Lean manufacturing concepts in wet grinder assembly line through value state mapping

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Abstract: The current focus of modern manufacturing is to convert the raw material to the finished goods with zero wastage and at least-cost. Lean manufacturing approach is considered as a successful strategy that minimises the non-value added activities (waste). Value stream mapping (VSM) is one of the tools in lean manufacturing to understand the value added and non-value added activities in the entire system. Such approach has not been explicitly practiced in wet grinder manufacturing system. An attempt has been made in this paper to systematically evaluate current state mapping (CSM) and implement future state mapping (FSM) in a wet grinder manufacturing system. CSM describes the present VSM and other activities that influence it. CSM has been developed by careful observation of cycle time, change over time and non-value added activities. The objective of this study is to minimise the non-value added activities and achieve the required TAKT time. The FSM is arrived by incorporating various improvements in the assembly line.

Keywords: lean manufacturing; value stream mapping; value added activities; non value added activities; current state mapping; wet grinder assembly line; TAKT time; cycle time; change over time; material storage; Kanban pull system; sustainability.

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1 Introduction

India is emerging as an advanced manufacturing location and many industries are seeking ways to excel their manufacturing capabilities by elimination of wasteful activities from their systems. The survival of the business due to increased competition and requirement for higher quality standards forced industries to adapt a technique for increasing the efficiency of the process (Porter and Lee, 2013). Understanding market dynamics is a crucial factor for those who want to design the manufacturing system (Gadalla, 2010).

Traditional manufacturing do not support the manufacturing industry in achieving world-class production systems (Zahraee et al., 2014). The breakthrough performance in present modern manufacturing system is lean, agile, sustainable manufacturing. Lean manufacturing system is designed for processes by utilising the resources in an effective and efficient manner. The main approach to lean manufacturing is identification and steady elimination of the underlying cause of waste through a set of tools and reduced inventory to improve the flow of work. As waste is eliminated quality improves while production time and cost are reduced (Juran, 1992). Toyota focused on minimising waste in all aspects of its operation by using important tools and techniques including Kaizen, cellular manufacturing, Poke-yoke, etc. (Herron and Christian, 2008). Shah and Ward (2003) used lean practices for reducing the cycle time and focused on factory production. An effective methodology for implementing lean manufacturing strategies and leanness evaluation metric in cellular manufacturing and continuous improvement programs is discussed by Bhasin (2006). Deros et al. (2013) applied single-minute exchange of dies (SMED) lean techniques for identifying factors that can help reduce setup time in assembly lines. Key benefits of the lean system are reduced inventory, reduced lead times, increased productivity (Ohno, 1988) and equipment utilisation and reduced amounts of scrap and rework. There is not a fixed standard tool for lean implementations (Hines et al., 2004). Czarnecki and Loyd (2001) defined various tools of lean manufacturing in which value stream mapping (VSM) is one among the tool that is used to represent the business process graphically and looking for ways to streamline inventory, waste and production time.

Dessens and Lopez (2011) focused VSM as a key tool for improving and redesigning manufacturing system to become more competitive, flexible and efficient. Singh et al. (2010) intended that VSM is a supportive tool in lean implementation and to develop the road map for improvement and also bridge the gap between existing and proposed mapping of manufacturing unit for becoming a highly responsive system to the customer. According to Chen and Meng (2010), VSM is a suitable lean tool that realised the Kaizen concept to meet out the competitive requirements. Upadhye et al. (2010) have studied that the changeover time is very high and used SMED technique in machining. Lean tool is the principle of applying lean thinking process that are broadly accepted by many manufacturing operations and have been applied successfully across many disciplines (Poppendieck, 2011). Singh and Sharma (2009) explained that how VSM is useful to lean implementation, to develop the road map for minimising the lead time, work in process (WIP) inventory and reduction in manpower in crank shaft gear manufacturing unit. Vinodh et al. (2010) highlighted that VSM is more supported for enabling leanness practice in Indian camshaft in organisation. Further, they conclude that VSM is an effective lean manufacturing practice which could be deployed in industrial scenario for enabling leanness for achieving competitiveness.

Miltenburg (2001) studied assembly lines to get the smooth flow in production system. In assembly lines, pull and lean systems are concepts frequently connected. Pull system towards the reduction of WIP and lean system towards minimising the buffer variability (Hopp and Spearman, 2014). Yadav et al. (2010) indicated in their study a keen interest on the part of Indian manufacturing sectors to implement new approaches and techniques in order to improve their performance; but it was only the beginning of a long journey. Ghosh (2013) has reviewed that the practice of lean adoption in Indian manufacturing industry and found its practice mainly by influencing on operational performance. Gill (2012) states, in an organisation, the need to 'see the whole' are the basis for systemic functioning of process improvement. Panizzolo et al. (2012) investigated the adoption of lean production in India as shown in Table 1.

Table 1 Diffusion of lean in India

Industry sector in India	*Level of diffusion*
Automotive	Very high
Machine tool	Medium to low
Electronics/IT/Engineering	High
FMCG	Medium to low
Process industries	Medium to low
Aerospace	Medium to low

Source: Panizzolo et al. (2010)

According to Panizzolo et al. (2012), the Indian automotive sector has the very high level of lean implementation followed by electronics/IT/engineering sector. In other sectors implementation of lean are seen on medium to low level.

Based on the literature review, it is found that though lean manufacturing principles have been adopted across different industrial sectors worldwide, whereas in Indian context, most of the organisations have started implementing lean concepts currently (Panizzolo et al., 2012). Paranitharan et al. (2014) reported that VSM is used in the sectors such as hospitality, manufacturing, service industries, automobile, Machining and casting industry, transportation. According to Parthanadee and Buddhakulsomsiri (2014), VSM is a tool for portraying the system to identify areas for improvement. Whereas lean manufacturing combines both enhanced customer service and process improvement (Radnor and Johnston, 2013). In India, the home appliances sector in spite of witnessing a huge growth since liberalisation and an important sector for the economy of the country the implementation of lean concepts are few. Lean techniques such as 5S, Kanban are currently under implementation, on the other hand, the proliferation of VSM in fast moving consumer durables (FMCG) specifically home appliances is found to be feeble. In this context the work has been carried out in home appliance sector specifically in wet grinder assembly line fusing VSM and leanness that has proved appreciable results for other sectors. Home appliance sector plays a vital role in giving employment to millions of people and also improving the standard of life of the people in the country. The motivation for this research work is to reduce the lead time and increase the productivity, by balancing the TAKT time in wet grinder assembly line to meet the customer demand by lean approach and VSM. This paper reports a research work that has been carried out in an Indian wet grinder manufacturing organisation. VSM is used for understanding the present manufacturing system and redesigning the system and lean practices for reducing the inventory, lead time and increasing the productivity. The market demand is achieved through implementation of future state mapping (FSM) in the wet grinder industries which falls under FMCG category. This research work analyses the current state of the manufacturing system of wet grinders, and arrived at the future state for improving the material flow and assembly line process. Current state mapping (CSM) describes the present VSM and other related activities that influences the VSM. Material flow is improved upon redesigning the store room layout to reduce material issue time. Implementation of Kanban and MRP improves material shortage and labour productivity. Change over time is reduced by clubbing two or more similar assembly operations. Changing the pattern of fixing base plate and the shell reduces the assembly time. TAKT time is achieved through the reduction of non-productive time in materials and change over time in assembly line.

2 Problem faced by the company

ABC industry is one of the leading manufacturers of wet grinders in Coimbatore, India. The company is a global supplier of more than 40 models of wet grinders used in Indian kitchen home appliances. The company faces challenges internally to improve its operations to meet the spurt in demand from the Government of Tamil Nadu. The productivity and delivery is low due to high non-value added activities in the system.

In this research, an attempt has been made to improve the productivity and lead time of the assembly that meets the increase in customer demand by achieving the TAKT time. For this purpose, a case study is carried out in ABC Company with lean approach through the implementation of CSM.

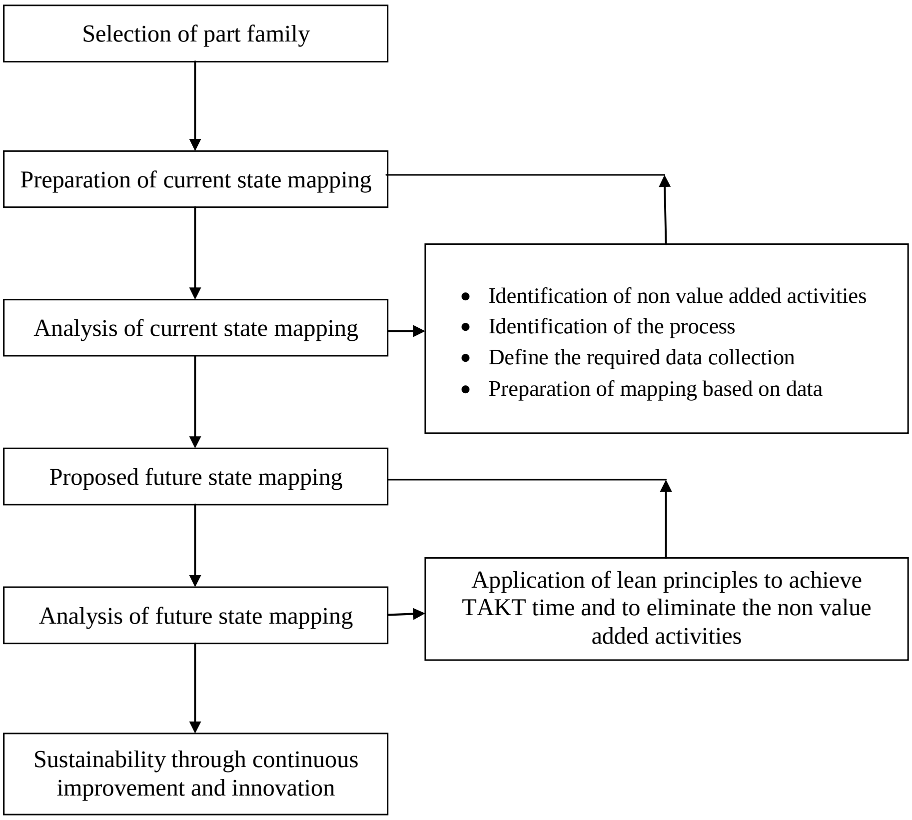
3 Methodology

Current and FSM of the wet grinder assembly system are drawn in the form of current and future states to focus on the material flow from raw material suppliers through manufacturers to the customers. The various steps involved in building effective way of VSM for assembly operations are shown in Figure 1. The methodology of constructing VSM technology used by Paranitharan et al. (2014) reduced the lead time period of modulator valve from 7.01–1.78 days and shown an improvement of 74.6%. Adapting the same proved methodology the VSM is done for wet grinder assembly line to balance the TAKT time by eliminating or reducing the non-value added activities.

3.1 Selection of product family

The foremost step in this methodology is selection of the product from various data analysis of the company. In this research, the researchers selected table top wet grinder assembly line for CSM analysis, as it contributes to 80% of the total sales volume of the company.

Figure 1 Methodology of constructing VSM



Source: Paranitharan et al. (2014)

3.2 Current state mapping

The next step after the selection of the product family is to draw a CSM of the existing process. The current VSM faces issues with material flow and hence CSM of material storage practice is also carried out without which proposed VSM will not give the desired results. CSM has been prepared by identifying the non-productive time in material flow and cycle time for each process in the existing assembly line.

The process flow of assembly of wet grinders involves 15 stations. A VSM is constructed by collecting the details regarding issue of materials, assembly line processes, such as cycle time at each work stations, inventory, change-over time, number of workers and operational hours per day from the respective departments. This is the basic step of a lean project which focuses on the process and to investigate and question how and why it is performed in particular way. The VSM of the current state is shown in Figure 2. Current state assembly line depicting the cycle time and change over time as shown in Table 2.

Figure 2 Current state VSM (see online version for colours)

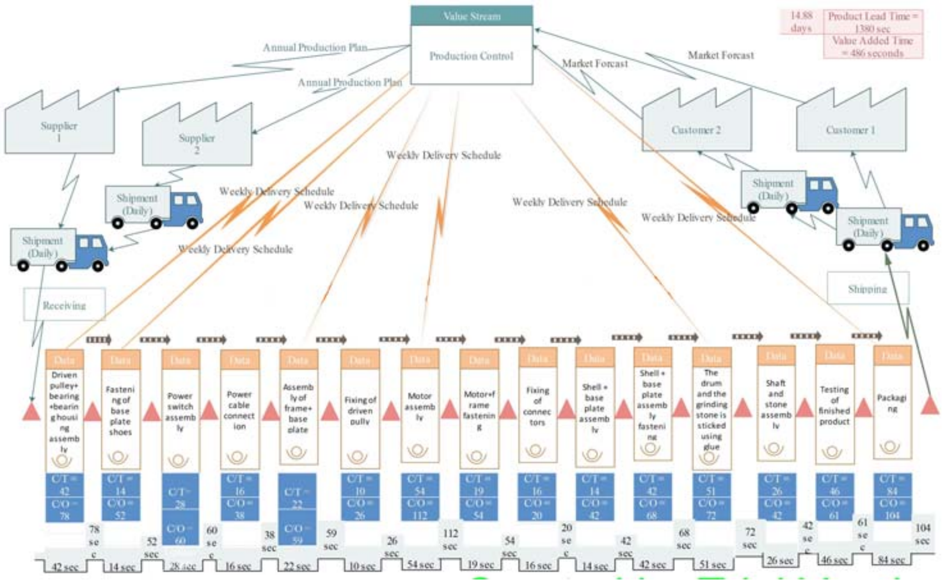


Table 2 Current state assembly line

S. no.	*Process*	*Cycle time in sec*	*Change over time in sec*
1	Driven pulley + bearing + bearing housing assembly	42	78
2	Fastening of base plate shoes	14	52
3	Power switch assembly	28	60
4	Power cable connection	16	38
5	Assembly of frame + base plate	22	59
6	Fixing of driven pully	10	26
7	Motor assembly	54	112
8	Motor + frame fastening	19	54
9	Fixing of connectors	16	20
9	Shell + base plate assembly	14	42
11	Shell + base plate assembly fastening	42	68
12	The drum and the grinding stone is sticked using glue	51	72
13	Shaft and stone assembly	26	42
14	Testing of finished product	46	61
15	Packaging	84	104
	Total	486	894
	Lead time	1,380	

3.2.1 Current state material storage

Material from the suppliers is stored in the store room of area 220 sq m (10 × 22 m) after inspection process. Existing store room comprises of rack 1, 2 and 3 for storing the finished components for the final assembly as shown in Figure 3. Materials that are to be given to the suppliers for further processing are stored in the semi-finished area. The raw materials for the motor are placed in motor section. There are two entrances, one is to receive the inward material, and the other one is for the issue of materials to motor section, sub assembly operation. Bulk materials are stored in a separate warehouse.

Figure 3 Existing store room

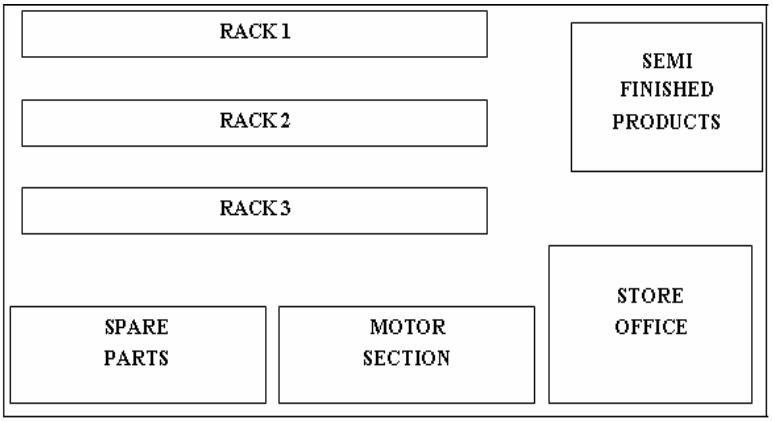
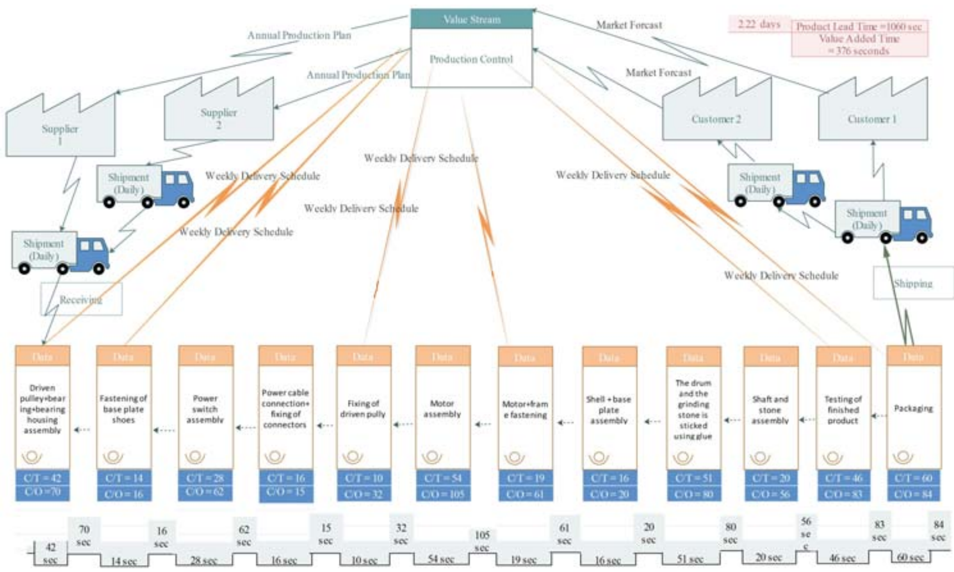


Figure 4 Future state VSM (see online version for colours)



3.3 Analysis of CSM

Current procedure of material storage will not support the proposed VSM. So, it is very much essential to improve store room layout for reducing the lead time and balance the TAKT time to meet the customer demand. From the direct time study of material issue, the average non-productive time by the three main factors are tabulated in Table 3. The average non-productive time in issuing the materials in stores is 144 sec and due to material shortage it is 410.46 sec. The average non-productive time due to labour in the assembly process is 214.417 sec for the assembly of a single grinder in prime model.

Table 3 Average non-productive time by main factors

Factor	*Average non-productive time (in secs)*
Material issue	144
Material shortage	410.46
Labour	214.417
Total	1,120.26

By analysing the assembly line in detail, it is clear that the process needs change and there is scope for improvement. The main objective is to reduce the lead time by combining the operations. Demand for the number of units to be produced has increased from 495/month to 645 units/month. There is a need to improve the existing manufacturing system performance. The details of the present system are as follows:

- number of working days per month = 26
- number of shift/day = 1
- available time per shift = 7 Hrs 30 Min
- customer demand/month = 645 units.

The customer demand flows from marketing to planning department and the material requirement is planned and communicated to various raw material suppliers through electronic media and telephone. In this case, the company maintains raw material inventory which is 14.98 days in stores and actual processing time with value addition is about 1,380 sec. The cycle time of current value stream is 486 sec and it is observed that the changeover time is 894 sec.

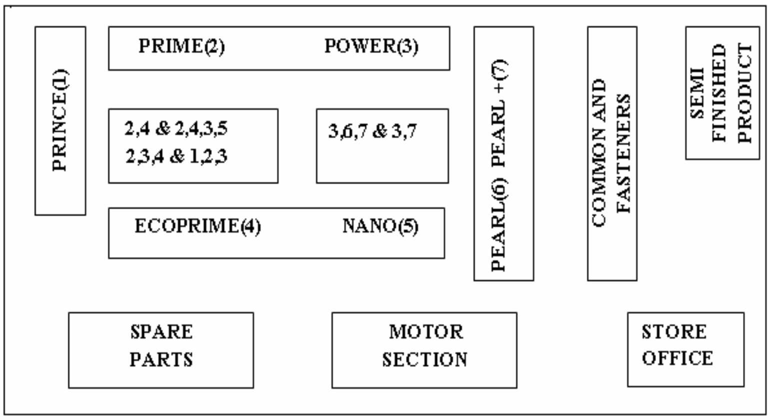
3.4 Proposed FSM

The proposed FSM has been prepared to balance the TAKT time of the assembly line. FSM of assembly line is shown in Figure 4. The fastening of base plate shoes and frame as two distinct operations, have been combined as one, so that separate fastening operation can be avoided. This reduces the changeover time from 52 seconds to 16 seconds. Power cable assembly has a cycle time of 16 seconds and fixing of connectors has a cycle time of 16 seconds. Both the cable assembly and connectors are combined as a single unit. Instead of doing the electric connections in separate stages, this combined cable and connectors are done at a single stage thus the cycle time is reduced by 16 seconds. The change over time of 38 seconds and 20 seconds for both the operations is reduced to 15 seconds by elimination of one operation. The base plate and the shell have been secured by clipping instead of fastening by screws thus reducing the cycle time from 42 seconds to 16 seconds and change over time from 68 seconds to 20 seconds. The modified assembly line has 12 stations instead of 15. The time consumed for each process after modification is shown in Table 4.

Table 4 Modified cycle time of the assembly line

S. no.	*Process*	*Cycle time in sec*	*Change over time in sec*
1	Driven pulley + bearing + bearing housing assembly	42	70
2	Fastening of base plate shoes	14	16
3	Power switch assembly	28	62
4	Power cable connection + fixing of connectors	16	15
5	Fixing of driven pully	10	32
6	Motor assembly	54	105
7	Motor + frame fastening	19	61
8	Shell + base plate assembly	16	20
9	The drum and the grinding stone is sticked using glue	51	80
10	Shaft and stone assembly	20	56
11	Testing of finished product	46	83
12	Packaging	60	84
Total		376	684
Lead time		1,060	

Figure 5 Modified store room layout



3.4.1 Proposed material storage

Rank order cluster analysis is used for establishing a new layout of the store room for efficient control and issue of material as shown in Figure 5. Items are grouped based on the similarities of the models in the layout to save time in identifying the material. Depending upon the frequency of the requirement, the most frequent models of the grinders are kept near the store office and hence the material movement is reduced. Most commonly used items and the fasteners are kept near the store office for easy accessibility. Systematic procedure is evolved in procuring the components in the right time to make sure that all items will be available for the final assembly. Developing a material requirement planning to the firm provide an efficient control and assure availability of items for the final products. The raw material inventory is reduced to 2.2 days in stores. Kanban pull system is introduced to enhance the material flow of WIP to meet the increase in customer demand.

3.5 Analysis of proposed FSM

The analysis of proposed state mapping shows the improvement that is made by introducing lean principle and techniques in order to achieve the objectives. In this case, total inventory is reduced from 14.98 days to 2.2 days as shown in Figure 6. Introduction of MRP and Kanban eliminates non-value added activities in material issue, material shortage and labour. Improved performance of lean system is to increase the output per month from 495 to 645 units. Figure 7 shows the achieved TAKT time in minutes to meet the demand from 495 to 645 units. The value addition of product is improved by suitable tools and techniques by reducing non-value added activities to achieve higher value addition of product. Table 5 indicates the comparison of the present and FSM with the percentage of improvement after implementing lean concepts through VSM.

Figure 6 Comparison of inventory time (see online version for colours)

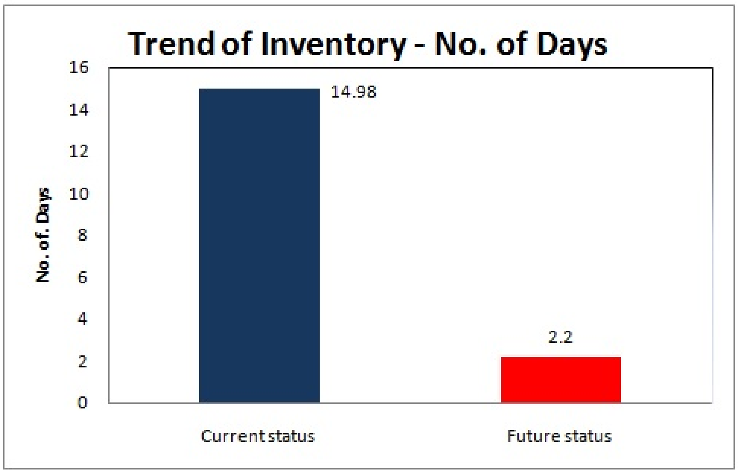
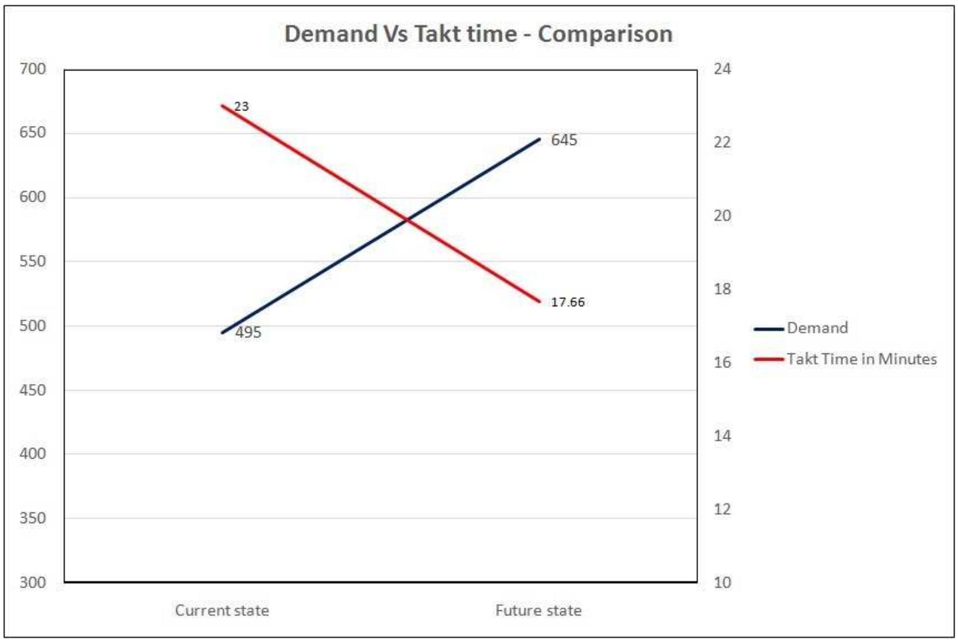


Table 5 Comparison of current and FSM

Improved parameters	*Current state mapping*	*Future state mapping*	*Improvement*
NPT due to material issue (in min)	12.85	8.03	37.5%
NPT due to material shortage (in min)	36.64	4.66	87.28%
NPT due to labour (in min)	19.14	5.8	69.69%
Output/month (number of units)	495	645	30%
Number of stations in assembly line	15	12	20%

Figure 7 Demand vs. TAKT time (see online version for colours)



3.6 Sustainability through continuous monitoring and innovation

Kaizen is implemented to eliminate any other form of wastes and to achieve sustainability in the system. The process is improved by eliminating large amount of inventory and procedure for storing and retrieving of components in stores. After implementing the lean practices it is continuously reviewed to find the opportunity for further continuous improvement and innovation in the process to meet the customer demand and to achieve the TAKT time. It helps the company to reach their ultimate goal of sustainability and profitable growth in the future. VSM is combined with lean practices to improve the store room layout and material flow, minimising change over time and cycle time in the assembly line.

4 Conclusions

Lean manufacturing is focused on the reconfiguration and restructuring of business processes based on waste elimination in the wet grinder assembly line, thereby reducing cost. The lean tools like VSM are employed to analyse and improve the current process in the assembly of wet grinder assembly line. Introduction of lean tools reduced the number of workstations from 15 in the CSM to 12 in the modified system. The total lead time of the assembly process got reduced by 23%. The researchers have used the FSM to the wet grinder assembly to meet the increased customer demand. The effectiveness of lean techniques is proved in a systematic manner and the benefits of lean concepts are evident from the reduced lead time and achieved TAKT time.

5 Limitations and future research direction

The implementation of TAKT time reported in this paper has been carried out for a single product line of a manufacturing organisation. In future, researchers may develop VSM for mixed model product lines. In addition, the extension of VSM implementation on other critical process and finally to the whole enterprise will be targeted. Future search can be on the investigation of the human element factor in analysing the performance of FSM.

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