3 Product Specification

1. QSK-23 flywheel housing is the part of part of the engine naming QSK23 which is being supplied to Cummins ltd.
2. Flywheel housing weighs around 183 kg made up of cast iron.
3. Machining of this job is done in three phase on two machines HMC & VTM.
4. First job on each machine is quality tested then after 10 jobs it is tested again with quality parameters.

4.4 Distribution of Work

4.4.1Production line is distributed in three phases:

1. Horizontal Machining Center Machine (PHASE I).
2. Vertical Turning Milling Machine (PHASE II).
3. Horizontal Machining Center Machine (PHASE III).

4.5 Observations Horizontal Machining Center Machine (PHASE I)

SR NO	PARAMETER	TIME(MIN)				Averages
		29/09/2018	6/10/2018	12/12/2018	21/12/2018	
1	Handling & Loading	3.50	4.00	3.55	3.52	3.64
2	Clamping	6.50	7.40	7.10	7.28	7.07
3	Cycle Time	109.42	109.39	109.37	109.45	109.40
4	Declamping and Unloading	10.54	1023	10.55	9.57	10.22
	Total	131.16	131.42	131.37	131.02	**131.24**

Fig -4: Setup Time Distribution of HMC Phase-I

4.5.1 Calculations of Actual OEE of HMC Machine Phase

1. Shift length = 480 min.
2. Lunch break, short breaks and bio breaks = 30+20+10=60min.
3. Planned production time: 480-60=420 min.
4. Actual number of pieces produced : 2.5 component
5. Average cycle time: 130min.
6. Operating time: 131.24*2.5 =325min.
7. Availability : Total time available/ total shift time = 420/480=0.87=**87**%
8. Performance=operating time/planned production time= 325/420=0.77=**77**%
9. Quality : Good pieces/total pieces=0.98=98%
10. OEE= availability*performance*quality

=0.87*0.77*0.98=0.65=**65**%

Current OEE of HMC = 65%

4.5.2 Target to Achieve on HMC I Phase in terms of performance.

1. To improve the OEE to 72 % and above.
2. Giving implementations techniques and guidelines of lean manufacturing tools to be use in the industry by using lean manufacturing.
3. HMC 1st phase is having lowest OEE as 65%.
4. OEE=availability*performance*quality =0.87*0.77*0.98=65%
5. Target OEE 0.72
   0.72/0.98*0.87 = 0.84
6. Performance=operating time/planned Production time= 325/420=0.77=77%
   0.84*420 = 352.8 min (target to achieve 72 percent OEE)
   352.8 – 325 = 28 min should increase.
7. 2.5 jobs per shift, 28/2.5 = 11.2 min per job performance should increase.
8. Average 21 min are required for loading, clamping, de clamping and unloading.

SR NO	PARAMETER	TIME (MIN)
1	Loading process • Tying strip around product and clamping it with crane • Moving up to the shop floor and using the crane • Crain speed with low rpm upholds the job • Fixing the job in the fixtures bolts	3.54
2	Clamping • Tightening of nuts by hands on fixtures • Then finding the tools for clamping in machine shop area • Tightening of bolts using spanner • Cleaning • checking	7.28
3	De clamping process • Loosening of nuts by tools or spanner • Keeping away all nuts	6.33
4	Unloading • Tying strip around product and clamping it with crane • Moving it down slowly to the requiredplace	3.95
	TOTAL	21.1 min

Fig -5: Distribution of loading, unloading and declamping of 21 min on HMC

4.6 Observations vertical turning milling Machine (PHASE II)

SR NO	PARAMETER	Time(min)			
		18/8/18	1/9/18	22/9/18	26/9/18
1	Handling and loading part on machines	1.15	1.12	1.17	1.13
2	Clamping of (OP 30)	8.20	8.18	8.23	8.24
3	OP 30 cycle time	15.10	14.44	14.52	15.58
4	Declamping for OP30 and clamping for OP 40	5.20	5.21	5.23	5.18
5	OP 40 cycle time	67.21	66.50	66.53	66.49
6	Declamping and Unloading	8.28	8.25	8.23	8.30
	TOTAL	105.54	104.50	105.11	106.12

Fig -6: Setup Time Distribution of VTM Phase-II

SRNO	DETAIL	TIME(MIN)
1	MACHINING TIME	82.09
2	TOTAL SETUP TIME	105.32

Fig -7: Summary Of Time Distribution of VTM Phase-II

4.6.1 Calculations of Actual OEE of VTM Machine Phase

1. Shift length : 480 min
2. Lunch breaks , short breaks and bio breaks : 30+20+10=60 min
3. Planned production time : 480-60=420 min
4. Operating time : 105*3=315 min
5. Actual number of pieces produced: 3 component/ shift
6. Expected rate : 4 component/shift
7. Availability : Total time available / Total shift time = 420/480=0.87=87%
8. Performance : operating time/planned production time =315/420=0.75=75%
9. Quality = Good pieces/total pieces = 0.98=98%
10. OEE = 0.87*0.75*0.98 = 0.63 = 63%
11. Current OEE of VTM = 63%

4.6.2 Target to Achieve on VTM Phase II in terms of performance.

1. To improve the OEE to 72 %.
2. Giving implementations techniques and guidelines of lean manufacturing tools to be use in the industry by using lean manufacturing.
3. VTM having OEE as 63%.
4. OEE=availability*performance*quality =0.87*0.75*0.98 = 0.63 = 63%
5. Target OEE 0.72 0.72/0.87*0.98 =0.84
6. Performance=operating time/planned production time= 315/420=0.75=75%
7. 0.84*420 = 352.8 min (Target to achieve 72 percent OEE)
8. 352.8 – 315 = 37.8min should increase
9. 3 jobs per shift , 37.8/3= 12.6 min per job performance should increase.
10. Average 23.23 min are required for loading, clamping, de clamping and unloading.

SR NO	PARAMETER	TIME (MIN)
1	Loading process • Tying strip around product and clamping it with crane • Moving up to the shop floor and using the crane • Crain speed with low rpm upholds the job • Fixing the job in the fixtures bolts	1.15
2	Clamping for OP-30 • Tightening of nuts by hands on fixtures • Then finding the tools for clamping in machine shop area • Tightening of bolts using spanner • Cleaning • checking	8.20
3	Declamping for OP-30 & clamping forOP-40 • Loosening of nuts by tools or spanner • Tightening of nuts by hands on fixtures • Tightening of bolts using spanner • Cleaning • Keeping away all nuts	5.20
4	Declamping &Unloading for OP-40 • Loosening of nuts by tools or spanner • Keeping away all nuts • Tying strip around product and clamping it with crane • Moving it down slowly to the required place	6.49+2.19 =8.28
	Total	**23.23 min**

Fig -8: Distribution of loading, unloading and declamping of 23.23 min on VTM

4.7 Observations Horizontal Machining Center Machine (PHASE III)

Sr no.	Parameter	13/1/2019	17/1/2019	20/1/2019	3/2/2019
1	Handling and loading part of machine	2.00	2.35	2.20	2.50
2	clamping	9.50	9.02	9.30	9.20
3	Cycle time	63.23	63.42	63.50	63.40
4	Declamping/ unloading	16.50	16.55	16.30	16.42
	Total time (min)	92.03	92.14	92.10	92.32

Fig -9: Setup Time Distribution of HMC Phase-III

Taking average for 4 observation= **92.59 min**

4.7.1 Calculations of Actual OEE of HMC PHASE III Machine

1. Shift length = 480 min
2. Lunch break, short breaks and bio breaks = 30+20+10 = 60min.
3. No. of pieces produced: 4 component/shift.
4. Average cycle time: 92min.
5. Planned production time: 480-60 = 420 min.
6. Actual operating time: 92*4 = 368 min.
7. Availability : Total time available/total shift time = 420/480 = 0.87 =87%
8. Performance = operating time/planned production time= 368/420=0.87=87%
9. Quality : Good pieces/total pieces=0.98=98%

10. OEE= availability*performance*quality= 0.87*0.87*0.98 = 0.74=74%
11. Current OEE of HMC = 74%

4.7.2 Target to Achieve on HMC Phase III in terms of performance

OEE of HMC Phase III is already optimized with 74% then there is no need of improvement in performance parameter.

SR NO	PARAMETER	TIME (MIN)
1	Loading process • Tying strip around product and clamping it with crane • Moving up to the shop floor and using the crane • Crain speed with low rpm upholds the job • Fixing the job in the fixtures bolts	2.26
2	Clamping • Tightening of nuts by hands on fixtures • Then finding the tools for clamping in machine shop area • Tightening of bolts using spanner • Cleaning • checking	9.25
3	De clamping process • Loosening of nuts by tools or spanner • Keeping away all nuts	11.10
4	Unloading • Tying strip around product and clamping it with crane • Moving it down slowly to the required place	5.15
	Total	**28.26 min**

Fig -10: Distribution of Loading, unloading and declamping of 28.26 min on HMC phase III

4.8 Current OEE of the flywheel housing line IN general machine tools

1. OEE of HMC phase 1 =65%
2. OEE of VTM phase 2 = 63%
3. OEE of HMC phase 3 = 74%
4. **Current OEE of the line = 63%**

4.9 IMPLEMENTATIONS

4.9.1 Lean tools to be selected from the given table below as per the industry requirements.

1. CTS (Coolant through Spindle)
2. Pneumatic Wrench
3. Double Pallet
4. Plant Layout
5. Kaizen
6. Poka Yoke
7. Visual Management
8. KANBAN
9. One-Piece Flow
10. Just In Time
11. Total Quality Management
12. Value Stream mapping
13. Continuous Flow Mapping
14. 7 Wastes
15. SMED
16. CTS (Coolant through Spindle)
17. Pneumatic Wrench
18. Double Pallet

4.10 HOPPER DAIGRAM

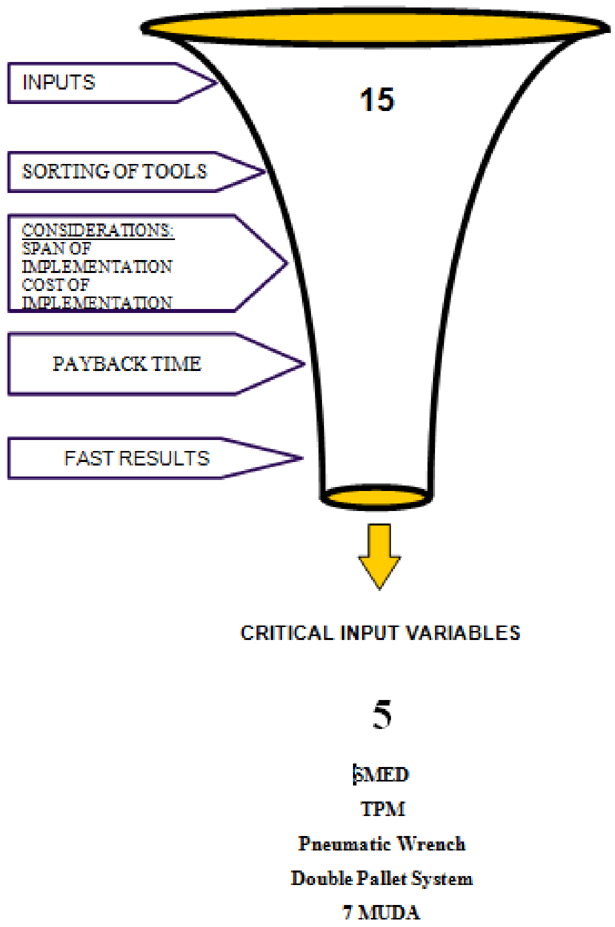


Fig -11: Hopper Diagram

4.10.1 SMED

Single-Minute Exchange of Die (SMED) is one of the lean manufacturing tools which is mainly focused on methods for reducing waste in a manufacturing process. It provides an efficient way of converting a manufacturing process from running the current product to running the next product.

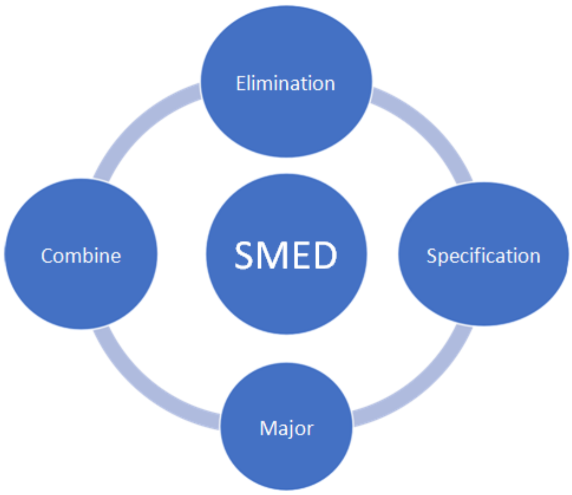


Fig -12: SMED Process

Implementation of SMED in industry general machine tool ltd:-

1. **Introduction**

   Industry situated in Ichalkaranji and it is manufacturing and machining different types of machine parts. In this industry we saw that there is need to implement lean manufacturing in Industry. We saw that lot of time was waste in changeover of die and tool in HMC AND VTM machine approximately 5 hrs to 6 hrs.

2. **Problem Formulation**

   To find the problems at time of changeover in HMC machine ,first we made the fishbone or cause and effect diagram of high setup time of HMC machine that shown in figure. In this figure we showed the causes of high setup time due to Manpower, Method, Machine and Equipment's. With the help of above diagram we have found out the root causes of this high setup time and easily resolve by the implementation of SMED technique.

3. **Methodology**

   After that we studied the different sources ,we found the procedure to implement the SMED technique with 5'S, its procedure is shown in figure, in which first we used 5'S techniques and then classified the internal and external set up to convert internal to external setup and streamlining all aspects of setup operation.

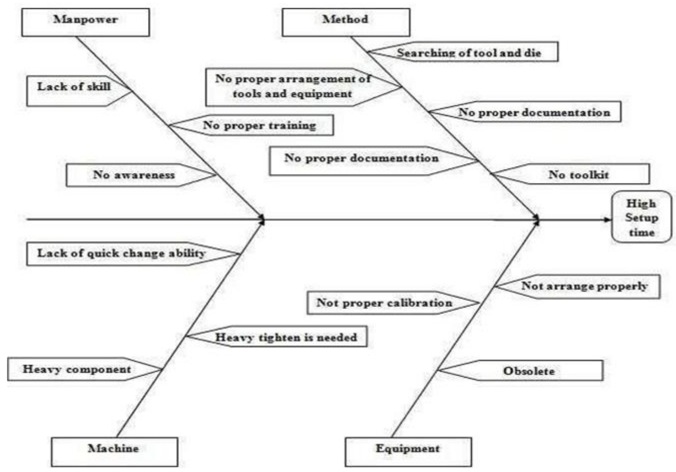


Fig -13: Fishbone diagram of high setup time of HMC machine

Guidelines Given To the Industry

1. Select the tool you need at workplace.
2. Minimize the bolt length and split the thread and using one turn fastener.
3. Use checklist operating procedure.
4. Increases the number of faster equipment's used in workplace to reduce internal set up time.
5. Increase awareness and skill of operator by appointing a trainer regarding SMED implementation.
6. Each machine should have its own toolkit as searching of tools is not value aided work from customers point of view.
7. Documentation report of CMM must be in time as observed that if CMM report is not available then the production remains closed till the report is available for the quality purpose.
8. Trolley system should be used which suggests that while one operation is being performed in the machine and we have to change the product with its particular fixtures then preparation of its tools, fixtures, toolkits, clamping materials, bolts etc. should be kept in trolley before the last production of that machine stops.

4.10.2 TPM (TOTAL PRODUCTIVE MAINTENANCE)

1. Total productive maintenance came under considerations because the losses with respect to maintenance came under lime light by observing the table below.
2. Price of the each product is Rs.18,550.
3. The machine cost of HMC is Rs.1,200 / hr.

SR no.	Months	Machine	Crane	Time period of breakdown	Costing as per cost of product	Costing as cost of machine per hrs.	Total loss
1	SEPT 2018	-	HMC CRANE	6 HRS	18550*3= 55650	(1200*6) = 7200	62850
2	OCT 2018	-	-	-	-	-	-
3	NOV 2018	VTM	-	4 SHIFTS	16*18550= 296800	28*1200 = 33600	330400
4	DEC 2018	-	-	-	-	-	-
5	JAN 2019	-	-	-	-	-	-
6	FEB 2019	HMC	-	5 DAYS	45*18550= 834750	105*1200= 126000	960750
Total							1354000

Fig -14: Estimated losses in terms of cost

Guidelines Given To the Industry

1. Electrical and Electronics items, and various mechanical systems in a machine to be serviced at scheduled period in order to avoid the machine breakdown
2. Part to be supplied from the before station to be on time to avoid the productivity loss
3. TPM training to be given to all shop floor employees in order to have zero breakdowns and zero accident
4. Implementation of gauges and measuring instruments to be done in all shop floor area in order to reduce wastages of idle time
5. Crane used to load the product from ground to machine is frequently facing breakdown which needs the preventive maintenance within the span of 3 weeks
6. Machine undergoes maintenance after 6 months as per the data given by company, which is not under proper practice as breakdown causes loss in productivity when machine breakdown in between 6 months.
7. Material transporting machines also need preventive maintenance because their breakdown can lead to external defect.

4.10.3 PNUMATIC WRENCH

1. Project result is to increase OEE of the housing flywheel line.
2. OEE depends upon availability, performance, quality.
3. Scope of work is in the performance area, in which the desired target of the machine is to be increased.
4. For HMC phase 1-11.2 min per job performance should increase.
5. VTM phase 2-12.6 min per job performance should increase.
6. HMC phase 3-4.2 min per job performance should increase.

I) Observations on three machines of time taken for clamping, Declamping, loading and unloading.

SR.NO	MACHINE	BEFORE	AFTER	Time reduced
1	HMC 1stphase	14min	6min	8min
2	VTM 2nd phase	14.48min	7min	7.48min
3	HMC 3rd phase	20.35min	10min	10.35min

Fig -15: Time reduced after using pneumatic wrench

1. Traditional way of tightening and loosening of bolts by using spanner which take very long time for clamping and Declamping.
2. Pneumatic cleaning machine is already available on each machine with 40 psi pressure.
3. Pneumatic wrench of torque range of 30-35 (lbfft) are suggested to assemble (1 lbfft =1.355 NM).
4. Pressure required to give the essential torque is 100 to 110 psi.
5. Cost of pneumatic wrench manufactured by powerhouse company having the optimize cost Rs1300.
6. Required torque is 50-80 Nm.
7. Two units of such pneumatic wrenches are required. Total cost 1300x2=Rs2600.

1. FOR HMC 1ST PHASE (MACHINING COST PER HOUR=Rs1200 per hour)

1. Number of jobs produced per shift=3
2. Time reduced for 1 job =8min
3. Total time reduced in 1 shift=8x3=24min
4. Total time reduced in 1 month=24x26=624min
5. Total time reduced in 1 year= 624x12=7488min (7488/60=124.8 hrs.)
6. Machining cost reduced in 1 year =1200x124.8= **Rs 1, 49,760/-**

2. FOR VTM MACHINE (2nd PHASE) (MACHINING COST PER HOUR=Rs 1250per hour)

1. Number of jobs produced per shift=4
2. Total time reduced in 1 shift=7.48x3=23.24min ≈23min
3. Total time reduced in 1 month=23x26=598min
4. Total time reduced in 1 year= 598x12=7176min (7176/60=119.6hrs)
5. Machining cost reduced in 1 year=1250 x119.6 = **Rs1, 49,500 /-**

3. FOR HMC 3rdPHASE (MACHINING COST PER HOUR=Rs1200 per hour)

1. FOR HMC 3rdPHASE (MACHINING COST PER HOUR=Rs1200 per hour)
2. Time reduced for 1 job =10.35min≈10min
3. Total time reduced in 1 shift=10x3=30min

4. Total time reduced in 1 month=30x30=900min
5. Total time reduced in 1 year= 900x12=10800min (10800/60=180 hrs.)
6. Machining cost reduced in 1 year =1200x180= **Rs 2, 16,000/-**

Total cost=1, 49,760+1, 49,500+2,16,000=**5,15,260 per annum**

4.10.4. Double Pallet System

Fig -16: Double pallet HMC machine

1. Double pallet system which provide 2 set of pallets in which 2 same or different jigs and fixtures setting can be performed.
2. When one of the pallet is under machining side other pallet can be used for loading and and clamping of another product which saves the internal wastages means it reduces machine stop time.
3. When the first product machining is done outside pallet can be moved inside for the machining of the particular product which saves the internal time.

Problem faced by the company

1. Due to lack of double pallet HMC machines in industry, they have settled up jig and fixtures of one product on one pallet and jig and fixture of another different product on 2nd pallet.
2. Due to which if they change the jig and fixtures of housing flywheel they take 5 hrs. again for setting it up on the machine.

Guidelines Given To the Industry

1. To use double pallet system which will increase the availability of the machine.
2. It will decrease the stoppage time of the machine which will increase the productivity of the machine.
3. Finally it will lead to increase in OEE of the machine.

4.10.5. MUDA wastages

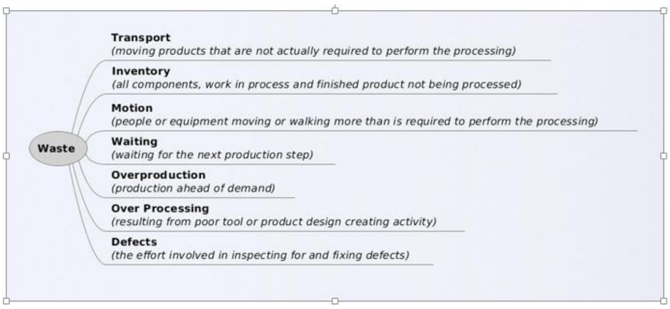


Fig -17:TIMWOOD

The wastages found in the company are in the area of:

1. **Transport**
2. **Inventory**
3. **Waiting**

1)Transportation

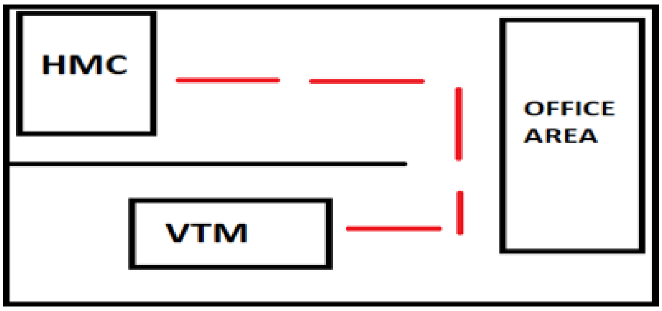


Fig -18: Tentative layout of shop floor of industry

Fig -19: Problems in transportation in HMC area

Fig -20: Problems in transportation in VTM area

Transportation of the product from HMC to VTM requires11.43 min

1. The product from HMC 1st phase unloads on the ground
2. Then the product is lifted up again with help of the crane to keep it on the trolley
3. Due to more inventory and lack of space time is been waste in the transportation
4. Then in front of VTM there is already inventories of another machine which don't allow the trolley to move inside

5. There are two cranes one in front of VTM another common crane to the hall
6. Then the product is lifted by the common crane and kept in front of the VTM
7. Then the crane near VTM lift it up and load it on the machine.

RESULT SUGGESTED

1. Every time a product is touched or moved unnecessarily there is a risk that it could be damaged, lost, delayed, etc. as well as losses in term of cost for no added value.
2. Transportation does not add value to the product, as transformation is not the parameter, for which the consumer is willing to pay.
3. Machines that are involved in manufacturing line should be as close as possible.
4. As the machines are not portable nor they are in practice with the standard layout like C shape, u shape , there will be increase in transportation waste.

2)INVENTORY& MOTION

1. Inventory is one of the seven wastes of lean manufacturing (or 7 MUDAS).
2. Inventory is the raw materials, work in progress (WIP) and finished goods stock that is held, we often hold far more than is required to produce goods.

Fig -21: Inventory of HMC

RESULT SUGGESTED

1. Industry has implemented 5 s 6yrs back , but is that tool which need continuous improvement in the process.
2. It was suggested to clear the area which was marked for transportation where the inventory was placed earlier.
3. Because of this the transportation time has reduced 4.34 min till VTM.

Fig -22: After suggestion inventory was reduced

4.11. CONCLUSIONS

4.11.1. SMED

1. As per suggestion industry supervisor and engineer are taking training from a lean manufacturing trainer with PHD in lean manufacturing and experience in implementation of SMED.
2. He takes training during Saturday and Sunday 9 to 3 and 2 to 5 respectively.
3. By giving training regarding SMED will surely decrease the setup time to single minute.

4.11.2TPM

1. Instead of 6 month, the inspection and preventive maintenance time should be reduce to 3 month.
2. Extra amount of 40,000 will be credited to the maintenance company but losses in revenue will decreased in GMT which will increase the profit of the company.
3. Preventive maintenance and inspection of crane should be done with span of 3 weeks to reduce loses in revenue as crane are very important for lifting because the product weighs 178 kg.
4. Product Transportation mobile also require proper maintenance because breakdown of them can cause accidents and rejection of the product.

4.11.3Pneumatic wrench

Total cost=1, 49,760+1, 49,500+2,16,000=5,15,260 per annum

4.11.4Double Pallet System

1. To use double pallet system which will increase the availability of the machine.
2. It will decrease the stoppage time of the machine which will increase the productivity of the machine.

3. Finally it will lead to increase in OEE of the machine.

4.11.5MUDA

1. Industry has implemented 5s 6yrs back, but that is tool which need continuous improvement in the process.
2. It was suggested to clear the area which was marked for transportation because of 5s implementation where the inventory was placed earlier.
3. Because of this the transportation time has reduced 4.34 min till VTM.

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