Continuous Improvement through Lean using VSM for Application in Machining Based Product Company

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Abstract: This paper is a consequence of a job in a business devoted to mechanical manufacturing (machining base product). During the entire manufacturing cycle, several wastes could be detected using a lean manufacturing approach by Value Stream Mapping (VSM). This paper proposes the techniques that are used to show the improvements to be achieved with each of the lean tools suggested. This work is primarily intended to be a guide for organisations that want to begin to implement lean production. The development of how lean management techniques are used continues dependent on the development of intelligent value today. Smart, creative techniques, critical information, talent, and big data need to be sustainable in other respects. I4.0 assumes a critical foundation of this latest vision for the organisation's future. As the results, the lean manufacturing approach by the VSM pointed out eight waste from the current production system, known as Kaizen burst that influence to company' profit which is high access inventory volume in between process, high rework and reject volume, delayed supplier and deliver product on time to customer, wrong forecast data, changeover time require long time, low machine performance/ inefficiency machine, travelled time in between process and lack on 5S activities. However, only three main findings based on the production system discussed in this paper.

Index Terms: Lean manufacturing, value stream map.

I. INTRODUCTION

In the past, the production activities were solely driven by profit, in order to guarantee the survival of organisations. However, the aim of maximising financial growth is becoming increasingly complex in conjunction with changing times. The performance of production operations has been affected by world competitions, a shorter product life cycle, dynamic demand pattern changes, and product diversities of internal operations [1]. In order to remain competitive, production should take into account the multi-dimensional strategies that are relevant to all aspects [2]. To meet market differences or customer needs, an effective solution is required. While manufacturing continues to increase globally, there is still a lack of overall production performance in that sector [3]. In facts, many manufacturing companies are actually still reluctant to take proactive action strategies [4]. Consequently, the strategy to promote best practices should be emphasized through several management approaches. These are to become the new driving force in creating a responsive manufacturing practice and thereby allow production companies to improve manufacturing society's performance and competences in the production of the products at minimum costs and economically. [5], [6].

The management philosophy of lean manufacturing is derived from the Toyota Production System [7], [8]. Before the term' lean' began, various similar terms and ideas were employed to describe this philosophy, such as world-class manufacturing, continuous flow manufacturing, zero inventory production and just-in-time [9]. It covers many principles, aims to primarily streamline the value-added activities and eliminate waste during the manufacturing process to reduce cost to meet the demand of the customer. In line with lean manufacturing principles for waste disposal during production, the aim is to meet and exceed the customer requirements [10]. Lean is used to improve information and material flow. Waste is primarily caused by unnecessary delays, tasks, costs and errors [11]. Overproduction, transport, inventory, over processing, waiting time, movement and defects are all seven waste items of Lean [12]. Lean operation within an organization demonstrated significant financial results, but it has been more difficult and often haphazard to increase lean implementation to an responsive production base [13]. Some of the challenges are due to the complex application of lean tools which need to be adapted to various production needs [14].

The concept of top management should cultivate a strong focus on lean techniques and methods, inspiring teamwork spirit among its staff, so as to generate a multi-value culture within the inner system and employee turnover of the organisation [15]. Womack also indicated that organisations should enhance the significance of defining issues and triggers for employees without being an excuse for a subsequent reprimand but an opportunity to congratulate them because company's worker has the opportunity to improve the firm. Numerous writers have described

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tools/techniques for supporting organisations main fields in the lean production sector as follows: flexibility; waste management; sustainability; process monitoring and human engagement, in order to present key ideas created by Taiichi Ohno in the Toyota Production System (TPS) [16]. However, Rother and Shook's initiatives with the implementation of Value Stream Mapping (VSM), to develop the value stream of a product [17]. In the most varied industries of activism, VSM is used as a waste detection instrument to promote the application of lean philosophy and has contributed to the elimination of certain obsolete ideas.

In this research the use of VSM is focused on the industrial product services sector to achieve company waste elimination targets. The industrial product service system is a production process based on the prioritisation of machine producers that results in an increase in quality, cost and time pressures [18]. In addition to the services and service providers, machine manufacturers confront increasing competition [19]. Other researchers also indicated that this leads to a more effective and efficient performance for the services [20]. Thus, performance measurement approaches response management by planning, control and performance monitoring, the method is then required as a methodology that methodically supports performance improvement with using the VSM [21]. The purpose of this paper is to help organisations to show how waste can be detected through the VSM production flow. This paper is organised accordingly: the research introduction on lean manufacturing through the approach of VSM. Then, the overview of the case study based on the selected company. The research method followed by a flow chart of this research. Next, the result and discussion through the general information and processes in the research. The paper concludes with conclusions and suggestions for further research.

II. OVERVIEW OF THE CASE STUDY

In this case study, a Small Medium Enterprise (SME) manufacturer was an automotive manufacturer of metal part machining based products is selected. The block cross member has been produced as a company business product for the automotive parts. The company mainly used conventional machining techniques with lower precision priority for its entire product throughout its timeline, while the outsourcing technique is used for products with high accuracy (such as measuring indicator and gear). These components are mainly used by car producers for the component that is used as a towing platform. In general, the company production workflow in manufacturing block cross member consists of three main stages which are detail order, fabrication and quality check as shown in Fig. 1.

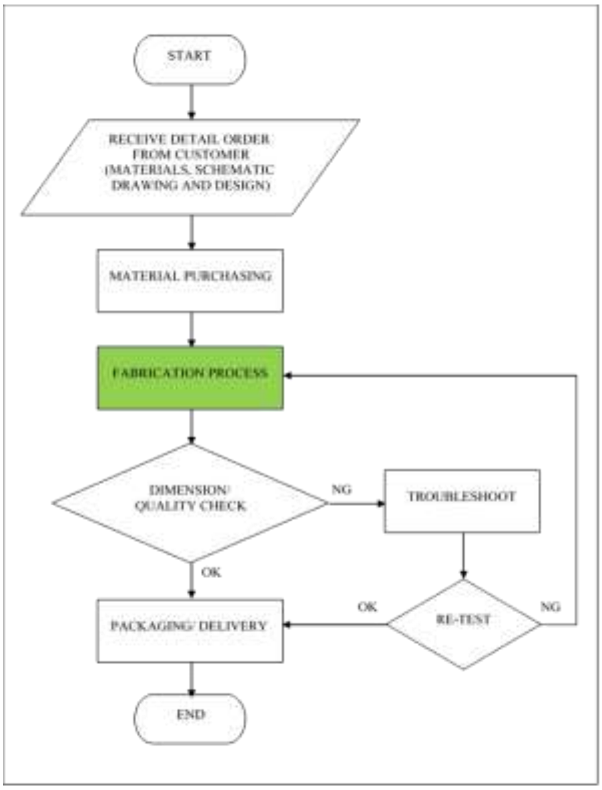

Fig. 1 Block cross member manufacturing workflow

III. RESEARCH METHOD

The research method presented in this section is based on the case study. Literature review as a research knowledge guidance in lean manufacturing approach. The lean manufacturing approach selected in this study are VSM. Identification of key elements for determining the main factors for implementing VSM. The main point is to get information that related to the case study for analysis methodologies, approach, and finding and the limitation of lean manufacturing in the various articles becoming future state VSM. From the waste found, consult and suggest for improvements to improve the production performance. Fig. 2 shows in a simple elaboration to figure out the method used in this paper. In this paper were discussed only three important Kaizen burst found from the future state VSM.

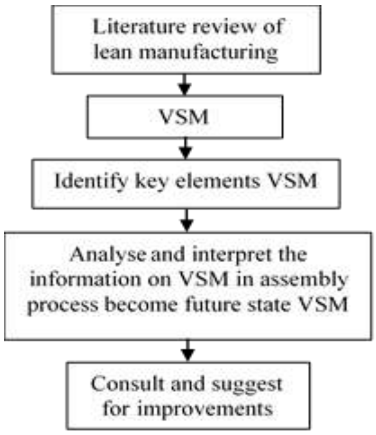

Fig. 2 Research method

IV. RESULT AND DISCUSSION

A. Current State Value Stream Map

The number of orders for the metal bar cross member sent by e-mail from the supplier monthly. Then the materials are ordered for the item by metal bar providers. The manufacturing planning is based on a customer order. It continues to the stage of manufacturing. The product is then manufactured in batch with one person on a machine 24 parts and 5 boxes per day. The products shall then be sent to the customer if the necessary box size is completed in a specified moment by approximately 13 boxes. The usual manufacturing lead time is approximately three days for producing 13 item boxes (by order). The block cross member is produced in four different classifications: cutting, milling, turning and tapping of materials. From the four processes are then divided into eight categories which are material cutting, material surface cleaning, cutting edge, first boring, second boring, third boring, threading, dimensional/ quality control, and packaging. The material is cut with horizontal band sawing machines for material cutting. The second sub-process after cutting requires the milling method, whereby the metal bar is cleaned, cutting edge and boring process. In the third sub process known as the turning method, two boring processes were carried out. The fourth sub process is similar to the boring method, tapping for a thread. All these are manufactured by the approach of human and machine. Finally, the quality check is to ensure that the final product complies with the specifications and functions before the packaging for delivery. The entire structure of every sub-process is turned into an end product called as a block cross member. Fig. 3 showed the current state mapping for the overall production.

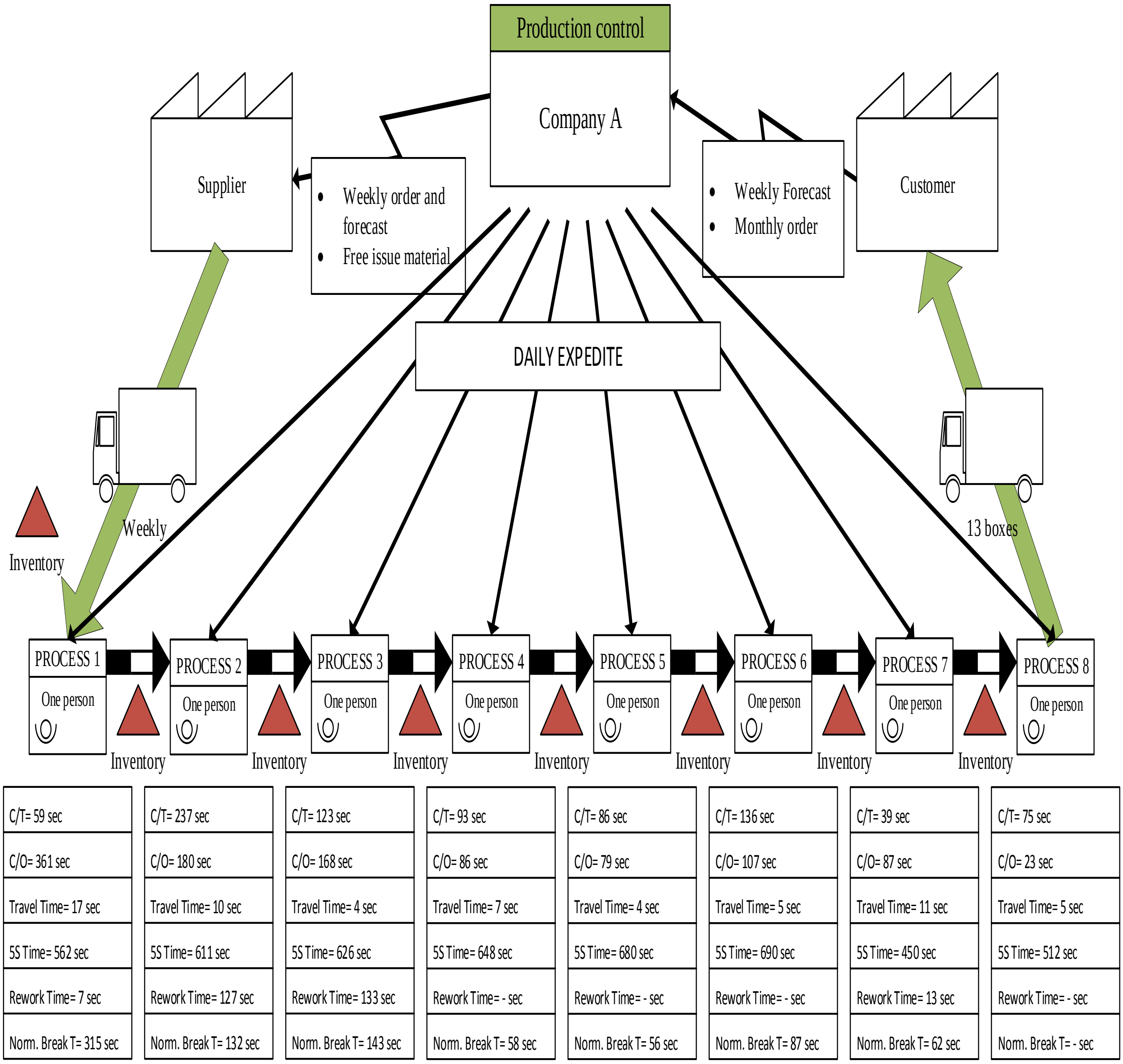

Fig. 3 Current State Value Stream Mapping

B. Future State Value Stream Map

Future State Value Stream Map provides an interim phase between the present map and the ideal state designed to improve the key to attaining business waste elimination objectives in the field of manufacturing. By using the current value map, the areas of concern which need improvement in the months to come and targets for company changes are identified. There are following wastages identified in the current system based on VSM of block cross member production process; high access inventory volume in between process, high rework and reject volume, delayed supplier and deliver product on time to customer, wrong forecast data, changeover time require long time, low machine performance/ inefficiency machine, travelled time in between process and lack on 5S activities. Fig. 4 showed the future state value streams for overall production with the Kaizen burst marking.

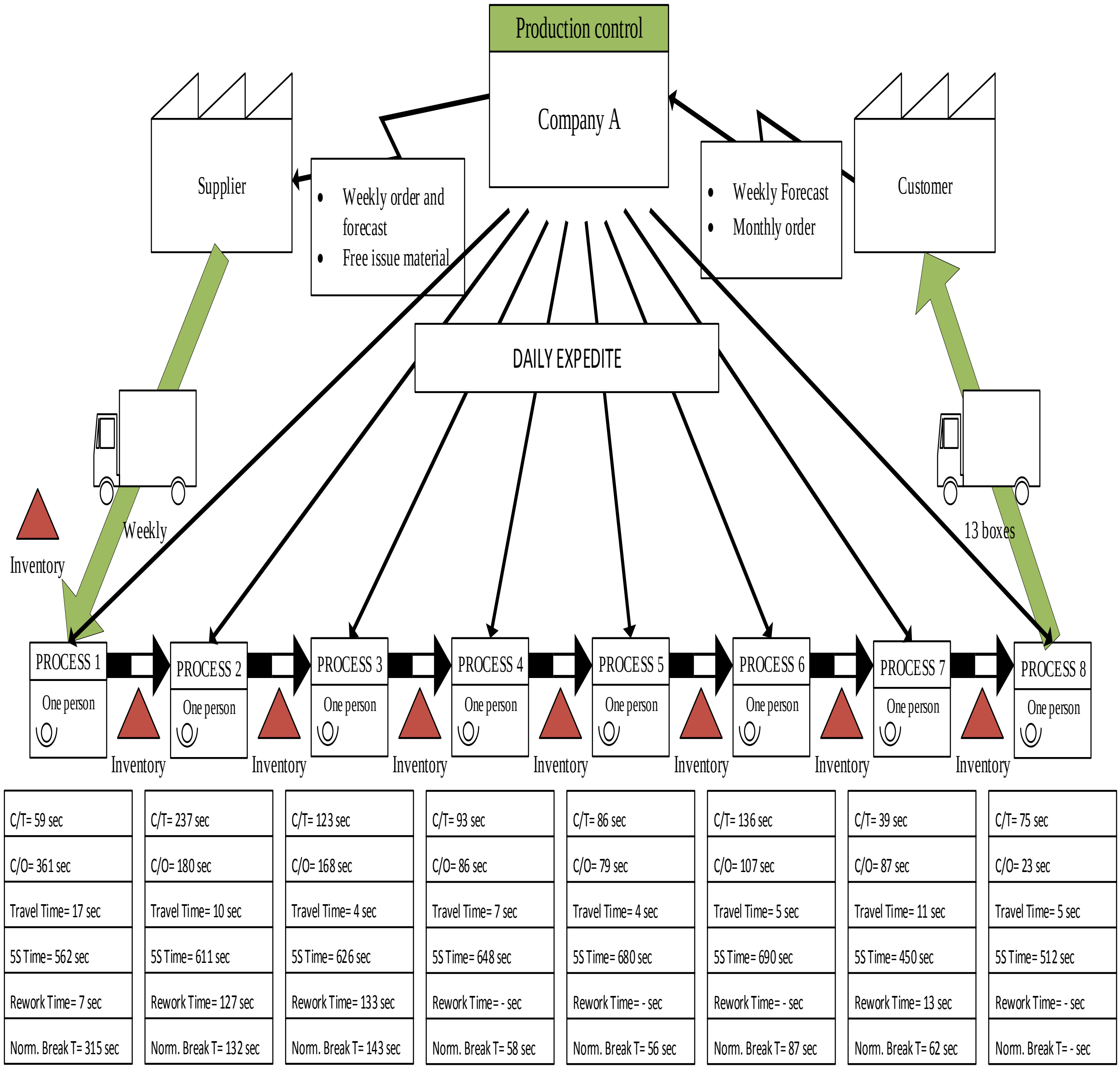

Fig. 4 Future State Value Stream Mapping

Delayed Supplier and Deliver Product on Time to Customer

Usually, raw materials from supplier and delivery order to customer is once a week. Delayed supplier and deliver the product on time to the customer will inhibit the travel of a company. Often happens in BRS when delayed from supplier occurs when the request exceeds the norm. This sequence is from the uneven customer's demand in the number of requests for every week. This can be seen from the secondary data (source from company' case study) for 4 months, March until June 2018.

In regular occurrence, the finished product will be delivered once a week to the customer. Based on secondary data observation from March until June 2018, the order from customer usually on Monday with the amount 312 pieces (13 boxes) and the promise date to deliver is after 3 days of work on Wednesday every week. Delayed usually occurs from the supplier company unable to comply with the additional order. Delay delivery of the product to the customer is due to an additional order requiring additional time to complete it. The time is taken in completing the additional order usually takes two days and will be delivered on Friday, two days later than the date of the appointment. Additional orders that cause this delay can be seen occurring each month which in March and June are delayed once and in April and May twice.

A string of it, whenever an additional order occurs the metal bar for the next order is forced to be used to fulfil the order. As mentioned before, the next metal bar will be less and require more orders than suppliers to complete the next order quantity. Thus, the hypothesis that can be made is an additional order from the customer will cause the delay of delivery and cause the addition of the order metal bar from the supplier which will also cause the delay of acceptance. Sometimes it will cause the operation to cease due to the absence of material. Therefore it will affect the working time for the process of manufacturing block cross member and delayed to deliver the order to the customer. In addition, high rework factors are also a source of failure to deliver the product to customers at the right time, then the company is forced to allocate the time for the process. The time used is a wastage that causes a delay. In the other hand, the weakness in order forecasting yearly data from the customer is also among the causes of this problems.

Changeover Time Require Long Time

Nowadays the methods for achieving the best number of changeover times have been taken into consideration and used by various techniques and instruments to reduce and standardise the time intermediary, especially in the production areas [22]. Referring to [23], manufacturing capacity is maximised by reducing the changeover that restricts the overall performance or the potential of a whole production line. In the production system of a variety of products, changeover time is becoming important [24]. Changeover time can be many categories of process, such as cleaning, set up of material, changing work time, retrieval of materials, changing instruments, changing tools, etc. Current situation in company' case study, the changeover take part in the process is material retrieve, material set up in the machine, cleaning chips from machine and changing cutting tool. The changeover process in the company' case study within 20 times observation (time study). The observation taken by stop watch to take the data as in second.

Table. 1 Average time of changeover for every machine

Process	Machines' Times (s)						
	Machine #1	Machine #2	Machine #3	Machine #4	Machine #5	Machine #6	Machine #7
Material retrieve	20.75	11.55	4.65	5.8	11.3	4	12.05
Material set up in the machine	14.6	20.85	15.1	7.6	12.25	12.1	7.85
Cleaning chips from machine	10.4	15.05	7.45	6.75	6.2	6.4	4.45
Changing cutting tool	317.35	144.6	155.55	83.2	57.1	57.25	57.85

The time difference in each machine process for changeover time is due to different machine procedure and size, different cutting tools, cleaning steps and distance for material retrieve. Changeover takes a long time for changing cutting tool in every machine, especially for machine #1, banding saw machine because of the bulky size of the blade, as well as precautions as dealing with blade insertion always involves physical contact with sharp objects. It takes around 5 minutes 3 seconds or 317.35 seconds for the changing cutting tool process. Vertical milling machine inserts change requires only around 2 minute minimum or 3 minutes maximum per insert (the total inserts per cutter: 8), although in usual cases for both machines, machine #2 and machine #3, not all 8 inserts will be changed simultaneously. The least is changing cutting tooling for lathe turning machine (drill cutting tool) and tapping machine (tap cutting tool) also takes time around 1 minute. Other than that, assuming material retrieve, material set up in the machine, cleaning chips from the machine are not give negative impact for the changeover time for the process.

In this case, reducing changeover time unlocks more productive time for running production. Another benefit is that by reducing changeover time you can reduce production batch sizes, work-in-process, and inventory especially in the changing cutting tool and precisely in machine #1.

Lack on 5S Activities

As part of continuous improvement, manufacturing chose to pursue a 5S workplace organisational and housekeeping methodology. The reason is that in high demand periods company always focuses on the case, the plant manager is overwhelmed and is more concerned about meeting customer delivery times rather than maintaining an orderly plant [25]. If the problems of 5S were not well conducted, safety risks may cause injury [26]. The current research aimed at assessing the effects of a 5S event on safety in a production environment by comparing all employees involved in batch processing.

i. Unorganized inventory
ii. Lack of cleanliness
iii. Too much and uncontrolled time for the 5S activities

Table. 2 Current 5S situation based on observation in BRS

5S Phase	Situation	Possible impact on safety
Sort	Unnecessary tools in machine Rough work flow Irregular excess inventory in between process	Irregular conditions can cause accident like tripping on access inventory during work
Set in order	Does not have tools box for the changing cutting tools equipment and other tools in every batch Take a long time to borrowing tools from other batch	Risk of using rusted or broken tools
Shine	Too many chip Wet floor because of coolant leakage	Risk on injured leg due to chips Risk slipping during work
Standardize	Does not have standard procedure is used in or while doing 5S Does not have any rules were created	-
Sustain	No daily, weekly, or monthly audits made to sustain on the 5S activities The workers not involved in making changes in the other workers workplace or batch	-

In the meantime, the 5S activities conducted is not much in preferred states as the disposal of waste materials are not properly arranged, thus may cause mishaps of irregular machine transmission behaviour due to the appearance; chips inside the transmission assembly or physical to the operators due to the lax of proper procedures of chip disposal. There also leak of coolant on the floor that not been properly clean. It may cause a wet floor that can lead to the workers slippery and odour at the surrounding. This situation if not resolved will cause undesirable things and it should be avoided to prevent any possible injury or accident happen. Table 3 shows the time study observation current activities in every batch before going home in 5 days based on sort, set in order and shine.

Table. 3 Current 5S activities in 5 days

Day	Batch 1	Batch 2	Batch 3	Batch 4	Batch 5	Batch 6	Batch 7	Batch 8
Day 1	555	619	625	640	666	685	439	516
Day 2	562	611	626	648	680	690	450	512
Day 3	558	613	631	645	665	677	452	524
Day 4	557	617	617	661	670	676	450	481
Day5	562	617	633	651	661	685	449	524
Average Time (s)	**558.8**	**615.4**	**626.4**	**649**	**668.4**	**682.6**	**448**	**511.4**

The table above shows the part of 5S activity which is sort, set in order and shine in 5 days and has been plotted into the average pie chart to determine the time rate for each batch. As can be seen in the pie chart diagram, the time recorded is between 448 seconds up to 682.6 seconds, 7.5 minutes and 11.4 minutes each. The highest time was recorded in batch 6 with an average time record of 682.6 seconds of activity with 14% of the total activity. For the lowest time is batch 7 with only 9% of the total activity of 448 seconds. Other than that, the things that can be seen from the diagram above are the activities that devote more time to the other activities for the 5 days of the findings. The activity is from shine activity showing more time than any other activity, which is sweeping and mopping.

V. CONCLUSION

Lean management consists of a number of techniques which enable businesses to gain firm benefits by an efficient implementation. Using a lean tools strategy is a straightforward and cost-effective way of achieving productivity and profitability, by focusing on waste management throughout the organisation. The lean tooling strategy is simple to use, involving the entire organisation and ensuring everybody's involvement, ensuring that the employees can be strengthened and all findings of the job visible. VSM implementation offers several advantages to the organisations, as VSM is used extensively in which human and machinery organisations work to improve equipment efficiency. Increasing productivity, better quality, fewer breakouts, reduced expenses, reliable supply, encouraging working environments, better safety protection and employee confidence to ensure through VSM implementation within an organisation. In the future, the results will then be extended with optimisation methodology and simulations to provide the best possible solutions in the machining based production system for quality and performance issues.

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