TEST Engineering & Management

July –August 2020

ISSN: 0193-4120 Page No. 2887 – 2897

Energy Consumption Optimization based on Six Sigma tool (Damic) and Energy Value Stream Mapping

NehaVerma, Vinay Sharma
Asst.Prof, Department of Mechanical Engg. SSIPMT Raipur
n.verma@ssipmt.com,
Professor, Department of Production Engg, BIT, Mesra (Ranchi)-835215, India

Article Info
Volume 83
Page Number: 2887 – 2897
Publication Issue:
July-August 2020

Article History
Article Received:*06 June 2020*
Revised: *29 June 2020*
Accepted: *14 July 2020*
Publication: *25 July 2020*

Abstract:
Lean management and Six Sigma are two concepts which share similar methodologies and tools. Six Sigma (6σ) is a set of techniques and tools for process improvement. It seeks to improve the quality of the output of a process by identifying and removing the causes of defects and minimizing variability in manufacturing and business processes. Lean management is an approach to running an organization that supports the concept of continuous improvement, a long-term approach to work that systematically seeks to achieve small, incremental changes in processes in order to improve efficiency and quality**.** Energy value stream mapping is a lean management tool that seeks to identify and eliminate cause of errors or defects in manufacturing process by focusing on outputs that are critical to customers. In this Paper will carry out a case study on a small-scale industry, XYZ where we have used the methodology of DMAIC of six sigma along with energy value stream mapping to study the value added and non-value added consumption of energy in that industry.
Keywords:*Six Sigma, Energy value stream mapping.*

INTRODUCTION

The manufacturing industries in India are one of the top consumers of energies, which consumes one-third of the total energy demand of the nation. Out of the total consumption of electricity, according to the data collected till 2014-2015, the industrial sector accounted for the largest share of 44.11% and of the total consumption of electricity in 2015-16, the industry sector accounted for the largest share of 42.30%.(Behera, 2015)The electricity consumption in the Industry sector has increased at a much faster pace compared to other sectors during 2006-07 to 2015-16 with CAGRs of 9.47% and 7.97% respectively. The graph below represents the electrical energy consumption in industries. The abscissa axis represents the year and the ordinate axis represents electrical energy consumed in Giga watt-hour.

July –August 2020

ISSN: 0193-4120 Page No. 2887 – 2897

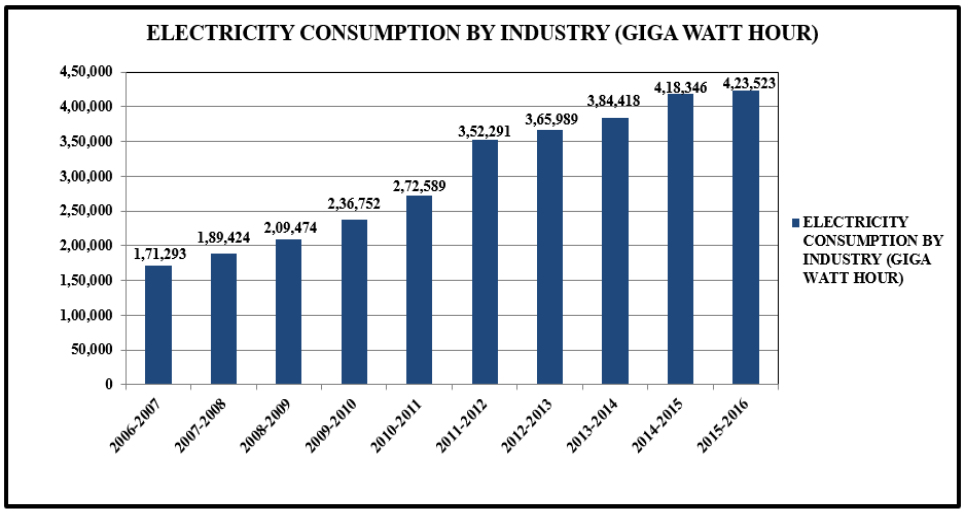


Figure.1Electricity consumption by industry in India(Behera, 2015).

This increase in energy consumptions can be addressed by using tools of lean and six-sigma. Lean management and Six Sigma are two concepts which share similar methodologies and tools, but they are different in many aspects. Lean management is focused on eliminating waste and ensuring efficiency while Six Sigma focuses on eliminating defects and reducing variability. Six Sigma improves the quality of a process output by identifying and removing the causes of defects with minimization of variability in manufacturing and business processes. It uses a set of quality management methods mainly empirical, statistical and creates a special infrastructure of people within the organization who have expertise in these methods(Soni Shashank, Mohan Ravindra, Bajpai Lokesh, 2013).Each Six Sigma project carried out within an organization follows a well-defined sequence of steps and has a specified value target. For example: To reduce process cycle time, pollution, costs and increases customer satisfaction and profits.

Processlayout

There are two process layouts, one for manufacturing of plate and other to manufacture angles and cleats.

July –August 2020

ISSN: 0193-4120 Page No. 2887 – 2897

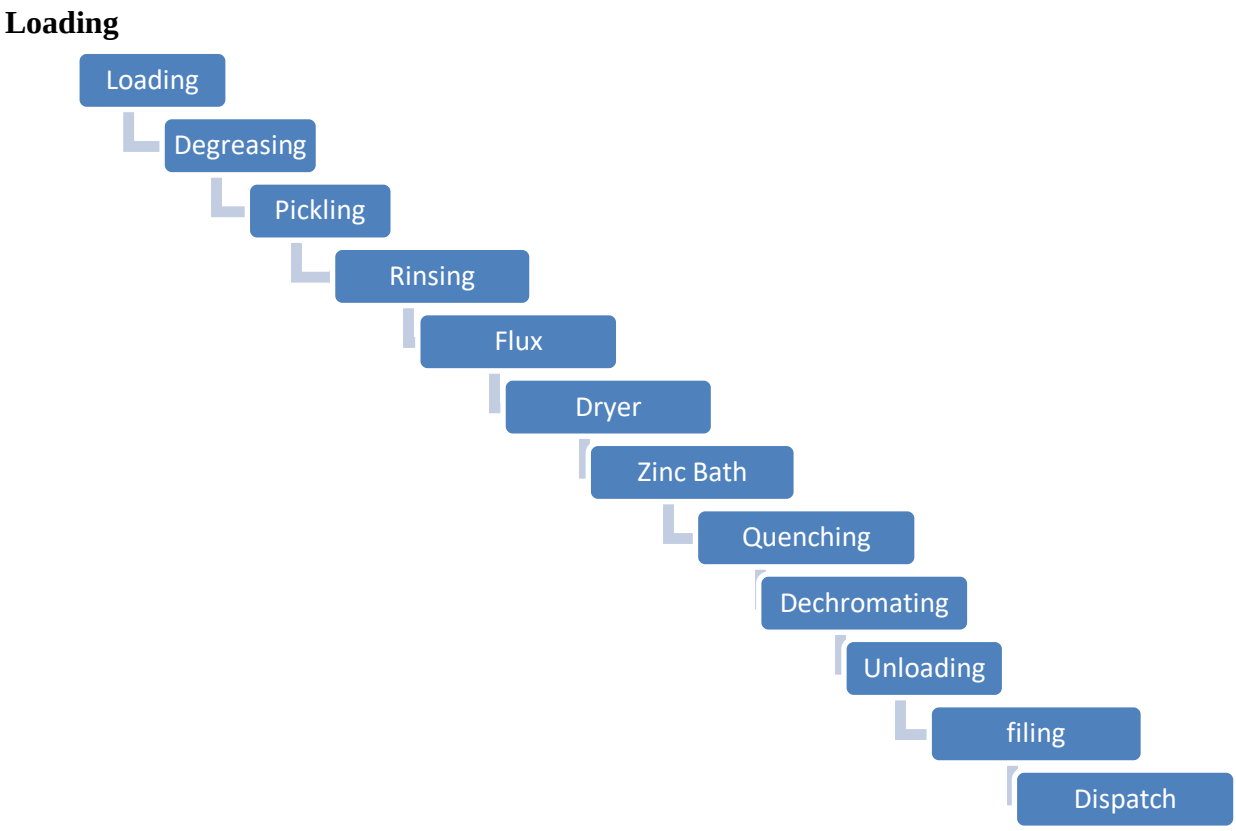


Figure.2 Step of operation

METHODOLOGY-

Value stream mapping is one of the most effective tools to identify the wastage in any system. In the present investigation, the researcher has modified the VSM to EVSM (Energy Value Stream Mapping) by adding energy components in it and analyzing the same with respect to time. The EVSMidentifies the level of energy utilization and wastage in each step hence determines the opportunities for energy conservations. The suggested model can be used not only for diagnostic purposes but also for energy budgeting and saving measures. The EVSM is integrated with the tools of six-sigma to the system robust with respect to energy conservation.

Implementation of lean-six-sigma for process optimization.

The six-sigma project starts with the identification of CTQ (critical to quality). In the present case, the CTQ is to minimize the energy conservation in the existing system. The tools used for the DMAIC in the selected process flow

Define

The first step is to define the CTQ and the CTQ is to identify and eliminate the energy-consuming steps. To identify the CTQ six-sigma tool SIPOC (suppliers, inputs, process, outputs, and customer) is used. Thisis a visual tool for documenting processes in any organization from start to end. SIPOC diagram is used to identify all the elements of a process for improvement of the project even before work begins.

July –August 2020

ISSN: 0193-4120 Page No. 2887 – 2897

SIPOC helps to define a complex project that may not be well assessed and is typically employed in the Measure phase of the Six Sigma DMAIC methodology.

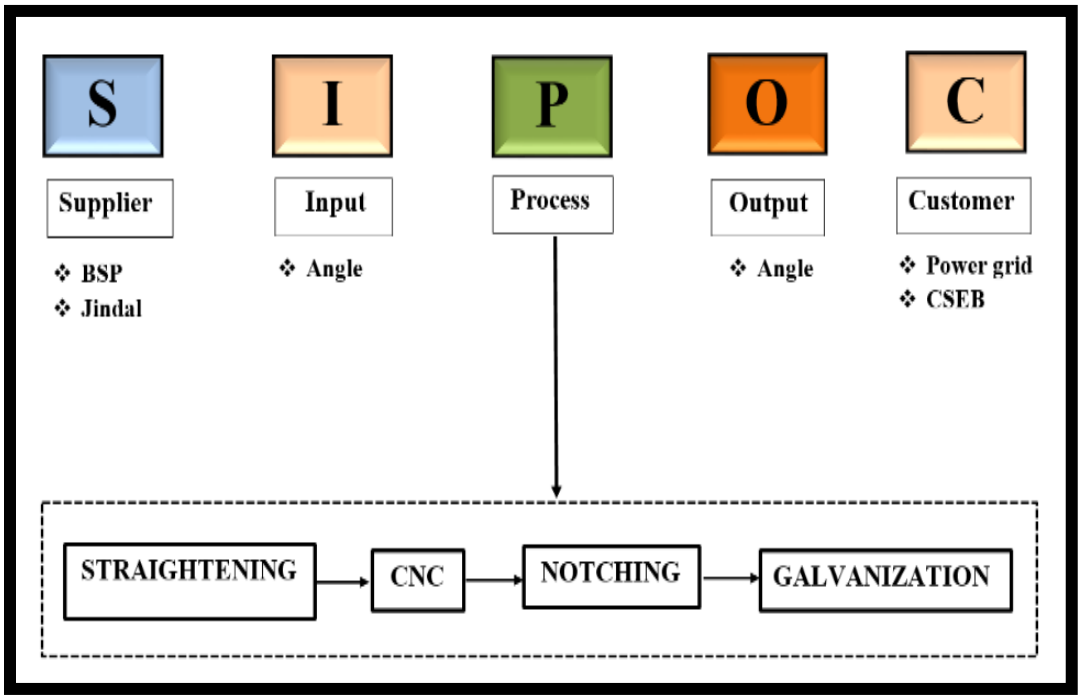


Figure.3SIPOC Diagram

Measure

EVSM is an effective tool to measure the amount of energy wasted in each process. The process starts with identifying the chronological order of the processes involved and other relevant information's

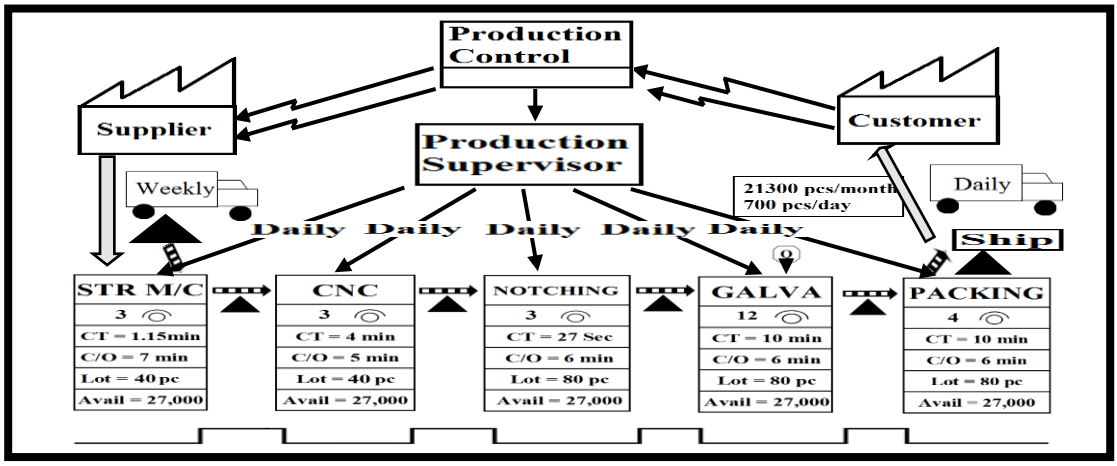


Figure.4Information flow value stream mapping

TEST Engineering & Management

July –August 2020

ISSN: 0193-4120 Page No. 2887 – 2897

Create Energy Value Stream Mapping

The energy consumption for each value-added and non-value-added activitiesis made based on energy consumed for each process according to days, month and year.

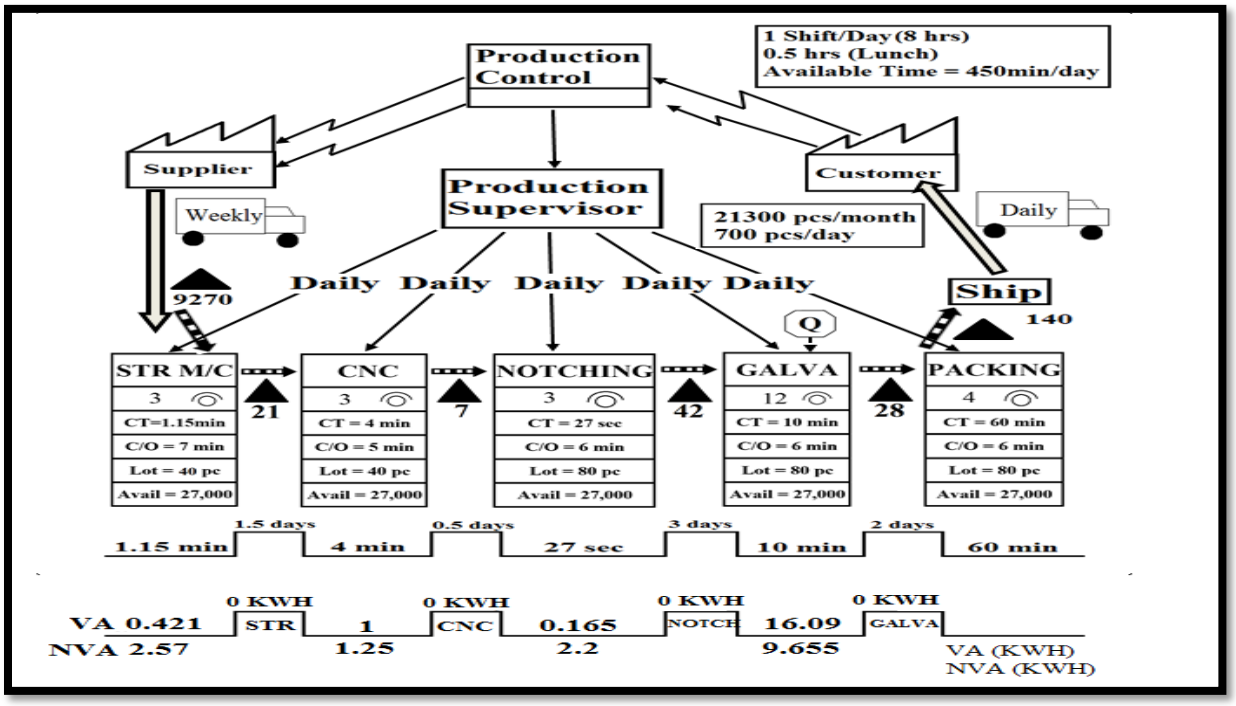


Figure.5 Energy value stream mapping

CNC	Notching	Process/Data	Straightening	Galvanization
15	22	Energy (KW)	22	96.55
4 min.	27 sec.	C/T	1.15 min.	10 min.
5 min.	6 min.	C/O	7 min.	6 min.

From the EVSM the data collected are Table.

TEST Engineering & Management

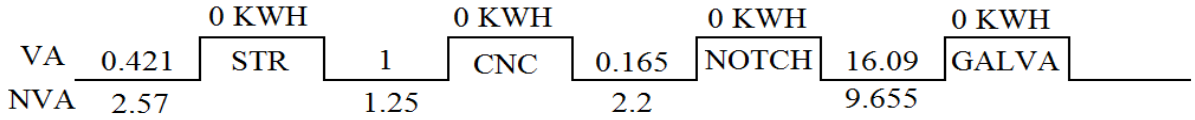
July –August 2020

ISSN: 0193-4120 Page No. 2887 – 2897

Energy Calculation for different processesis shown in Table.2

Process / Energy	Straightening	CNC	Notching	Galvanization
EVA (C/T)	$22\times\frac{1.15}{60}$ = **0.421KWH**	$15\times\frac{4}{60}$ = **1KWH**	$22\times\frac{27}{3600}$ = **0.165KWH**	$96.55\times\frac{10}{60}$ = **16.09KWH**
ENVA (C/O)	$22\times\frac{7}{60}$ = **2.57KWH**	$15\times\frac{5}{60}$ = **1.25KWH**	$22\times\frac{6}{60}$ = **2.2KWH**	$96.55\times\frac{6}{60}$ = **9.655KWH**

Timeline Diagram:



Calculation of energy consumption by value added (EVA)& non-value-added activity (ENVA):

EVA = 17.677 kWh

ENVA = 15.672 kWh

Time Study

Time Study For CNC (CNCVP-942) shown in Table.3

S.No	Cycle	Start Time	End Time	Total Time	Remark
1.	CYCLE 1	02:36:00	02:40:00	00:04:00	6 min loss for checking machine setup
2.	CYCLE 2	02:41:00	02:45:00	00:04:00	35 sec loss for changing the punching pin
3.	CYCLE 3	02:45:00	02:49:00	00:04:00	
4.	CYCLE 4	02:56:00	02:59:00	00:03:00	
5.	CYCLE 5	03:02:00	03:05:00	00:03:00	

TEST Engineering & Management

July –August 2020

ISSN: 0193-4120 Page No. 2887 – 2897

The time of each operation is calculated with the help of a stopwatch.First, we perform all the operations with the help of a stopwatch. We calculate the cycle time from start to end. We start our stopwatch, when the bar is loaded on the machine then the bar is going for further process like stamping, punching, and cutting. After this the bar unloaded by one worker then we stop the time and take the reading of 1 cycle. The further process will continue about 5 to 6 cycle for obtaining the average time for 1 bar in a lot. So we can easily conclude the actual time for the whole lot will complete.

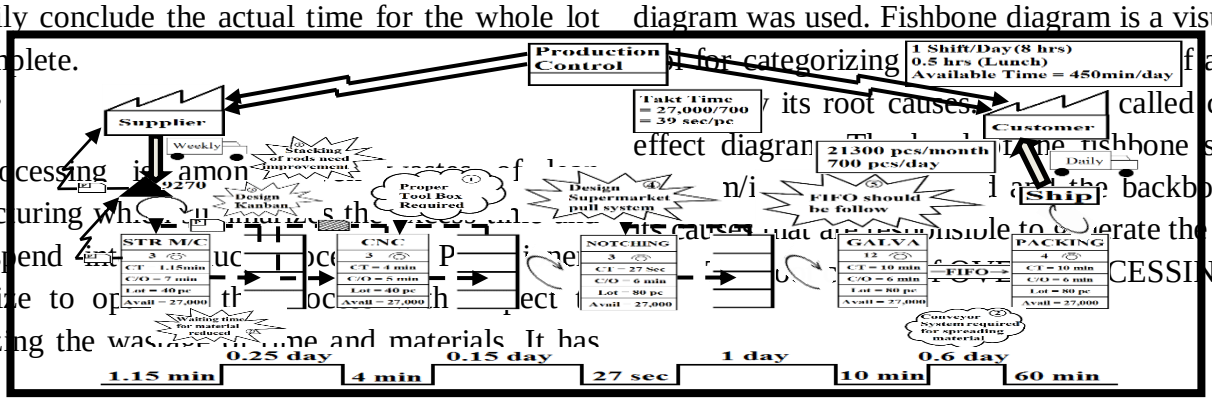
Analyze

Over-processing is amon[illegible] manufacturing wh[illegible] effort spend [illegible] emphasize to op[illegible] minimizing the wa[illegible] been identified that the main problem occurred in Galvanizing Section i.e. "Over-processing". Galvanizingis a process of applying a protective Zinc coating to Steel or Iron, against rusting. Fishbone diagram is consisting of 4M (Man, Machine, Material, Method)

Head ⟶ Problem (Over Processing in Galvanization Process)

Backbone ⟶ Causes of Problem

For identifying the cause of problems, the fishbone diagram was used. Fishbone diagram is a visualization [illegible] for categorizing [illegible] a problem its root causes. [illegible] called cause and effect diagram. [illegible] The fishbone shows the [illegible] and the backbone shows the causes that are responsible to [illegible] CESSING are:



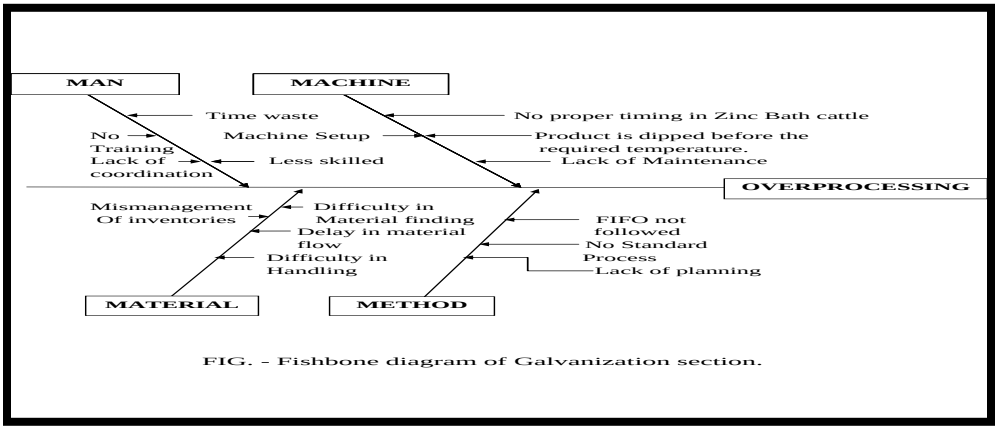


FIG. - Fishbone diagram of Galvanization section.

Figure.6 Fishbone Diagram

Improvement

Future State MapA future state map bridges the gap between current and ideal state. It highlights the

TEST Engineering & Management

July –August 2020

ISSN: 0193-4120 Page No. 2887 – 2897

realities of technical limits, budgets and time. The purpose of value stream mapping is to highlight sources of waste and to eliminate them and implementation of the future state value stream to make it feasible. Symbol used in future VSM .The main aim of the future state map is to build a chain of production where the individual processes are linked to their customers either by continuous flow or pull and each process gets as close as possible to produce what and when a customer needs the product.

Figure.7 Symbols used in future state map

Analysis of Future State Map

- The process steps are the various operations that are performed on the product, during its conversion from inbound inventory to outbound logistics. A production Kanban is applied between these two stages to ensure an uninterrupted and intimesupply of raw materials. FVSM .

- The production Kanban and material pull system is applied between the inventory and process line. The material pull system helps to reducein-process inventory and maintain the smooth flow of material.

- Between Straightening and CNC, a supermarket is introduced. Between supermarket and straightening, a production Kanban is used & between CNC and supermarket, a withdrawal Kanban is used. This production Kanbanwill give the information about the product requirement of the CNC while the withdrawal Kanban will give the information of the products that have been withdrawn from the supermarket to ensure the flow of material without interruption.

- Between CNC and notching, supermarket and material pull system is applied. The supermarket indicates the management of inventory in which various parts can be kept without knowing in what order the parts will be taken from the inventory and the pull symbol represents physical removal of stored inventory from supermarkets.

- Notching is followed by the galvanization process. Between notching and galvanization, supermarket and material pull system is being

TEST Engineering & Management

July –August 2020

ISSN: 0193-4120 Page No. 2887 – 2897

used. The quality problem symbol indicates a quality problem in the galvanization process. In order to limit the inventory input, the FIFO symbol which indicates first in first out system is applied between galvanization and packing. Pullover is performed between packing and shipping to ensure the outlet of the product as soon as its production is completed.

- ***Control***

The main objective of the control phase is to improve the current process or product performance to ensure the targets are achieved.Here how these improvementscontrol the problems between the different processes:

1. **Control of excess inventories between the two workstations: -**

"Supermarket symbol" is introduced between two workstations. This supermarket indicates the management of inventory between the two workstations in which various parts can be kept without knowing in what order the parts will be taken from the inventory.

- "Production Kanban" & "withdrawal Kanban" is used. This production Kanban will give the information about the product requirement of the CNC & ensure the flow of material at the time of requirement without delay. Withdrawal Kanban will leave the information of the products that have been withdrawn from the supermarket. This is to ensure the flow of material without interruption.

Result and Discussion -

After drawing the current state value stream map and analyzing it, a future state map has been drawn and after applying all the improvements, it has been found that there is a reduction in the delay time between various operations. Shown in

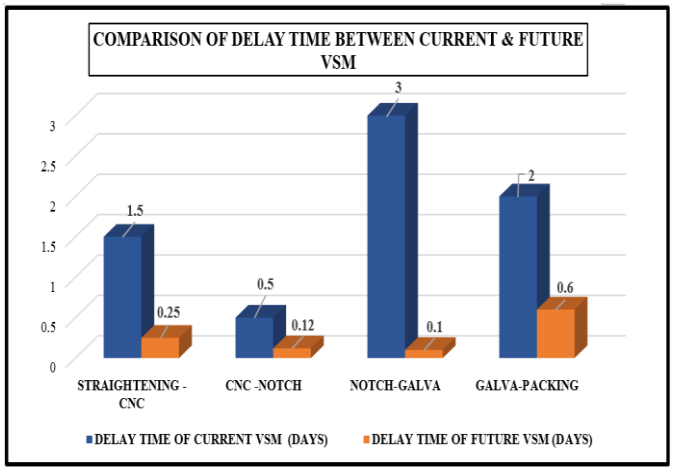


Figure.9 Comparison of delay time between current state & future state value stream map

In energy calculation by value-added and non-value-added activity, it has been found that 17.677kWh energy is value-added and 15.672kWh energy in non-value added.shows the comparison of delay time between the current state and future state value stream mapping

Find out the bottleneck station

The graph below shows the bottleneck in the process line. The graph of various operations and their cycle time has been plotted. A dotted line represents the takt time. Takt time is the maximum amount of time in which a product needs to be produced in order to meet customer demand. From the graph below It has been observed that the maximum deviation from the takt time is shown in the galvanization operation. Hence, the bottleneck occurs in the galvanization process.

$$\text{Takt Time} = \frac{Available\ working\ time\ per\ shift}{Customer\ demand\ rate\ per\ shft}$$

July –August 2020

ISSN: 0193-4120 Page No. 2887 – 2897

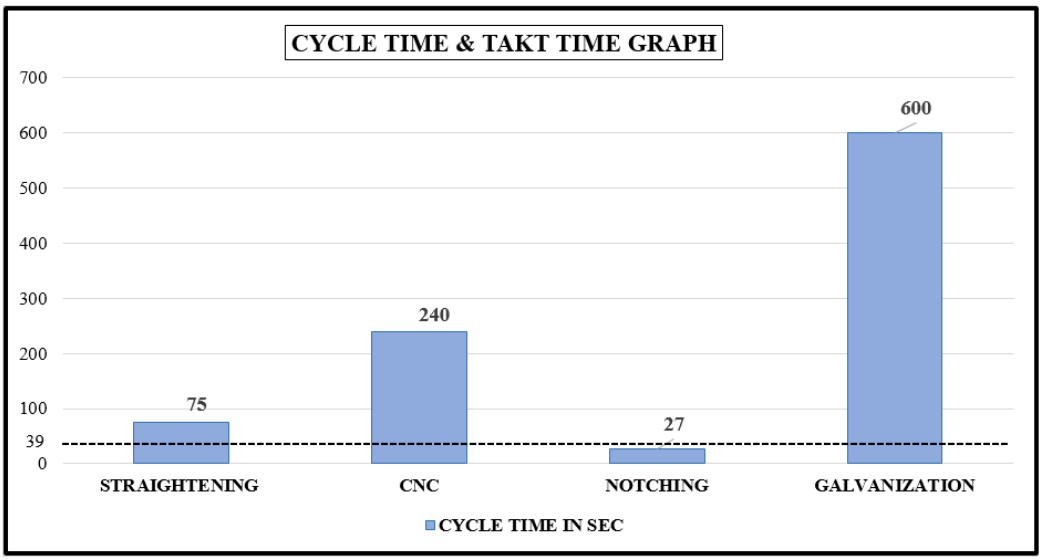


Figure.10 Cycle time &Takt time

CONCLUSION

In the case study Large scale industry XYZ Six Sigma methodology has been implemented along with energy value stream mapping to calculate rejection & rework with value-added and non-value-added energy in the overall process line. In this value stream map, the following processes have been considered: straightening, CNC, notching, and galvanization. After plotting current and future state value stream map, there is a reduction in delay time between stations. Also, it has pointed out the problem of over-processing, while solved the stacking problem existed in the inventory. The method that has been applied is the FIFO method, i.e. first in first out method to maintain the material flow in the industry. The detailed improvements are indicated in the form of kaizen in the future state map.

References

1. Valles A.,Sanchezs J., Noriega S., Nunez B.(2009). Implementation of Six Sigma in a manufacturing process, International Journal of Industrial Engineering.
2. Neha. V, Vinay. S “A Literature Review on Energy Value Stream Mapping (EVSM)” International Journal of Advanced Science and Technology Vol. 27, No.1, (2019, pp. 01-08, ISSN: 2005-4238,SERSC Publication.
3. Sihag A., Kumar V., khod U.,(2014). Application of Value Stream Mapping in small scale industry, International Journal of Mechanical Engineering and Robotics Research.
4. Kane J., Dupont E.I., (2003). Using Six Sigma to Drive Energy Efficiency Improvements at DuPont. Conference.
5. Kaushik P., Khanduja D., (2007). DM Make Up Water Reduction in Thermal Power Plants Using Six Sigma DMAIC Methodology, Journal of Science and Industrial Research.
6. Kaushik P., Grewal C., Bilga P., Khanduja D., (2008). Utilising Six Sigma for energy

July –August 2020

ISSN: 0193-4120 Page No. 2887 – 2897

conservation: a process industry case study, International Journal of six sigma of competitive Advantage.

7. Gahlot P., (2013). Energy Management Through Six Sigma: A Case Study Journal of Information, Knowledge and Research in Mechanical Engineering.
8. Lee J., Yuvamitra K., Guiberteau K., Kozman T., (2014). Six Sigma Approach to Energy Management planning, Strategic Planning for the Energy and Environment, Association of Energy Engineers.
9. N. Verma ,V. Sharma "Sustainable Competitive Advantage by Implementing Lean Manufacturing-A Case Study for Indian SME" Available Online At Www.Sciencedirect.Com, Materials Today: Proceedings 4 (2017) 9210–9217 Www.Materialstoday.Com/Proceedings ICAAMM-2016
10. Baswaraj A., Rao M., Kumar A., (2015). Energy consumption Optimization for Secondary Steel by Six Sigma, International Journal of Modern Trends in Engineering and Research.
11. Verma N., Sharma V., (2016). Energy Value Stream Mapping a Tool to Develop Green Manufacturing, Elsevier Limited.
12. Kaushik p., Mittal K., Rana P., (2016). Energy Paybacks of Six Sigma: A Case Study of Manufacturing Industry in India, Growing Science Limited.
13. Sharma S., Singh H., (2016). Energy Saving Using DMAIC Approach in Milk Plant: A Case Study, International Journal of Engineering and Technology.
14. N. Verma, V. Sharma "An experimental research in sustainability analysis in industries based on lean green and six sigma using AHP and Fuzzy AHP" International journal of innovative technology and exploring engineering ,ISSN 2278-3075 ,Volume-8,Issue -8S3, June2019