VALUE STREAM MAPPING AT A SOUTH AFRICAN BUTTERFLY VALVE MAKING COMPANY

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ABSTRACT

Purpose of the paper

The purpose of this paper is to uncover and reduce waste through the application of value stream mapping (VSM) on the butterfly valve production line at Paltechnolgies Pvt Ltd, hereafter referred to as Paltech. Moreover the study was done to re-engineer the butterfly valve making process.

Design/Methodology/Approach

The research was conducted through a number of stages. Firstly the study conducted literature review on VSM. Secondly, a study was done on the existing production lines in Paltech and a decision was made to focus VSM on the 100 mm butterfly valve production line. The decision was prompted by the low throughput in the line. Thirdly, the study monitored and measured the activities within and between the process steps. For each process a record was made of the; throughput time, preparation time, people required, cycle time, value-add time, time delays and distance moved. This data helped prepare the current state map. Fourthly, an analysis of the current state map revealed the magnitude of non-value adding processes. Improvement proposals were formulated and deployed in the future state map. Fifthly, an action plan was developed to minimize waste, thereby bridging the gap between the current state and the future state. Lastly the future state map was studied over a period of two months.

Findings

VSM helped Paltech visualise the present level of wastes occurring in the organisation and the future possibility of reducing/eliminating them. It provided the baseline view for optimising the utilisation of resources. After implementation of the future state map benefits were gained in throughput time, preparation time, cycle time, value-add time, time delays, distance moved and people required.

Research limitations/implications

Deductions made in this study are based on a study that was carried out on a single product line at Paltech. The benefits could be different if VSM were applied in other manufacturing processing, i.e. project, jobbing, mass and continuous. If one were to conduct a similar study one would need to consider constraints associated with different production process, i.e. project, jobbing, batch, mass or continuous.

Practical implications

VSM approach is a lean approach that can be adopted in project, jobbing, batch, mass and continuous production environments as well as in the provision of services. It benchmarks the value adding and wasteful activities at a given point in time with what the process might look like when a realistic percentage of the waste is removed. This gives practitioners an opportunity to mobilise resources required to bridge the gap between current state and future state.

Originality/value of the paper

VSM theory is not new, but is still relevant to the needs of today. In this study it helped identify waste, reduce it and improve value adding processes.

Keywords: Value stream mapping, Butterfly valve manufacturing, Waste minimisation, Process reengineering.

INTRODUCTION

Paltech is a manufacturer of high performance butterfly valves, flanged diaphragm non-return valves and foot valves that have applications in potable water plants, desalination plants, gas handling plants, pulp and paper mills, chemical and petrochemical processing plants, food and beverage factories, air conditioning and refrigeration and utilities. The full product categories that Paltech makes are shown in Table 1.

Table 1: Paltech product range

Product Name	Size	Pressure Rating	Material from which the product is made
T-bar high performance single eccentric butterfly valve	50mm to 250mm	20 bar and 40 bar working pressure	Aluminium, Carbon Steel and other Exotic Alloys
BIAX high performance double eccentric butterfly valve	150mm to 300mm	Class 300	Carbon Steel, Stainless Steel and other Exotic Alloys
Flanged Diaphragm non-return valve	50mm to 500mm	16bar, 25 bar and 40 bar working pressure	Cast Iron, SG iron, Stainless and other Alloys
Flanged Foot Valve	50mm to 500mm	16 bar working pressure	Cast iron and Stainless Steel
Wafer Swing Check Valve	40mm to 700mm	16 bar and 25 bar working pressure	Carbon Steel, Stainless Steel and other alloys
Slurry Sleeve Valves	25mm to 80mm	10 bar working pressure	Carbon steel, Stainless Steel and other Alloys

Facilities available in the company enable it to design, machine, assemble, inspect and test butterfly valves. To enhance its competitiveness, Paltech introduced ISO 9001 quality assurance, ISO 14001 environmental management and occupational health and safety systems. With this capability, the company has managed to sell its products in South Africa, Africa, Europe, USA and Australia.

According to Tapping et al., (2002) customers define one's value stream. Paltech makes butterfly valves for a variety of customers. The specifications from the customers have resulted in six product families; each with its own value stream.

The purpose of this study was to minimize waste through the application of value stream mapping (VSM) on the 100 butterfly valve production line. This valve is shown in Figure 1. Low throughput prompted the decision to study the value chain for this valve. The company was not flexible enough to meet all the orders for butterfly valve.

Figure 1: Paltech 100mm Butterfly Valve (Source: Paltech website)

The butterfly valve value stream in Paltech has three segments: the supplier segment, manufacturing segment and the customer segment. This study excludes the upstream value chain that is involved in the casting of the valves. It also excludes the downstream activities beyond the dispatch stores and focuses on the manufacturing segment.

LITERATURE REVIEW

Value stream mapping is an important tool in lean manufacturing and helps to visualise the present level of waste occurring in an organisation and the future possibility of reducing/eliminating them (Vinodh et al., 2010). In addition it is effective in analysing and redesigning of; production and supply chain processes, material flow, as well as information flow (Matt, 2012). When waste is addressed productivity and capacity utilisation in an organisation are bound to improve (Vinodh et al., 2015). Other tools and techniques used in conjunction with VSM to eliminate waste in industry are; total productive maintenance, total quality management, single minute exchange of die, cellular layout, pull production system, poka yoke, visual controls, failure mode and effect analysis, 5S, quality function deployment, Kanban, and kaizen (Vinodh et al., 2010).

VSM applications span many sectors including automotive, electronics, white goods, and consumer products manufacturing (Abdulmalek and Rajgopal, 2007). It serves as a starting point to help management, engineers, suppliers, and customers recognise waste and its sources (Seith et al, 2008). VSM generally consists of three components (King, 2009):

i. material flow- all the process steps are shown and generally inventory levels are also presented,
ii. information flow, and
iii. time line: - it takes the form of a square wave at the bottom of the VSM (King, 2009).

Although VSM is such a wonderful tool, Romeo (2011) observed the following limitations with it:

i. it is not possible to map multiple products that do not have identical material flow maps,
ii. it fails to relate transportation and queuing delays to operating parameters such as machine cycle times and measures of performance such as takt time of the manufacturing system,

iii. it lacks any worthwhile economic measure for 'value' (profit, throughput, operating costs, inventory expenses),
iv. it lacks the spatial structure of the facility layout, and
v. it is based on manufacturing systems with low variety and high volume.

The value stream includes the value adding and non-value adding activities that are required to bring a product from raw material through delivery to the customer (Alaca and Ceylan, 2011). It is an outline of a product's manufacturing life cycle that identifies each step throughout the production process (Alaca and Ceylan, 2011). It is a micro-level analysis of material and information flow through the various levels of planning and linking lean initiatives through systematic data capture and analysis Vinodh et al. (2010). The focus of VSM is on product value stream for a given product family i.e.products that follow the same overall production steps (Romero, 2011). Such a useful tool has been evolving through its different applications, under many cases of study, under different environments and contexts (Romero, 2011).

Waste is an activity which will not provide any value addition to the final product or customer aspects (Jasti and Sharma, 2014). VSM has been widely used to evaluate intra- and inter-company waste (Rother and Shook, 1997).

Based on the analysis of what is called current state map, one develops a future state map by improving the value adding steps and eliminating the non-value adding steps (Romero, 2011). In the future state design, major issues that create waste in the process are addressed. The future state map forms the basis for the development of the implementation plan that focuses on improvement initiatives (Romero, 2011).

In this study, value stream mapping was first used to map the current operating state for the 100mm butterfly valve production line. This map was used to identify sources of waste and to identify lean tools for reducing the waste. A future state map was then developed for the system with lean tools applied to it.

METHODOLOGY

The methodology followed in this study is shown in Figure 2. Firstly the study conducted a literature review on Value stream mapping.

Secondly a product-quantity analysis and product-routing analysis on Paltech was done. This resulted in choosing the 100mm butterfly valve production line for a study. The product was popular across industries and its demand was increasing. In 2017, the product was bought by nineteen different companies whose business focus was making: automated valves,control valves, actuators, switchgears and positioners, fire protection system, process control valves, water and effluent treatment plants, hydraulic and pneumatic cylinders. However, Paltech had low throughput rate of the product. Hence the study concentrated on this particular line to improve the performance of the line.

Thirdly, in order to develop the current state map for the butterfly valve, the team physically conducted a gemba walk along the value stream. The walk along the value stream helped understand; the sequence of the processes, the purpose of the process, and skills requirements for the processes.

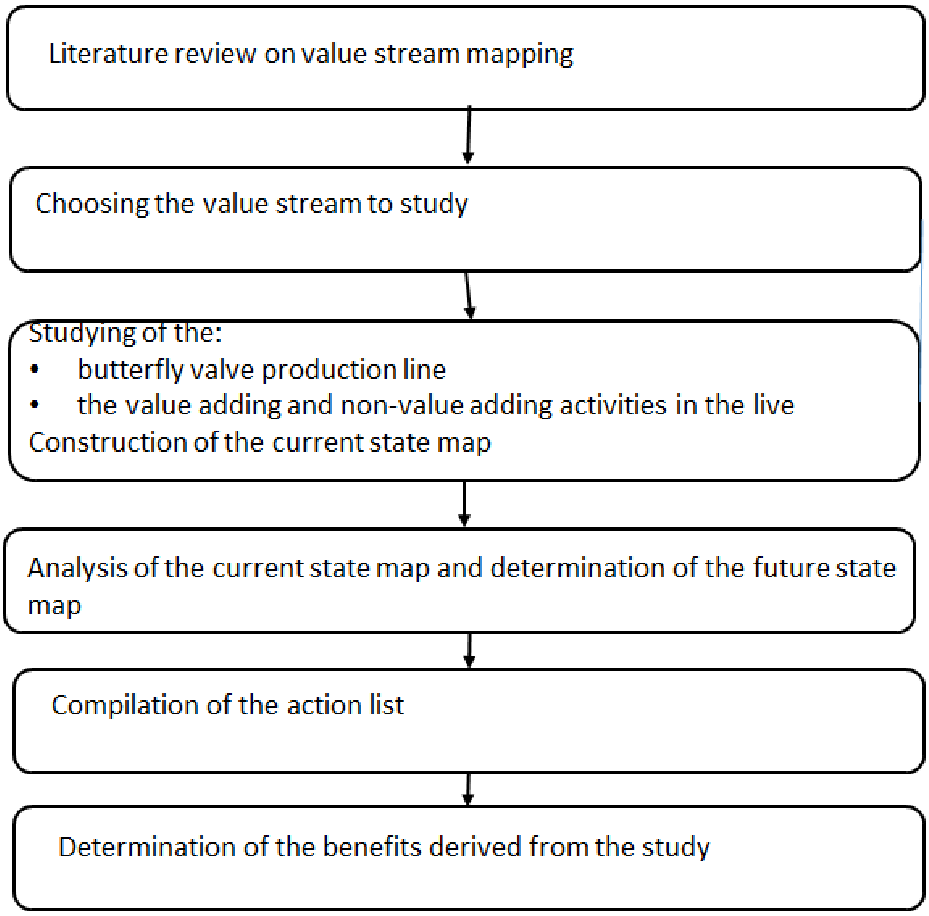

Figure 2: Methodology

Data regarding material and information flow within the value stream was collected. This was an intra-company exercise. The study focused on defining the activities and measuring the time it took from receiving raw material to shipping finished products to the customer(s). The data was gathered through participatory observations and by measuring the time it took to perform different activities. The processing and set-up times were based on the averages captured through time studies. All this put together was the basis on which the current state map was prepared. Subsequently, relevant and useful process data on; customer demand, cycle time(C/T), setup time, and number of operators (OP) was collected.

A multi-disciplinary team composed of; the director, the SHEQ manager, workshop manager and an industrial engineering intern was formed to assist with the value stream mapping. Potential areas for improvement were noted and all delays were shown on the map. Discrepancies such as waiting times and lead times that seemed too long or just irregular were analysed in detail and 5 whys method was used to find the root cause of the lead times.

Fourthly a future state map was created. This emanated from the current state map, and this was a picture of the management's near future desire after the minimisation of waste.

Fifthly, improvements that would take the company to the future state map were proposed. This was then followed up with an action plan.

FINDINGS

The product-quantity analysis for the valves is shown in Table 2 and the routing analysis in Table 3. The average monthly production runs were studied over a period of three months. The data collected from this study was the basis for choosing the product to study.

Table 2: Product-Quantity Analysis

Number	Product	Quantity
1	Flanged Diaphragm non-return valve	2
2	Flanged Foot Valve	4
3	Wafer Swing Check Valve	6
4	Slurry Sleeve Valves	6
5	T-bar high performance single eccentric butterfly valve (100mm butterfly valve)	16
6	BIAX high performance double eccentric butterfly valve	10

Table 3: Product-Routing Analysis

Quantity	Product	Process sequence							
		1	2	3	4	5	6	7	8
2	Flanged Diaphragm non-return valve	Facing 1st side	Facing 2nd side	grooving	insert	Drill holes	paint	Test	
4	Flanged Foot Valve	Facing 1st side	Facing 2nd side	grooving	insert	Drill holes	paint	Test	
6	Wafer Swing Check Valve	Facing 1st side and grooving	Facing 2nd side and grooving	Machine the seat	fettling	Wash	Test		
6	Slurry Sleeve Valves	Cutting for the O-ring with milling machine	Fettling	Welding	Fettling	Paint	Test		
16	T-bar high performance single eccentric butterfly valve	Face the 1st side of the body	Face the second side of the body	Machine the seat	Drilling. Milling and facing	Remove the groove	Fettling	wash	Test
10	BIAX high performance double eccentric butterfly valve	Face the 1st side of the body	Face the second side of the body	Machine the seat	Drilling. Milling and facing	Remove the groove	Fettling	wash	Test
	Lugged bodies	Facing the 1st side	Facing the 2nd side and groove	Machine the seat	Lug bore	Face and remove the groove	fettling	Wash	Test

The T-bar high performance single eccentric butterfly valve (100mm butterfly valve) was selected for the study since it had the highest number of units produced. The valve was popular product and had wide applications. In 2017 it was bought by 19 different companies that were direct consumers. The companies used the product in automated valves, fire protection systems, water and effluent treatment plants, pneumatic systems, and lift jacks.

The Current State Map

Figure 3 is a map of the current state, showing material and information flow for the 100mm butterfly valve production line. It was developed collectively by the industrial engineering intern, the workshop manager, storeman, and machine operators. The SHEQ manager and the director of the company participated in the validation of the map. The team went to the factory floor and measured the time it took to accomplish different activities related to the production of the 100mm butterfly valve, from receiving raw materials to final testing of the assembled product. The boxes in Figure 3 represent the process and each process has a data box which contains; batch size, cycle time, setup time, and number of operators.

The timeline at the bottom of the current state map in Figure 3 has two components. The first component is the production waiting time (minutes) which was obtained by summing up the lead-times for each inventory triangle in the production line. The total observed waiting time was found to be 7200 minutes which is 79.4% of the total lead time. The second element of the timeline was the processing (value-adding) time, which was 1872 minutes, making 20.6% of the total lead time. Thus the total lead time (sum of value adding and non-value adding time) was 9072 minutes, i.e. 18.9 days. The set-up time was 3 hours and 20 minutes (200 minutes), which is 2.2% of the total lead time.

When the implementation team analysed the current state map, areas that stood out as potential areas for improvement were:

i. problems related to setting up the machine, at the "drilling, milling and facing" workstation which was taking on average 1 hour 10 minutes,
ii. queuing times at "D", and "H" which were 1 440 minutes and 2 400 minutes respectively,
iii. housing keeping throughout the factory. The implementation team initiated 5S.
iv. production schedules - each process was producing to its own schedule and this resulted in buffer storages between processes.

The current state map helped Paltech understand where it was before it could decide where it wanted to go. It gave the researchers a clear picture of the wastes that inhibited flow. In creating the future state map in Figure 4, an effort was made to identify lean manufacturing tools to drive the inventory and lead time down.

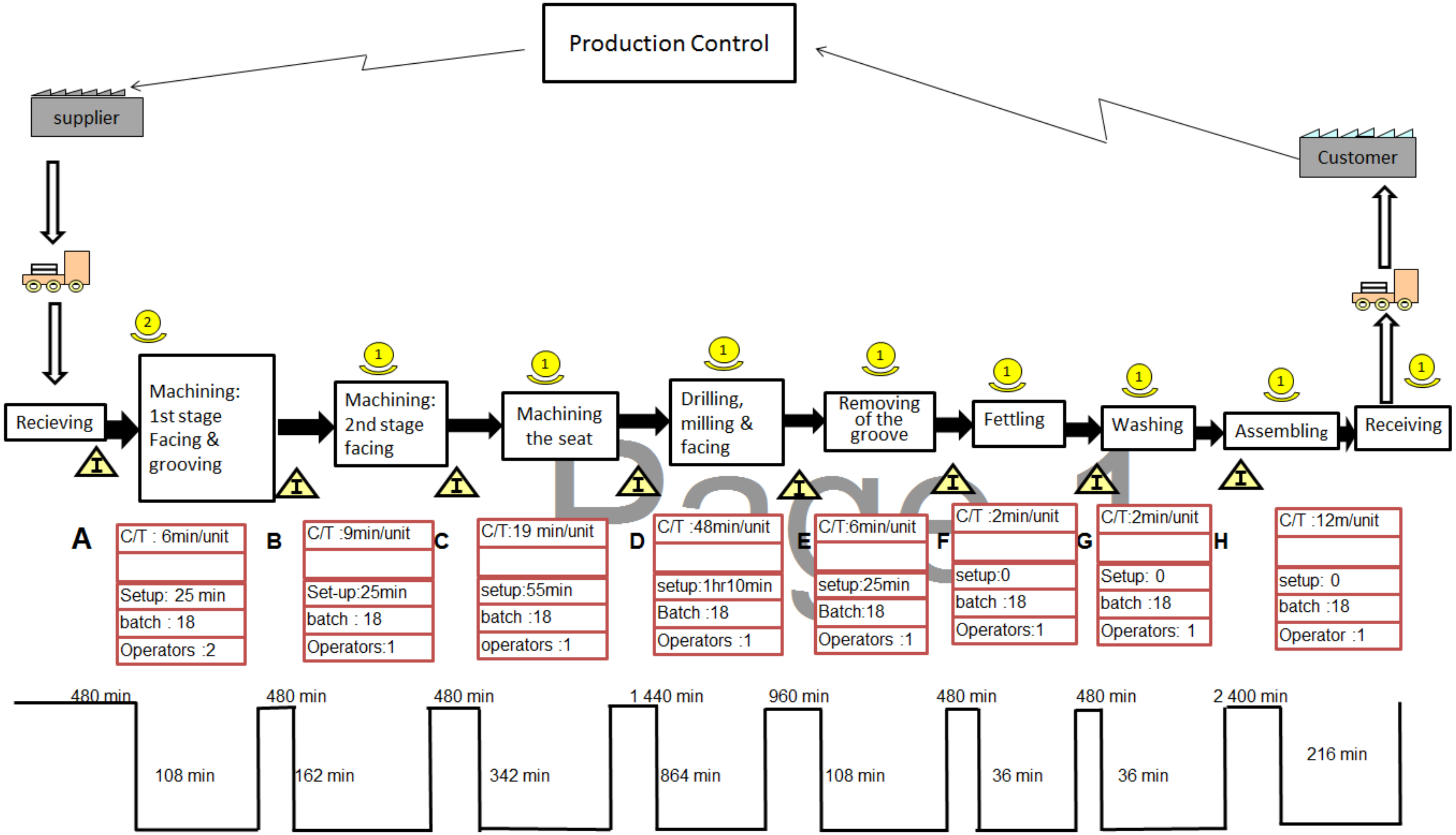

Figure 3: Current State Map – Paltech 100mm Butterfly Valve Line

The Future State Map

When the future state map was developed, the implementation team made a resolution to reduce the total lead time from 9072 minutes to 5 337 minutes, giving a 41.2% reduction in lead time. This arrangement increased the company capacity, thereby helping the company to consistently meet customer orders on time all the time. In order to realise the above benefits, an intervention plan in Table 4 was proposed. The plan sought to:

i. understand the customer demand for the butterfly valve;

ii. Establish continuous flow throughout the plant by introducing safety stock, buffer stock, and finished good supermarkets;

iii. Free space by redesigning of the plant at the fettling and washing bay;

iv. Eliminate bottlenecks in the line.

The tasks were defined and allocated to the implementation team members as shown in Table 4. Attending to these problems would help bridge the gap between the current state and the future state maps.

Table 4: Implementation Plan

No	Department	Problem	Action	Responsible
1	Stores	Late delivery of raw material from suppliers	Communicate with suppliers on weekly basis	Buyer/Storeman
2	Production planning	Poor production planning	Develop production plans for the butterfly valve	Workshop manager
3	Fettling	Excessive work in progress	Do line balancing	Industrial engineering Intern
4	All workstations	Lack of knowledge of plant capacity	Conduct work-study	Workshop manager/Industrial engineering intern
5	All workstations	Failing to meet production target	Design an appropriate visual management system	Workshop manager
6	All workstations	Excessive material and tools on the floor	Conduct 5S	Industrial engineering intern
7	Fettling and washing bay	Workflow delays	Plant layout	Industrial engineering intern
8	Drilling, milling and facing workstation	Bottleneck	Double number of machines	Workshop manager
9	Seat machining station	Bottleneck	Double number of machines	Workshop manager

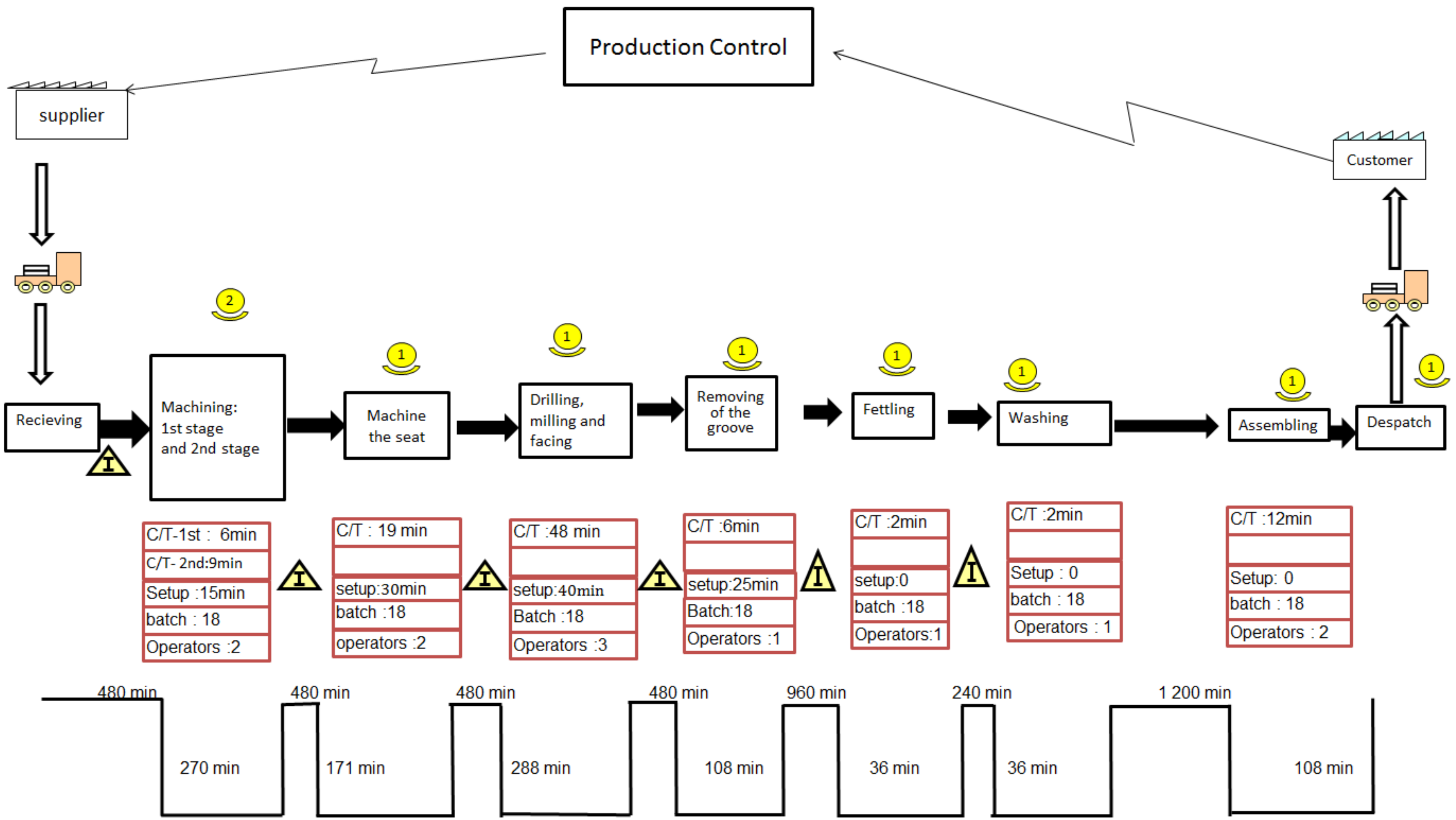

Figure 4: Future State Map - Paltech 100mm Butterfly Valve line

An action plan was devised for which the team scheduled biweekly meetings to ensure that communication flowed and that all involved parties remained on the same page. The plan was devised to be in sync with the future state, i.e.: the team planned how it would:

i. Meet customer demand,

ii. Improve the process flow, and

iii. Level production.

CONCLUSION

This was the first time that value stream mapping was applied at Paltech. According to Seith et al., (2008), lack of institutional experience obviously limits the benefits enjoyed. Value stream process can fail to achieve the intended results if people do not apply it properly or if they lack a fundamental understanding of the nature of the process (Tapping et al., 2002). For one to benefit from value stream mapping there is need to; (a) define value from the customer's perspective, (b) identify the value stream, (c) eliminate the seven deadly wastes, (d) make the work flow, (e) pull the work, and not push it, and (f) pursue to perfection (Tapping et al., 2002). However Paltech managed to benefit as follows:

- The current state map helped to show times taken by the different activities in the production line (value adding and non-value adding). This way, areas that had potential to improve were isolated.
- Based on the findings from the two maps, the implementation team was able to come up with a plan to reduce the gap between the current state map and the future state map. Moreover it identified resources necessary to effect the improvements.

Although the analysis was limited to the 100 mm butterfly valve, this could be replicated to other production lines. It can be exploited, with the necessary adjustments, in project, jobbing, batch, mass and continuous processes.

Value stream mapping is a tool that is helpful to companies that have embarked on continuous improvement. Gains recorded during the first run will act as a baseline for future improvements.

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