Reducing Throughput Time through Implementation of VSM in SEM- A Case Study

R. Duraisamy*[1], C. Dhanasekaran[2], P.R. Ramakrishnan[3], Pugazhenthi. R[4]

[1] *Research Scholar, VISTAS, Chennai, India*

[2] *Professor, Department of Mechanical Engineering, VISTAS, Chennai, India*

[3] *Professor & Dean - School of Management & Commerce, VISTAS, Chennai, India*

[4] *Associate Professor, Department of Mechanical Engineering, VISTAS, Chennai, India*

Abstract:

Customers of any business need Higher Quality, Lower Cost and Fast Delivery of products or services. These expectations are increasing faster than time. Any organization should meet out these demands to survive and grow. While meetings customer's needs, the organization should take care of other stake holders in terms of making surplus profits. To achieve these conflicting and difficult objectives, organizations must become flexible, able to serve fast, need to find new ways to reduce the manufacturing lead times. These can be achieved by eliminating waste in the whole value stream and by reducing throughput time. This case study is regarding reduction of throughput time through Value Stream Mapping (VSM). VSM was done in a manufacturing SME located in Tamil Nadu, India. Along with VSM, other new methods like TIMWOOD matrix, SWCT etc has been introduced. This case study proved successful implementation of lean manufacturing with excellent results.

Keywords: *Lean Manufacturing, throughput time, TAKT time, cycle time, bottleneck, VSM, SWCT, Man-machine balance, TIMWOOD Matrix.*

1. INTRODUCTION

VSM helps in reducing manufacturing and overhead costs, deliver products in less time, free up capital through reduction in inventories, improve labor productivity, improve quality, reduce the cost of poor quality, and reduce time-to-market. VSM is a way to visualise a product´s flow from the beginning to the end, and draw a map of every process of both the information and material flow in one map. When a current state map is done, come up with improvements and draw a future state map. Create an action list where the improvements and responsibilities are defined. Implement improvements by using PDCA

VSM is a tool for Improvement, allows you to see what is actually happening, gives everyone a clear picture of where Waste (Muda) is in the organization and it is useful to highlight cost savings, inventory reductions to help justify investment. To analyze a process in the company to make it more efficient by eliminating waste. VSM is to find problems and make Kaizens. VSM is a Lean Manufacturing technique used to analyze and improve the flow of Materials & Information.

Wastes in manufacturing environment are classified in to 7 Categories which are called as 7 Wastes. These are Transportation, Inventory, Motion, Waiting, Over Production, Over Processing and Defect (TIMWOOD). Among the 7 wastes, "Overproduction" is a deadliest waste, since this will result in other 6 types of wastes. VSM is used to

reduce cycle time, change over time, lead-time, identify bottlenecks, determining capacity and to make decision in process flow. It scrutinizes business processes from beginning to end. It exposes process inefficiencies, transactional and communication mismatches. A shortened lead-time means less inventory in the system -- fewer inventories equates to increased flexibility and decreased obsolescence. Shorter lead times increase the number of inventory turns.

2. LITERATURE REVIEW:

[Amir Azizia et al] did a case study to reduce the total lead time (LT) through eliminating non-value added activities. They examined how VSM improves the quality of production line and reduce production cost and manufacturing LT. [S.Mahendran et al] applied MATLAB simulation software to calculate the reduction in lead time, NVAs and distance travelled. [S Hartini et al] proposed sustainable VSM indicator includes economic, environmental, and social dimensions. [A.Mohammed Faisal et al] presented the case study of the goods manufacturing company regarding reducing waiting time.

[Dushyanth Kumar KR et al] conducted a case study of VSM in a pump manufacturing industry and shown the benefits comparing CVSM and FVSM. [Laila Driouach et al] conducted a detailed literature review to study the progress of Lean Manufacturing at SMEs worldwide. [Hariram VR et al] presented a case study on implementing VSM in SMEs with success indicators. [Pranav Seth et al] carried out re-engineering improvements in garments industry using VSM. They were able to reduce the overall lead-time substantially. [Mastan Singh et al] presented a case study regarding VSM implementation in a fastener industry. [Arvind Kumar Shrimali et al] explored the most common and easily implementable nine most common Lean Tools/Techniques in Indian SMEs. [Sunil Kumar et al] presents implementation of Lean-Kaizen concept in a small- and medium-scale enterprise (SME). They performed two Lean- Kaizen events towards takt time based line balancing and to reduce rejection and rework through implementing Poka-Yoke.

[Hemant H Kore et al] have done a Systematic Literature Research (LSR) by adopting PDCP and PDCA approaches. They had reviewed the depth and effect of LMS in Indian MSMEs. They captured the need for LM practices and its advantages with critical lean barriers. They have also reported the Government of India (GOI) measures to promote LMS. [Abdullah Alkhoraif et al] attempted for identifying the main challenges faced by SME through Systematic Review Methodology. [Kanda Boonsthonsatit et al] carried out a case study on lean supply chain management (LSCM) of the automotive industry in Thailand. Shorter lead time contributes to higher flexibility, lower cost, higher profit, and better competitiveness. [Dorota Klimecka-Tatara et al] presented the results of the vale stream mapping analysis supported by the OEE (Overall Equipment Effectiveness). It was found that the partial digitization of the one production operations in SMEs has a positive effect on the course of the process. [Putri Citra Marifa et al] used VSM method to evaluate production wastes at a batik SMEs in Indonesia to create competitive advantage and done Process improvement to reduce the highest waste, defect, using quality filter mapping (QFM) and VALSAT. [Salman Ahmed Hashmi et al] used this technique to optimize and identify the bottlenecks in a development of R&D prototyping and reduced their time to market. [Rushil Batra et al] attempted to investigate the significance of VSM in the lean transformation in a tool room. Jishuken (self-learning) activities have been designed.

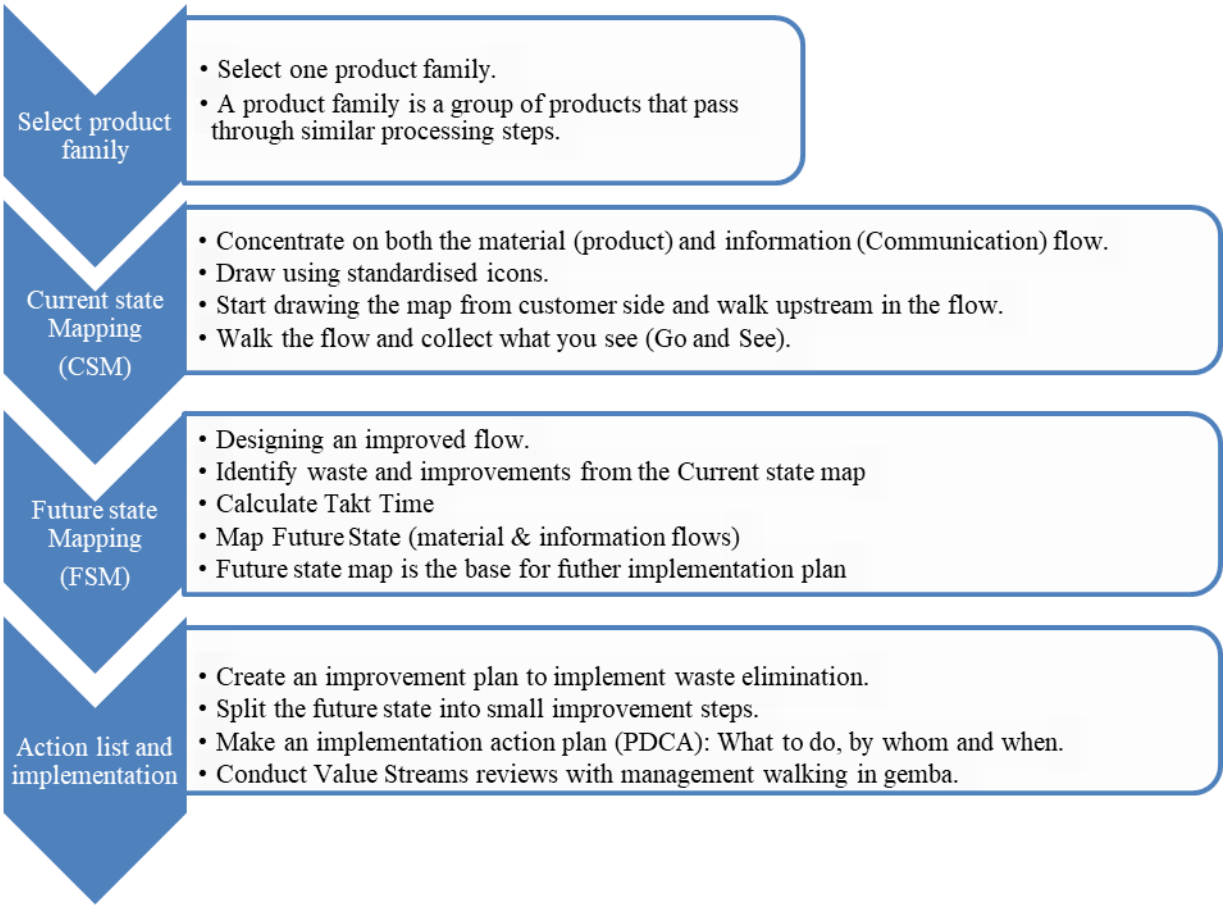
3. RESEARCH OBJECTIVES:

To deploy the powerful lean tool VSM in a SME,

- To reduce the throughput time.
- To balance the flow for capacity increase
- To improve 4M (Man, Machine, Materials and Method) productivity.

4. METHODOLOGY ADAPTED:

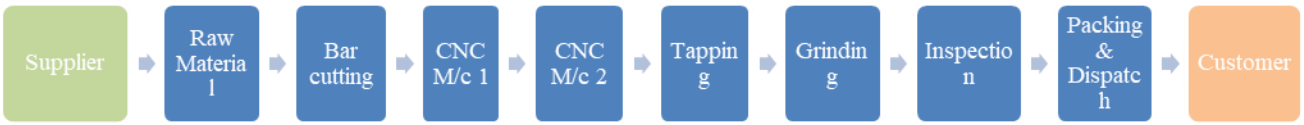
VSM execution is more of a practical, pictorial and Gemba (workplace) oriented technique. Following are the four major steps in making VSM until implementation.



The first step in the VSM methodology is selecting the product family by making product vs. process matrix. In our case study, being a SME and also only this family of products are produced in the organization, we have selected this product flow as it is for current state mapping.

5. MAPPING THE CURRENT STATE:

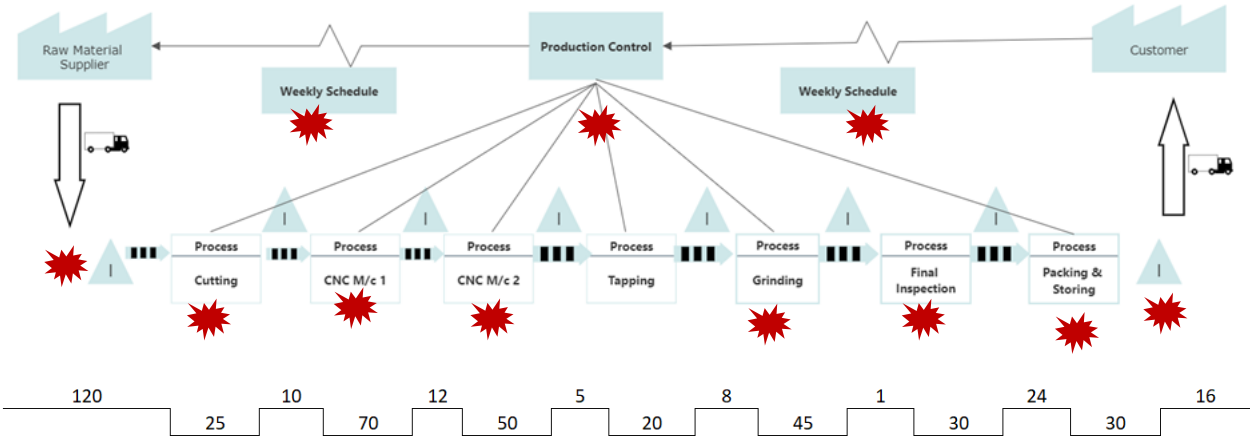
SCOPE OF VALUE STREAM (SUPPLIER – COMPANY – CUSTOMER):



Scientific approach behind the type of data collected

- The Start time, End time and Time taken for each Process must be noted down.
- Each Stage / Process must be recorded thrice to calculate the Average time taken.
- Time taken for value added and non-value added activity must be recorded separately.
- Enter the calculated and recorded values in their appropriate places in CVSM
- Map the Data using Standard symbols used in VSM

Current State Value Stream Mapping (CVSM):



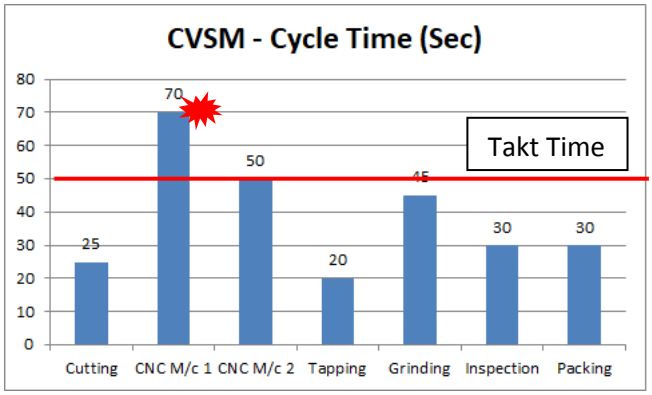
Kai-Zen Burst

	Cutting	CNC M/c 1	CNC M/c 2	Tapping	Grinding	Inspection	Packing
Cycle Time (Sec)	25	70	50	20	45	30	30
Set up Time (Mins)	25	80	70	20	120	0	20
Availability (%)	79	80	75	90	70	100	100
No of worker	1	1	1	1	1	1	1

$$\frac{\text{Total VA Time (Secs)}}{\text{Total Lead Time (Secs)}} = \frac{270}{705870}$$

$$\text{Value Add Ratio} = 0.038\%$$

Sl No	Metrics	UOM	C-VSM
1	Value Added Time (Cycle Time)	Sec	270
2	Non-VA	Sec	705600
3	Total Lead Time	Sec	705870
4	VA Ratio	%	0.038%
5	No of Workmen	Nos	7
6	Line capacity	Nos	656



- Bottlenecks are identified with Kaizen burst indicator.
- The Process with Highest cycle time (i.e. CNC M/c 1) is taken for further analysis and improvement.

TIMWOOD MATRIX

Process	Transport	Inventory	Motion	Waiting	Over Production	Over Processing	Defect
Transportation from Supplier	YES	YES	YES	YES	NA	NA	NA
Storage	YES	YES	YES	YES	YES	YES	YES
Cutting	YES	YES	YES	YES	YES	YES	YES
CNC M/c 1	YES	YES	YES	YES	NO	YES	YES
CNC M/c 2	YES	YES	YES	YES	NO	YES	YES
Tapping	YES	YES	YES	YES	N0	YES	YES
Grinding	YES	YES	YES	YES	N0	YES	YES
Inspection	YES	YES	YES	YES	NO	YES	YES
Packing & Storage	YES	YES	YES	YES	YES	YES	YES
Transportation to Customer	YES	YES	YES	YES	NA	NA	NA

The 'YES' in the matrix indicates that there is waste present in the value stream. We use the improvement methodology Eliminate, Combine, Rearrange, Simplify (ECRS) through Kaizen. Kai-Zen is continual improvement process.

We may not be able to eliminate all the waste from the value stream. In fact, certain wastes are necessary wastes for time being. Customers may not be willing to pay for certain business processes what the organization does (example: employees' welfare, incidental processes, statutory expenses etc.). But the organization has to do it. Such wastes are classified in to unavoidable waste or Business Value Add (BVA). Hence,

Business Process = Value Add (VA) + Non-Value Add (NVA) + Business Value Add (BVA)

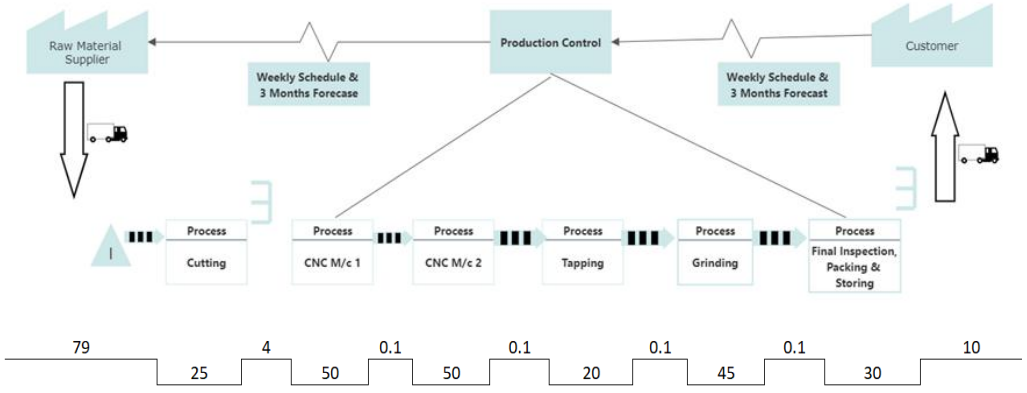
6. FUTURE STATE MAPPING (FVSM):

Selection of appropriate lean Tools and Techniques (T&T):

1. CVSM, FVSM
2. SMED
3. Inventory Management (PULL System)
4. ECRS (Eliminate, Combine, Rearrange, Simplify)
5. Gemba / Gembutsu
6. KAIZEN
7. Line Balancing to Takt time
8. Man-Machine Balance Chart (Standard Work Combination Table (SWCT))
9. Micro Motion Studies of CNC Tool Path, Optimization of Cutting tools and cutting parameters
10. Why-Why Not? Technique

Every activity in the CVSM was critically studied by applying ideation techniques like Why?-Why not? In this process, we don't accept status quo. We ask Why?. If needed, multiple Why?s. To create alternate solutions, we make the team to think by asking Why not? For example if the material supply frequency is 2 times a week, we ask why not once? Why not thrice?

Future State Value Stream Mapping (FVSM):



	Cutting	CNC M/c 1	CNC M/c 2	Tapping	Grinding	Inspection & Packing
Cycle Time (Sec)	25	50	50	20	45	30
Set up Time (Mins)	10	20	20	10	30	0
Availability (%)	90	90	90	90	90	100
No of worker	0.5	1			1	

Calculation of Takt Time:

Takt time = Available time per day / customer demand per day.

In our case, the available time per day was 45900 Sec and the customer demand was 918 Nos per day.

Hence Takt time = 45900/918 = 50 Secs.

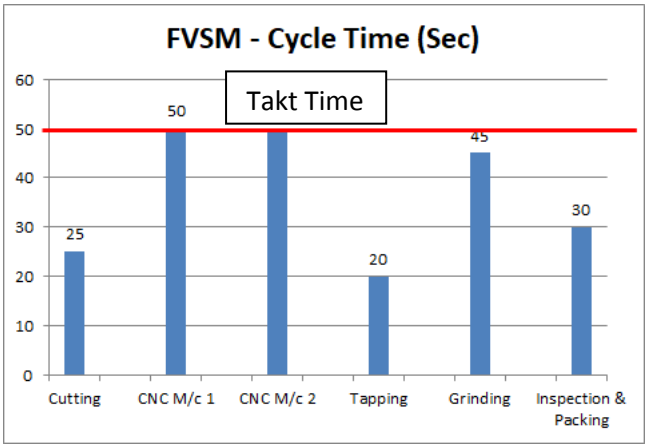
Identification of Bottleneck Process (Constraining Capacity):

While drawing the Takt time line in the bar graph, it was visible that the cycle time of CNC M/c 1 was 70 Seconds whereas the takt is only 50 Secs. That means CNC M/c 1 is the bottleneck process and the cycle time has to brought down in line with Takt time. Videography and Tool wise Micro motion studies were carried out. Cutting parameters, Cutting tools, Tool path were optimized to bring the cycle time to 50 Secs.

Action list and implementation:

The 4th step in our methodology is preparing action list and implementation. A detailed action plan was prepared in the methodology of 3W1H (What?, When?, Who? and How?). Every action was meticulously implemented. Daily reviews were conducted in line with P-D-C-A (PLAN-DO-CHECK-ACT) method. Employees have shown exemplary interest in trying out new ideas and implementing it encountering the initial teething issues. So we could implement the major improvements first and rest of the improvement is ongoing.

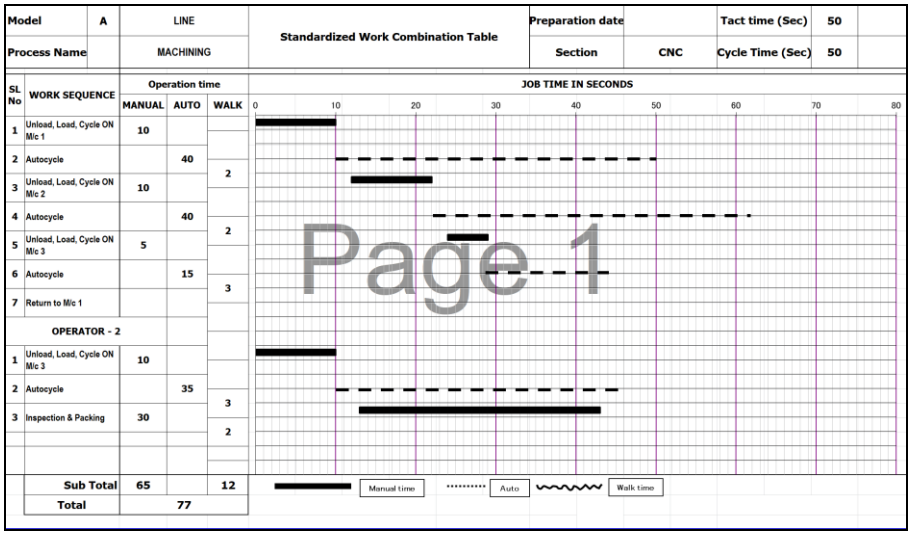
The below chart shows the cycle time of each processes after “debottlenecking” the CNC M/c 1 process. Just by reducing the cycle time of one process, the overall system capacity is enhanced to



Standard Work Combination Table (SWCT):

This is one of the marvelous tool to analyze the balance between Manual work and Auto cycle time in a pictorial format. This is also called as Man-Machine balance chart. In many manufacturing situations, either the operator will be waiting for the machine or the machine will be waiting for the operator. The basic idea is to engage the operator as long as the machine is running.

By using this tolls SWCT, we could make one operator operating multiple machine. This is a great change in the manpower deployment in SMEs. The below chart indicates the work flow of Operator 1 & Operator 2.



7. GIST OF IMPROVEMENTS CARRIED OUT:

Sl No	Process	Waste	Kaizen
1	Customer & Supplier Scheduling	Forecasts were not clear	3 Months forecast and one month firm schedules implemented
2	Material Inward & Storage	Uneven (Imbalanced) material inventory	Inventory Norms established. Scientific material ordering system with ROL and ROQ implemented
3	Production System	Batch Production. Random inventory between processes	Single Piece Flow (SPF) or One Piece Flow
	Production System	PUSH System	PULL System
4	Production Line	Machines in Zig-Zag Position	Implemented Cell Concept
	CNC M/c 1	Low Cutting Parameters	Better tools with higher cutting parameters
5	Production Line	Set up times higher	SMED implemented
	Production Line	Low availability	Machines availability improved
6	Machine Operators	One Operator – One Machine	One Operator – Multi Machine. SWCT Study and improvements introduced
7	Machine Operators	Narrow skills for operator	Multiskilling, Versatility introduced

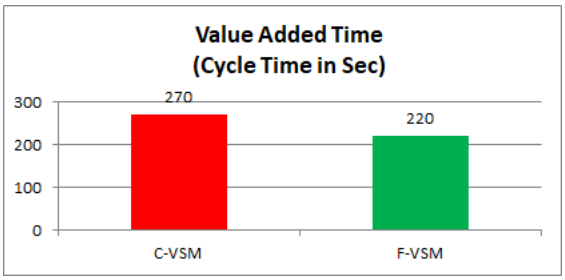
STANDARDIZATION & TRAINING TO EMPLOYEES

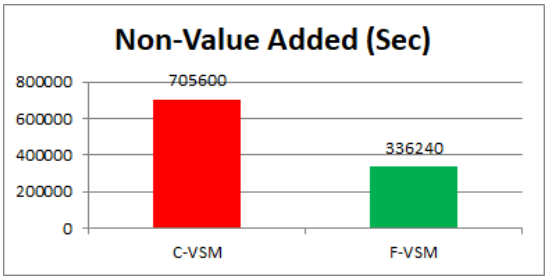
- Standard Operating Procedures (SOP) made
- Employees were trained in new method of working.
- Checkpoints included in the company's manufacturing documents.

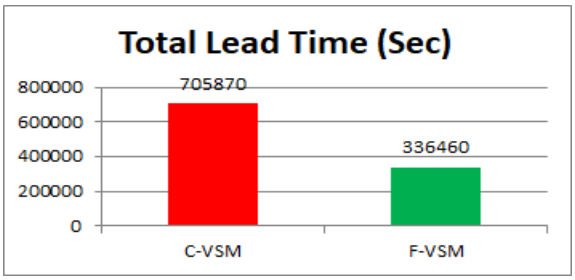
8. RESULTS

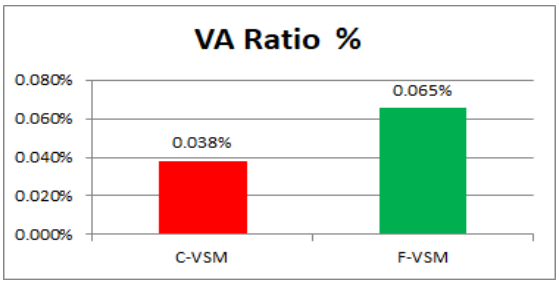
8.1 TANGIBLE RESULTS:

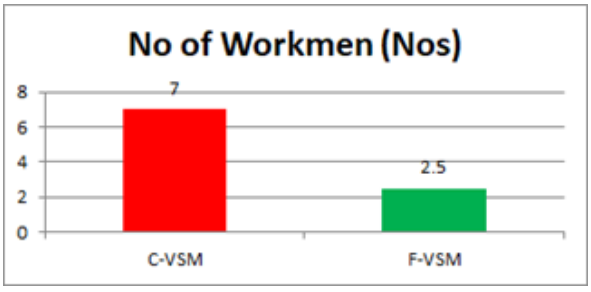
Sl No	Metrics	UOM	C-VSM	F-VSM	Benefit %
1	Value Added Time (Cycle Time)	Sec	270	220	19%
2	Non-VA	Sec	705600	336240	52%
3	Total Lead Time	Sec	705870	336460	52%
4	VA Ratio	%	0.038%	0.065%	71%
5	No of Workmen	Nos	7	2.5	64%
6	Line capacity	Nos	656	918	40%

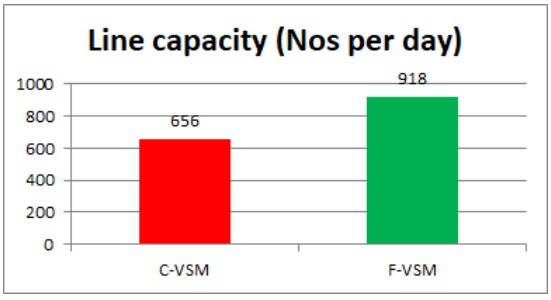












8.2 INTANGIBLE RESULTS:

1. Employee stress, fatigue reduced

2. Employees morale, satisfaction, motivation, involvement Improved

9. CONCLUSION:

VSM links the information and material flow together in one map. It provides a pictorial representation of entire value chain and a structured way of implementing improvements. It ties together man lean tools and techniques and guides us towards major improvements. This case study provides ample proof that VSM can be used in SME for throughput time reduction. This study was done in manufacturing with the scope of "Raw Material to Finished Goods". Future research works can be on implementing VSM in SME to reduce throughput time with larger scopes like "order to cash", "concept to launch" of new product development.

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REFERENCES

1. Amir Azizia, Thulasi a/p Manoharan, Designing a Future Value Stream Mapping to Reduce Lead Time using SMED-A Case Study, 2nd International Materials, Industrial and Manufacturing Engineering Conference, MIMEC2015, 4-6 February 2015, Bali Indonesia, Procedia Manufacturing 2 (2015) 153 – 158.
2. S.Mahendran, A.Senthilkumar, Implementing lean manufacturing principle in an automobile valve manufacturing Industry with simulation analysis – A Case study, Journal of the Balkan Tribological Association Vol. 24, No 3, 600–607 (2018)
3. S Hartini, J Manurung, R Rumita, Sustainable-value stream mapping to improve manufacturing sustainability performance: Case study in a natural dye batik SME's, IConISE-ACISE 2020, IOP Conf. Series: Materials Science and Engineering 1072 (2021) 012066 IOP Publishing doi:10.1088/1757-899X/1072/1/012066
4. A.Mohammed Faisal, K.Sankar Singh, Implementing Lean Technique by using Value Stream Mapping (VSM) in a Labourintensive Small and Medium Enterprise (SME): Case Study of Goods Manufacturing Company, International Journal of Research in Engineering, IT and Social Sciences, ISSN 2250-0588, Volume 9, Issue Special, February 2019, National Conference On Technology Enabled Teaching And Learning In Higher Education, School of Management Studies, VISTAS, Chennai, India
5. Dushyanth Kumar KR, Shivashankar GS, Rajeshwar SK, Application of Value Stream Mapping in Pump Assembly Process: A Case Study, Ind Eng Manage 2015, 4:3 DOI: 10.4172/2169-0316.1000162
6. Laila Driouach, Khalid Zarbane, Zitouni Beidouri, Literature review on lean manufacturing in small and medium enterprises, International Journal of Technology, October 2019, DOI: 10.14716/ijtech.v10i5.2718
7. Hariram VR, V.Muthukumaran, Implementation of value stream mapping in an SME, Asia Pacific Journal of Research , Vol: I. Issue LIII, July2017, ISSN (Print): 2320-5504, ISSN (Online): 2347-4793
8. Pugazhenthi, R., and M. Anthony Xavior. "Minimizing Material Processing Time and Idle Time of a Critical Machine in a Flow Shop." In Advanced Materials Research, vol. 984, pp. 106-110. Trans Tech Publications Ltd, 2014.

9. Mastan Singh, Er.Gurjinder Singh, Er.Jonny Garg, Value Stream Mapping: A Case Study of Fastener Industry, IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 12, Issue 5 Ver. III (Sep. - Oct. 2015), PP 07-10, DOI: 10.9790/1684-12530710
10. Arvind Kumar Shrimali, Vimlesh Kumar Soni, A study on the Utilization of Lean techniques/tools in Indian SMEs, PRODUCTION ENGINEERING ARCHIVES 20 (2018) 32-37, ISSN 2353-5156 (print) ISSN2353-7779 (online), DOI: 10.30657/pea.2018.20.07
11. Sunil Kumar, Ashwani Kumar Dhingra, Bhim Singh, Process improvement through Lean-Kaizen using value stream map: a case study in India, Int J Adv Manuf Technol, DOI: 10.1007/s00170-018-1684-8
12. Hemant H Kore, Saroj Koul, Indian MSMEs–Review of Dynamic Capabilities with Lean Production, International J. of Opers. and Quant. Management, Volume 27, Number 4 December 2021, pp. 361-382, DOI: 10.46970/2021.27.4.4
13. Abdullah Alkhoraif, Hamad Rashid, Patrick McLaughlin, Lean implementation in small and medium enterprises: Literature review, https://doi.org/10.1016/j.orp.2018.100089
14. Kanda Boonsthonsatit, Siripong Jungthawan, Lean Supply Chain Management-based Value Stream Mapping in a Case of Thailand Automotive Industry, Conference Paper · May 2015 DOI: 10.1109/ICAdLT.2015.7136593
15. Dorota Klimecka-Tatara, Manuela Ingaldi, Digitization of processes in manufacturing SMEs - value stream mapping and OEE analysis, Procedia Computer Science 200 (2022) 660–668
16. Pugazhenthi, R., and M. Anthony Xavior. "Optimisation of permutation flow shop with multi objective criteria." international journal of applied engineering research 8, no. 15 (2013): 1807-1813.
17. Pugazhenthi, R., and M. Anthony Xavior. "Optimisation of permutation flow shop with multi objective criteria." international journal of applied engineering research 8, no. 15 (2013): 1807-1813.
18. Pugazhenthi, R., and Anthony Xavior. "A genetic algorithm applied heuristic to minimize the makespan in a flow shop." Procedia Engineering 97 (2014): 1735-1744.
19. Rushil Batra, Sahil Nanda, Shubham Singhal, Ranganath Singari, Study of Lean Production System Using Value Stream Mapping in Manufacturing Sector and Subsequent Implementation in Tool Room, SAE Technical Papers · April 2016 DOI: 10.4271/2016
20. Rother, M. & Shook, J. (1999), "Learning to See: Value Stream Mapping to Add Value and Eliminate Muda", Brookline, MA: Lean Enterprise Institute (www.lean.org)
21. James P. Womack, D. T. (2003). Lean Thinking: Banish Waste And Create Wealth In Your Corporation. London: Simon & Schuster UK Ltd.
22. D Ohno T., Toyota Production System: Beyond Large scale Production, Productivity Press, and New York 1988.
23. Womack,J.P., Jones, D.T., Ross, D., 1990, The Machine that Changed the World. Macmillan Publishing Company, Canada
24. Mark A.Nash, Sheila R.Poling, Mapping the total value stream, Productivity Press Taylor & Francis Group 270 Madison Avenue New York, NY 10016
25. Dan Jones, Jim Womack, Seeing the Whole : Mapping the Extended Value Stream, The Lean Enterprise Institute, Brookline, Massachusetts, USA.
26. Pugazhenthi, R., M. Anthony Xavior, and R. Saravanan. "A case study on effect of grouping technique in a multi-stage hybrid flow shop." International Journal of Computing Science and Mathematics 7, no. 1 (2016): 42-53.
27. Vivek, P., R. Saravanan, M. Chandrasekaran, and R. Pugazhenthi. "Minimizing idle time of critical machine in permutation flow environment with weighted scheduling." ARPN Journal of Engineering and Applied Sciences 11, no. 5 (2016): 473-3483.