Engine Oil Change Lead-Time Reduction Using Lean Management in A Commercial Vehicle Service Centre

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***Abstract*—This research aimed to investigate the root causes of wastes in an authorized service centre to improve its overall service lead time, especially the engine oil changing service for light commercial vehicles. The engine oil change service process was grouped into three phases, i.e. pre-checking, maintenance and post-checking. The lean management concepts such as value stream mapping, 7 wastes, ECRS method, brainstorming, etc. were utilized for finding issues and wasteful activities in the current process. Furthermore, the concept of dual mechanics was adopted to reduce service time in the maintenance phase. Overall, the ineffectivenesses were classified into three groups, namely ineffectiveness from service advisor (SA), workshop management, and parts management. The appropriate recommendations were given for quickening the engine oil change process and being a prototype model for other authorized service centres in Thailand. The results showed that the range of engine oil changing service time was reduced from 1.3-3.3 hrs. to 1.1-2.6 hrs. for non-appointment customers and from 1.2-2.5 hrs. to 0.9-1.8 hrs. under the utilization of dual mechanics.**

***Index Team*—Service Centre, After-Sales Service, Light Commercial Vehicle, Lead-Time Reduction, Lean Management**

I. Introduction

According to the Thai industry overview (Table I and Table II), although the market volume in 2019 was decreased by 9.20% from the previous year, the overall market value growth trend of the Thai automotive market was still increased by 15.50% and it will continuously rise over the next 5 years [1]-[3].

TABLE I
Thai Car Market Value And Volume From 2015 To 2019

Year	Thai Car Market Value		Thai Car Market Volume	
	$ Billion	% Growth	Thousand units	% Growth
2015	12.1	-	772.3	-
2016	13.4	10.60%	805.0	4.20%
2017	13.6	1.30%	818.4	1.70%
2018	18.9	39.30%	877.0	7.20%
2019	21.8	15.50%	796.3	-9.20%

Source: Available from https://0-advantage-marketline-com.pugwash.lib.warwick.ac.uk/Analysis/ViewasPDF/thailand-car-manufacturing-98454 [Accessed May 5, 2020]

TABLE II
FORECASTION THAI CAR MARKET VALUE AND VOLUME FORM 2019 TO 2024

Year	Thai Car Market Value		Thai Car Market Volume	
	$ Billion	% Growth	Thousand units	% Growth
2019	21.8	15.50%	796.3	-9.20%
2020	21.6	-1.10%	814.9	2.30%
2021	23.5	8.80%	819.9	0.60%
2022	25.5	8.30%	825.7	0.70%
2023	27.4	7.60%	830.5	0.60%
2024	29.4	7.10%	834.7	0.50%

Source: Available from https://0-advantage-marketline-com.pugwash.lib.warwick.ac.uk/Analysis/ViewasPDF/thailand-car-manufacturing-98454 [Accessed May 5, 2020]

The case study company is one of the leading Japanese commercial vehicle manufacturers which has established the distribution headquarter in Thailand since 1960. The company supplies vehicles, produces parts and grants authorized dealers to up to 80 companies with 332 branches all over Thailand. The dealers are responsible for selling vehicles and providing after-sales services in terms of car maintenance and repair. The main products of the company are divided into two segments, including light commercial vehicles (LCV), e.g. pick-up and multipurpose 7 seat vehicles (SUV), and trucks which are highly popular in Thailand by having been continuously dominated the commercial vehicle market for more than a decade with excellent quality and meet the needs of the market. In the current situation, it cannot be denied that the business disruption is likely to happen quickly and the after-sales business becomes to be a key important part of business sustainability. The income from the operations of the company and authorized dealers considered by the number of served cars at the service centres have continuously declined over the past eight years. Hence, the company and dealers must adapt themselves to the rapid change in customer behavior including the faster service time, availability of tools and equipment, skills of mechanics, and workshop management to increase customer satisfaction for the sustainability of the after-sales business. Moreover, the current serious problem is the declined number of LCV service units to come to receive services from the dealers from the year 2009 to 2019 (Table III).

TABLE III
THE NUMBER OF NATIONWIDE LCV SERVICE UNITS FROM 2009 TO 2019

Year	Total Service Units	% Change
2009	2,430,809	-
2010	2,758,942	13%
2011	2,795,766	1%
2012	2,577,386	-8%
2013	2,509,491	-3%
2014	2,396,253	-5%
2015	2,306,240	-4%
2016	2,215,925	-4%
2017	2,200,889	-1%
2018	2,139,289	-3%
2019	2,192,221	-2%

To pave way for improving customer satisfaction, this research focuses on the service time reduction of the highest majority of the services, i.e. the engine oil changing service, which offers preventive maintenance for vehicles. This is because 80% of the sales volume of the company comes from LCV (i.e. pick-up and SUV) and the remaining comes from trucks. This research aims to apply the lean concept to identify non-value-added activities over the whole process of the engine oil changing service of LCV and recommend the improvement tactics to reduce the lead time in car workshops.

The expectations intended to accomplish from this research are as follows: (1) To reduce the current service time of engine oil changing to compete in the market, (2) To improve the workshop management to make a better bay turnover rate about oil changing resulting in getting more service units and more income from customers, (3) To compete in the car after-sales business and get a competitive advantage, and (4) To create a good brand image which can convince absent customers to come back to the service centre, leading to brand loyalty.

The remainings of the paper are presented as follows. The related literature is reviewed in Section 2. Section 3 presents the methodology used for solving the problems. The results are explained in Section 4. Finally, the concluding remark is given in Section 5.

II. Literature Survey

A. Importance of Lead Time Management

From the management of the supply chain, the definition of lead time is the period from placing an order to receiving products by customer. Recently, customer behavior was changing rapidly and many companies try to offer better value and faster time to get a competitive advantage and also gain more profit with the improvement of quality and time. In the industries, shorten lead time will help the company to increase sales volume. Some researchers explain that the way to reduce the lead time in manufacturing is not a new thing to learn. They might want to remind organizations to discover the chance to wipe out inessential time in the process. The time for providing a service is very important to customers. They suggest that the firm should reduce lead time through a company strategy to define this issue more efficiently [4].

To get a competitive advantage, customer satisfaction and loyalty are the key issues for after-sales businesses to increase profit and make a sustainable business. Hardly, the satisfaction of the client shows the difference between perceived and expected perspectives. Therefore, concerning the vehicle service maintenance based on customers' requirements will be the main objective. In terms of the importance to the car owners bringing their cars to service, the workshop is under 5 principles, i.e. reliability, responsibility, assurance, empathy, and tangible. The way of controlling the service process may require the system to support many activities and quality control is the main success factor of the process. So quality controller and operational checks can save the risk to make any mistakes [5].

B. Methods of Lead Time Reduction

Han and Zhu [6] showed one of the principles of Toyota's core (Fig. 1). They explained that the primary goals of the lean concept are to decrease the wastes and improve the operation, learn about the client conduct to expand productivity, and limit the non-esteem costs, prompting getting the return on advantages.

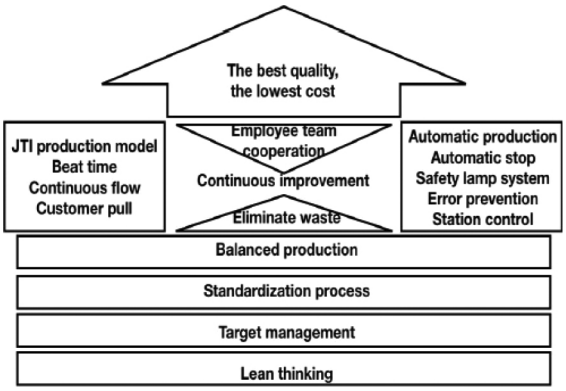

Fig. 1. The principle model of lean production

The basic elements of the production process include three stages. First, the operation process may have to be more flexible for responding to the market changes relating to the modular design of the production line which may improve the responsiveness of the firm to the market and improve the efficiency of utilization of the company resources. Developing the production flow is the second priority. Third, unnecessary activities should be eliminated. The production and processing processes should be stabilized so that both of them can make a reference processing route. After analysis of the processing technology, the non-value actions are removed [6].

C. Framework of DMAIC

To get a competitive advantage in the manufacturing and service industry, Total Quality Management (TQM) has related to the approach of strategy to respond to the challenges in the business world. TQM has become to be a part of the strategic management in the company which can lead to continuous improvement and the involvement of the organization by focusing on quality to make awareness in each step from the beginning of production and service to the end customer. The continuous improvement can outrun other competitors in the market that the company can provide products or services with high quality and low prices by culminating Six sigma which means 99.99927% defect-free targets in production.

The main consideration is about the improvement of quality and adds a Six Sigma approach which is a business improvement strategy to improve the financial business in terms of profit and cash flow, to reduce unnecessary costs from waste, to improve the adequacy and productivity of all things considered leading the better consumer loyalty to cover nearly the TQM components. The method of TQM has divided into five phases with the following details:

Define Phase: For the first one, it will define the research's objectives and scope by collecting information on the process, the requirements from customers, and finding other factors from both internal and external environments [7].

In this project, Value Stream Mapping (VSM) will be the methodology to use which is a model to identify the waste and losses within the operation and plan to improve the flow of the production process and the information of materials through the process. VSM is different from other tools that can show only the tasks that are accomplished to complete a process. It can show the interaction between functions in the manufacturing process such as planning, scheduling, production, purchasing, etc. VSM can help coordinate in-process materials which are likely to be a common source of significant loss. This effective tool can visualize the limitation factors and highlight problems within complex systems.

However, every problem cannot be solved by VSM. This tool has some consideration points before making a final decision. It cannot map the diversity of products that do not have verified in the production flows. It fails to make a relationship between transportation and material handling queuing, and transferring in batch sizes from poor plant layout or manufacturing system. The company cannot use only VSM which unlike the flow process charting technique to measure economic factors such as profit, operating costs, etc. It fails to help the management team to allocate or utilize internal resources such as work-in-progress storage, floor space, and electrical aisles. This tool tends to be a special method to focus only on high-volume and low-variety functions and design a factory that will consider only continuous flow, the pattern of an assembly line, Pull scheduling [8]. To summarise, VSM is a fascinating device that can embrace breaking down this project. Composing VSM accurately will assist the creator with understanding the procedure stream more clearly, seeing the cooperation of multiple functions in an organization which these things will help to investigate and implement a lead-time reduction plan.

Nallusamy and Adil Ahamed explain that in a rapid change of business, many industries give importance to reducing lead time, low costs, and, get better customer satisfaction. Considerably, the firm can find the main problem issue up to 90% to make high lead times which came from the existing non-essential activities and these problems should eliminate. So the lean concept idea may have to apply to increase the value perception of customers and reduce the unnecessary things of the products (Table IV). This principle is based on performance to increase profit and competitiveness by eliminating seven wastes, reducing non-value time, and saving costs. Another production, for example, refers to the automotive industry at Chennai, they used the Value Stream Mapping (VSM), 5S, the standardization of process in the manufacturing area. VSM is one of the effective tools to see the time cycle of a process and investigate how a process operates one by one step. So the combination of lean and VSM can enhance the improvement of the process [9].

TABLE IV
DIFFERENT TYPES OF WASTES

Types of wastes	Explanation
1. Overproduction	Produce the non-order items
2. Waiting (time on hand)	Waiting for the next process, switching on tools or materials
3. Unnecessary transport	Transferring with long distance between processes or working process
4. Over-processing	Processing with unnecessary steps to prepare the parts from poor design or tools
5. Excess inventory	Producing excessiveness of raw materials, work in process, or finished goods in the inventory
6. Unnecessary movement	Not effective for employee perform during their work
7. Defects	Scarp or replacement from defective materials
8. Unused employee creativity	Not developing skills, ideas, or ignoring the engagement of employees leads to less employee satisfaction

Measure: Desai and Shrivastava explain that this stage presents each procedure mapping, operational definition, information assortment, assessment of the current framework, evaluation of the present degree of procedure execution, etc. Analyze: This stage depicts the potential causes which have a huge effect on the low procedure yield, cause-and-effect diagram (Fishbone), the analysis of Pareto, Why-Why methodology, and so on. These models will help to distinguish the essential root causes of the problems and decide which elements have to be controlled to bring about the ideal improvement [7]. Improve: Abdulmouti explains that the methodology of continuous improvement is called Kaizen which is in Japanese characters to imply great or better. Thus, this principle can help the company to focus on the improvement plan for the short and long term. In 1902, Sakichi Toyoda invented a verification framework that changed production forever. It was built by the Toyota company. This turned into the Jidoka idea of Toyota Production System (TPS) that it can help the firm to review what the current operation is and how to reduce some unnecessary activities (Muda) in the system [10].

Kaizen's philosophy focuses on rearrangements by separating complex procedures into their sub-procedures and improving them with little or no extra costs. Generally, Kaizen starts with how to convey gainfully with restricted assets, for example, man, material, and machine. It is not essential to utilize all the accessible resources assets and labour. Despite what might be expected, it should find a plan to save the existing resources as much as possible. For instance, if something is seen as unused, it is better not to attempt to utilize it. Saving investment of Kaizen can be accomplished by asking how much labour and what number of products are expected to accomplish a target level of productivity. Most firms effectively occupied with continuous improvement to utilise the arrangement as Plan, Do, Check, Act for critical thinking.

Control: After implementing all improved plans, periodic solutions should be reviewed the standardization of work procedure need to review to sustain the long-term profit. The business quality management carried the control of strategy by reviewing the mission and targets of each process which may impact the overall business goals [7]. The relative departments may need to generate the instructions of old and current procedures to prepare for the continuous improvement plan. This may lead to the use of control charts and check sheets to remind what staffs have to do regularly and also make awareness through internal training as well [11].

III. METHODOLOGY

As mentioned earlier, this research concentrates on the reduction of oil changing lead time for LCV in Thailand. The secondary data related to historical services reported by a selected dealer are summarised and utilized as the main input data. Besides, the top management insists that the proposed method should offer a pragmatic ground so that it could be easily adopted by all dealers in the future. Other main concern is also on the investment needed for improving the existing process should not be so high so that all dealers are affordable. These criteria need to keep in mind as the significant issues listed in the top priority while developing possible improvement solutions. The approach to come up with appropriate solutions consists of five steps as shown in Fig. 2. These steps are adapted from the DMAIC of Six Sigma.

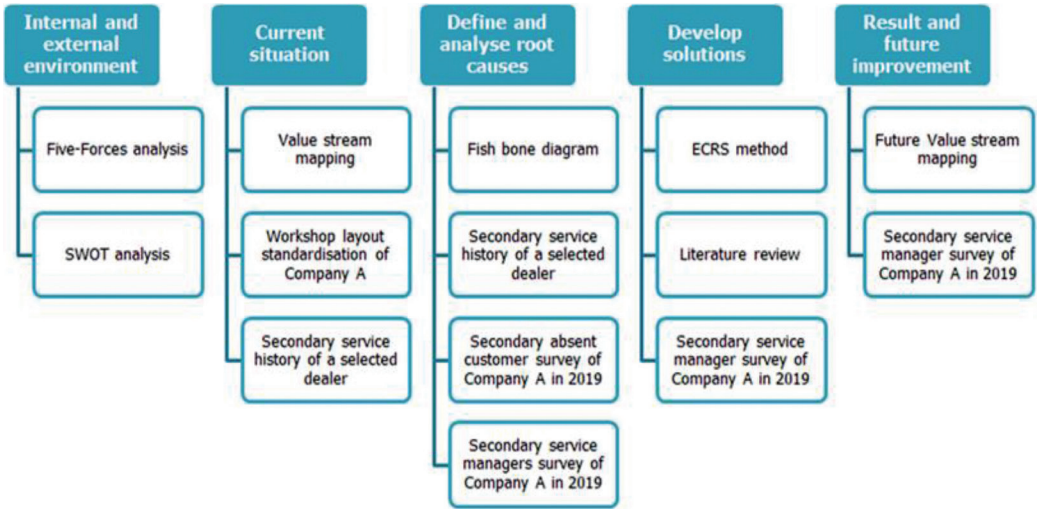

Fig. 2. The research plan used in this research

The first step is the analysis of internal and external factors through the Five-Forces model and SWOT analysis. These tools help clarify weaknesses and threats currently encountered by service centres and highlight strengths and opportunities for developing a possible development plan in the next step. In the second step, the data recorded from the real service history in the selected service centre from October 2019 to December 2019 are summarised. The workshop layout, as well as the current operational process of the dealer, are pictorialist through the value stream mapping (VSM) to represent the overall operational procedure of the service provider.

The third step involves the define and analysis of the root causes. Before conducting workshops to draw a fishbone diagram, three sources of information are utilized (Fig. 3), i.e. the service history of all staff in the service centre, the list of non-returning customers, and the service manager surveys. These data could reflect the internal and external perspectives about the current service centre situation. The company assigns a specific department to regularly conduct surveys to collect and summarise data for monitoring and reporting to the management team. As a result, this research takes the summarised results to declare some interesting factors, both internal and external, during the root cause analysis to determine proper means for improvement.

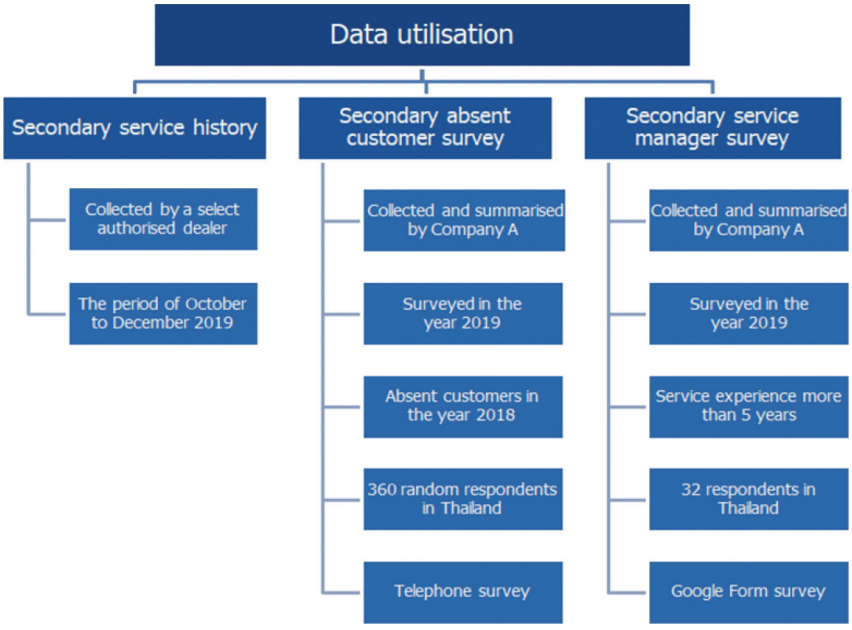

Fig. 3. The secondary data used in the research

For the non-returning customer survey, the customers who visited the service centre in the year 2017 and did not come back in 2018 are randomly selected. 360 respondents from different regions of Thailand have participated in the telephone survey. Besides, a survey with randomly selected and willing-to-joined 32 service managers who have service experiences of more than 5 years is done via a Google form on the Google platform. The problems and bottlenecks in the current process are identified through the analysis of the VSM along with all necessary secondary data. As a result of the analysis, the fishbone diagram is systematically developed under brainstorming sessions of the working team.

Once the root causes are notified, the improvement mechanism is proposed in the fourth step. Related literature is reviewed to discover the same or similar cases of problems. Also, the lean technique of ECRS (i.e. eliminate, combine, resequence and simplify) is applied to the current VSM to reform it into a better shape. In the last step, the new VSM, as well as the new operational procedure, is drawn. This new procedure is implemented and evaluated for a certain period to determine its effectiveness.

IV. Result and Discussion

A. Pre-Checking Phase

Fig. 4 and Fig. 5 illustrate the VSM of the engine oil changing process in the pre-checking phase for non-appointment and with-appointment customers, respectively. It is noticeable that a service advisor (SA) has to check the vehicle condition and perform a preliminary checking for all customers one by one (points 1, 2, and 3 in Fig. 4 and Fig. 5). However, the preliminary checklists of SA are quite similar to those used in the workshop by mechanics. Although some customers feel good about that particular activity, it is a wasteful activity in terms of service lead time. Hence, the service center needs to eliminate and adjust the duplicated activities for reducing the service time. Moreover, some SA may not have sufficient technical knowledge to appraise mechanical problems due to their educational backgrounds. Most mechanics can do this job a lot better than SA due to their direct skill and responsibility. Since these activities are non-value-added as suggested by the working team, they should be eliminated from the pre-checking phase. However, SA still needs to check the vehicle condition, e.g. dents and distorted points appeared on the vehicle's body, and get customers' acceptance before sending the vehicle to the workshop. The new process consumes only 2-3 minutes This new arrangement can save time up to 80% of the whole SA process in the pre-checking phase. It is found that customers with appointments receive a direct benefit from such lead time reduction by spending only 12-36 minutes with the new process instead of 15-43 minutes under the current procedure.

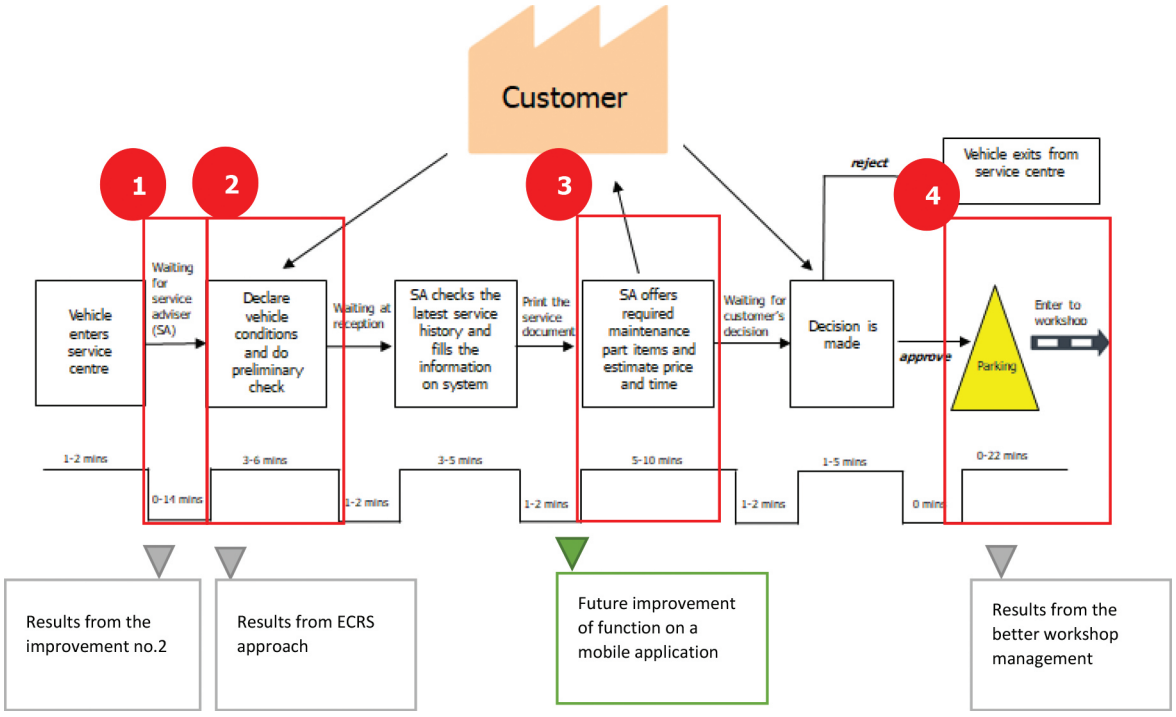

Fig. 4. The VSM of the engine oil changing process in the pre-checking phase for customers without appointments

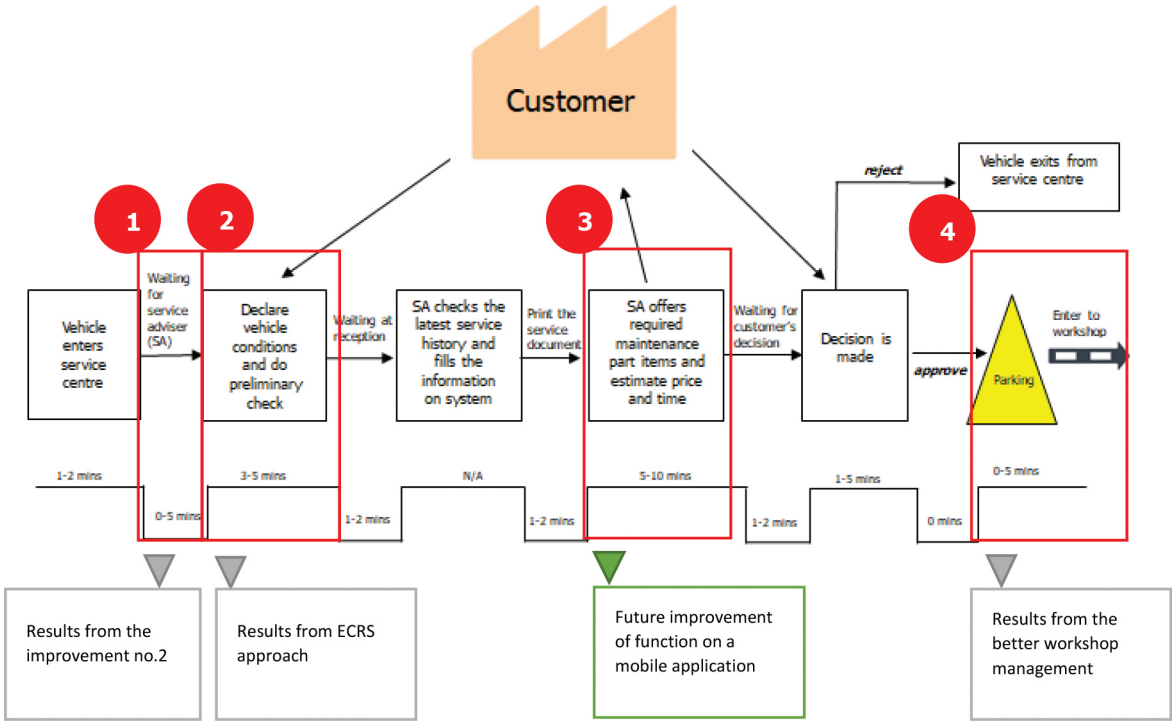

Fig. 5. The VSM of the engine oil changing process in the pre-checking phase for customers with appointments

Since we are in an age where digital technology is thriving, the existing technology should be utilized as much as possible. As a result, a mobile application is developed to provide effective customers appointment and resource planning (Fig. 6). However, SA still has to print out the service lists to show the estimated price and service time to confirm with customers. If SA can fill in this information and send it to the customers' mobiles to get their approvals, this paperless procedure can even save more time and cost to the service provider. All these improvements impact the pre-checking process directly because SA not only can manage the workflow in the reception area smoother but also he can send the vehicle to the workshop quicker. The new process reduces service time by up to 30% for walk-in customers.

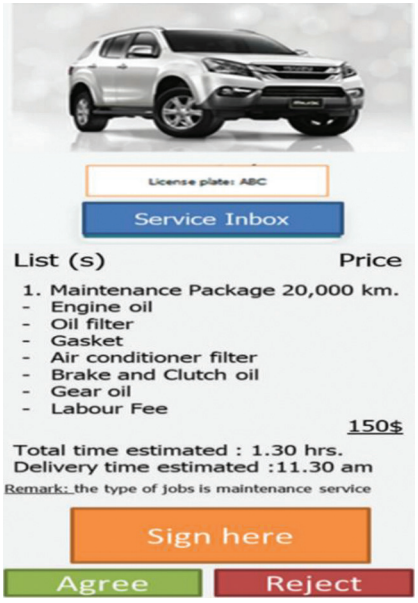

Fig. 6. The service confirmation platform on a mobile application

B. Maintenance Phase

The maintenance phase controls the overall engine oil change service time (Fig. 7 and Fig. 8). The chief mechanic is the key man who controls every step in this phase (points 5-7 in Fig. 7 and Fig. 8). However, his management seems to be in a mess reflected in the non-systematic work order and the lack of work priorities. The result of working team meetings comes up with the following ways to improve the workflow in the workshop. The historical data need to be utilized to prepare necessary resources and planning for the workflow in the maintenance workshop. From the data analysis, the peak days are on Monday and Saturday, and the peak hours are between 07.00-11.00 a.m. According to the VSM, the chief mechanic must assign work queues for all mechanics based on the historical data (point 5 in Fig. 7 and Fig. 8). Moreover, he must set up the morning meeting before the work starts for 10-15 minutes to let all mechanics be informed about the expected walk-in service volume, service appointment for that day, and plan to handle and assigned mechanic queue, to let them run their duties immediately and need not wait for the command during the peak period [12].

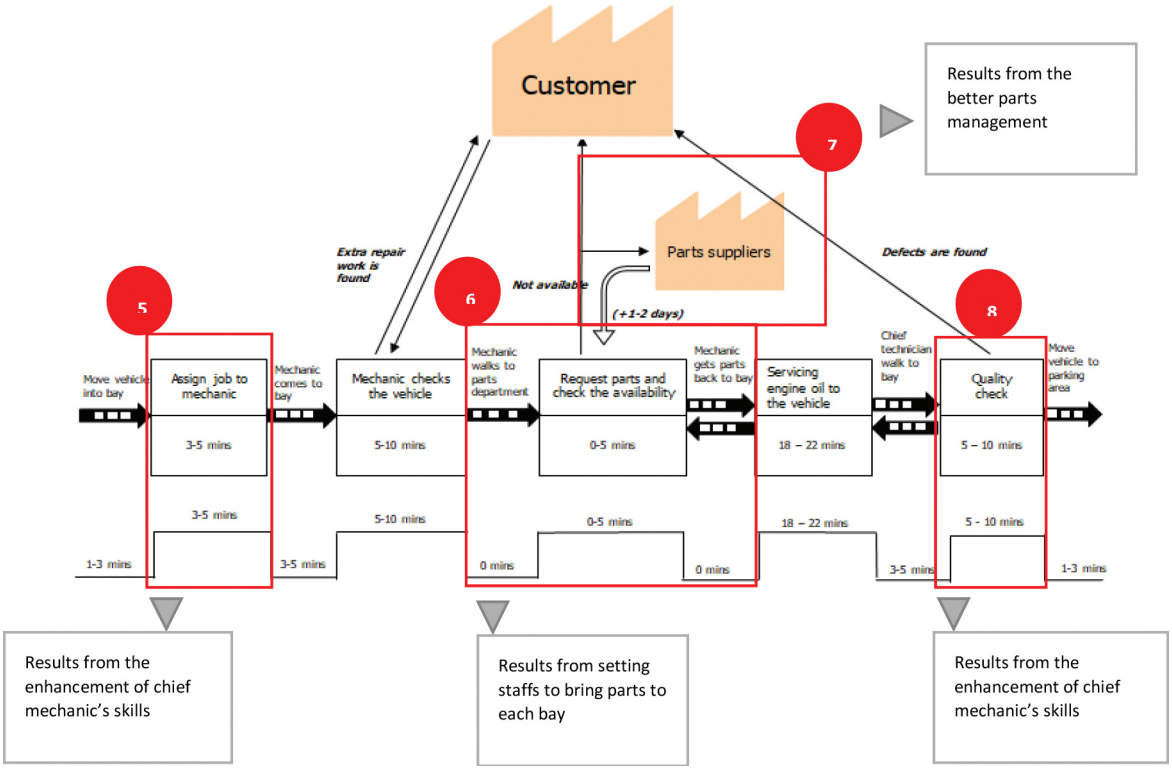

Fig. 7. The engine oil changing process in the maintenance phase for non-appointment (single mechanics)

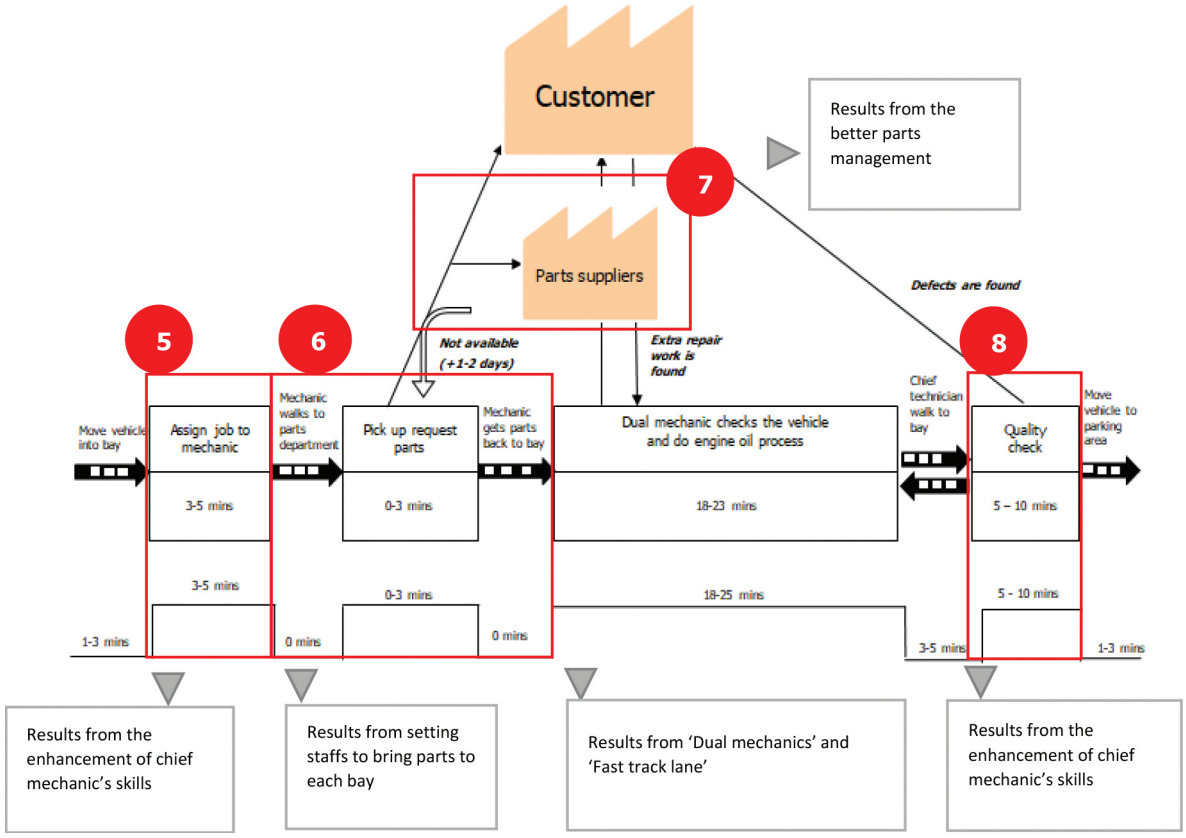

Fig. 8. The engine oil changing process in the maintenance phase for appointment (dual mechanics)

For the walk-in customers, after SA fills the service lists into the computer system, the data will be transferred to the parts department immediately to let the staff in the parts department prepare the requested items (point 6 in Fig. 7 and Fig. 8). Moreover, the service centre should prepare one spare staff who will send the requested parts from the parts department directly to the bay attended by individual mechanic directly so that the mechanic can concentrate on his job and does not waste his time walking around the parts department (point 7 in Fig. 7 and Fig 8). However, during peak hours, mechanics may need to wait for the requested items but normally this takes very little time. This new way of work reduces the processing time from 25 minutes to 10 minutes or less. Meanwhile, the parts staff can prepare the set of parts used in the engine oil changing for the customers who make an appointment in advance.

Another problem that needs attention comes from the forecast error which is caused by the wrong choice of the estimating technique related to current, seasonal, or future patterns of parts. This results from the internal culture, attitude, and understanding of the staff in the parts department. Thus, training is necessary to provide decent knowledge to the parts staff. The contents in the instructional manual must involve the explanation of parts, life cycles, future patterns, and proper forecasting techniques. Once trained, the forecast error must be monitored constantly to see the increased expertise of the parts staff.

The last step in the maintenance phase (point 8 in Fig. 7 and Fig. 8) is the quality checking which takes around 5-10 minutes (point 8 in Fig. 7 and Fig. 8). While performing quality checking, the chief mechanic may not be able to fully control the workshop management, leading to the run out of time and the ignorance of quality control. However, from the previous solutions in each step, this problem can be eliminated which helps the chief mechanic to have more time to perform quality checking, leading to the reduction in the reworks.

Interestingly, to be more effective, the working team asks the company to launch the dual-mechanic working scheme. The idea is that two mechanics are needed to complete an engine oil service together because both of them have to work on different service lists of a vehicle simultaneously without waiting for each other (Fig. 9). As a result, the engine oil change time can be reduced by half. Arguably, the service centres may feel that the concept will incur a higher cost because it needs to utilize one more mechanic to help run this concept. But if the dealers use this concept to increase the bay turnover rate, they will get more income due to the increase in

the service volume and getting higher customer satisfaction due to quicker service time. Hence, the service centres are recommended to apply this idea during the peak day or peak hours to reduce the bottleneck in the workshop.

Maintenance service at 40,000 kilometres	
No	**Example of job contents for Mechanic A**
1	Checking the alarm system before getting car on the lift
2	Peliminary check For example; brake pedal and clutch pedal for travel and play, steering condition, parking brake condition, and horn
3	Discharging engine oil
4	Refill engine oil
5	Check tire pressure

Maintenance service at 40,000 kilometres	
No	**Example of job contents for Mechanic B**
1	Preparetion tools and instruction sheet.
2	Peliminary check For example; light, emergency light, turn signal indicator, internal lights controls, internal condition controls, operation of wiper and washer jets, and gear control mechanism for looseness
3	Replace oil filter
4	Replace engine oil gasket
5	Check tire pressure
6	Start the engine and check the engine condition

Fig. 9. The dual-mechanic working scheme for the engine oil changing service

C. Post-Checking Phase

For the post-checking stage (Fig. 10), both non-appointment and appointment customers are indifferent. The waiting time for delivering finished vehicles to customers and the procedure of confirmation serviced lists have two wasteful activities (points 9 and 10 in Fig. 10). In this phase, customers have to come to check their serviced vehicles. However, the dealer does not control when the customer will come. To remedy the situation, again the customer's confirmation can be improved by using the mobile application as a fast track to help SA to foresee customers' arrival times.

Table V and VI summarise the improvements between current and proposed procedures. For the customers who prefer to wait at the service centre while waiting for the maintenance service can gain full benefits from the new procedure. The proposed procedure can improve the whole process used for the engine oil changing from 1.3-3.3 hrs. to 1.1-2.6 hrs. for non-appointment customers, and from 1.2-2.5 hrs. to 0.9-1.8 hrs. for appointment customers. However, for those who do not want to wait at the service centre, the benefits after using the new procedure are on the pre-checking and post-checking phases only. However, both customers (waiting or non-waiting) can get the advantages from the reduction of the engine oil changing lead time. The new office layout of the dealer is also developed as shown in Fig. 11 to facilitate the new workflow.

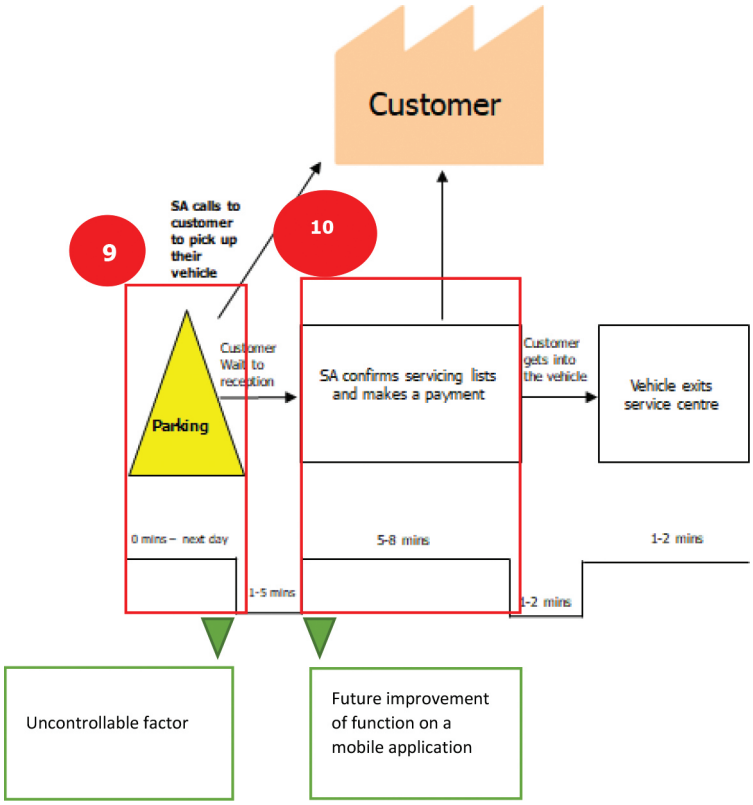

Fig. 10. The engine oil changing process in the post-checking phase

TABLE V
THE COMPARISON BETWEEN BEFORE AND AFTER IMPROVING ENBINE OIL CHANGING SERVICE

Phase	No.	Non-value activities	Main problems	Solutions	Time used (before)		Time used (after)	
					Non-appointment	Appointment	Non-appointment	Appointment
Pre-checking	1	Waiting for service advisor (SA)	- Issue of inefficiency and communication skills of SA working	- Result from second and third points	0-20 mins	0-5 mins	0-14 mins	0-5 mins
	2	Declare vehicle conditions and do preliminary check	- Issue of inefficiency and communication skills of SA working - Issue of poor workshop management	- The enhancement of SA skills - Eliminate duplicated preliminary check	5-10 mins	5-10 mins	3-6 mins	3-5 mins
	3	Offer required maintenance parts items and estimated price and time	- Issue of inefficiency and communication skills of SA working	- The enhancement of SA skills - Creating a tool to enhance the communication via mobile application	5-10 mins	5-10 mins	5-10 mins	5-10 mins
	4	Waiting for vehicle's moving into the workshop	- Issue of poor workshop management	- Result from second and third points	0-30 mins	0-5 mins	0-22 mins	0-5 mins
Maintenance	5	Assign job to mechanic	- Issue of poor workshop management	- The enhancement of chief mechanic's skills	5-10 mins	5-8 mins	3-5 mins	3-5 mins
		Mechanic comes to bay			3-5 mins	3-5 mins	3-5 mins	3-5 mins
	6	Mechanic walks to parts department	- Issue of parts management	- The enhancement of chief mechanic's skills	3-5 mins	3-5 mins	0 mins	0 mins
		Mechanic requests parts and check the avalibility			5-10 mins	0-3 mins (Pick up request parts)	0-5 mins (Wait for request parts at bay)	0-3 mins (Wait for request parts at bay)
		Mechanic gets parts and back to bay			3-5 mins	3-5 mins	0 mins	0 mins
	7	Insufficiency of parts	- Issue of parts management	- Better forecasting demand by improving internal culture and selecting appropriate forecasting methods - Life cycle of parts - The commitment between company and parts suppliers	1-2 days	1-2 days	0 mins	0 mins
	8	Quality control check	- Issue of poor workshop management	- The enhancement of chief mechanic's skills - Set the KPI for non-reworking for engine oil change service	5-10 mins	5-10 mins	5-10 mins	5-10 mins
Post-checking	9	Waiting customer comes to receive the vehicle	- Issue of inefficiency and communication skills of SA working	N/A	0-next day	0-next day	0-next day	0-next day
	10	Service confirmation and payment	- Issue of inefficiency and communication skills of SA working	- The enhancement of SA skills - Creating a tool to enhance the communication via mobile application	5-10 mins	5-10 mins	5-8 mins	5-8 mins

TABLE VI
THE TOTAL ENGINE OIL CHANGING SERVICE TIME BEFORE AND AFTER IMPROVEMENT

Phase	Total time used			
	Before (Non-appointment)	Before (Appointment)	After (Non-appointment)	After (Appointment)
Pre-checking	18-88 mins	15-43 mins	16-70 mins	13-38 mins
Maintenance	54-96 mins	45-87 mins	39-68 mins	31-54 mins
Post-checking	8-19 mins	8-19 mins	8-17 mins	8-17 mins

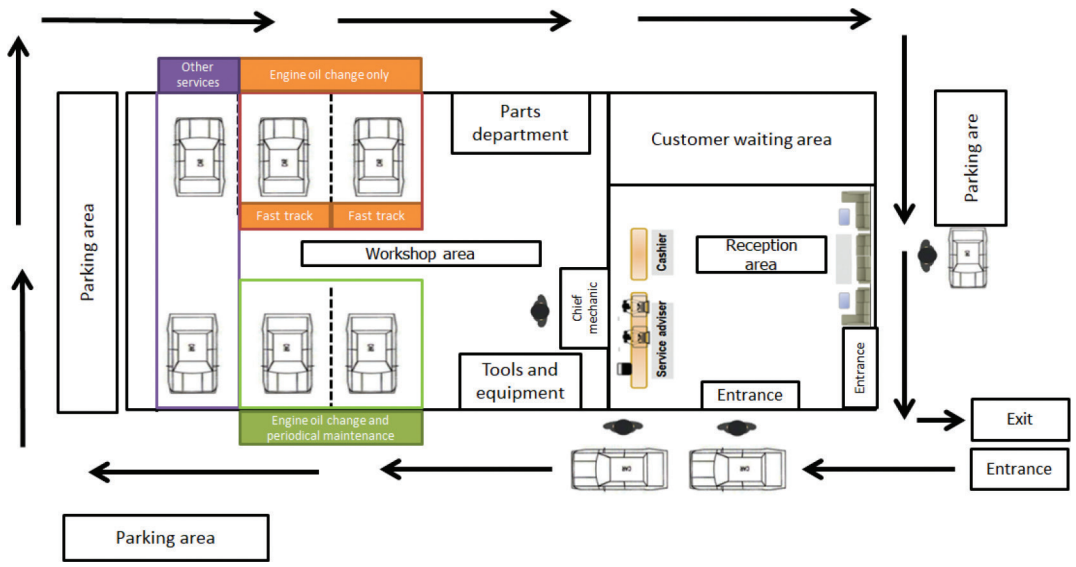

Fig. 11. The new office layout of the dealer

For the future recommendation, all dealers should implement a 100% appointment which can be an effective tool to help staff manage internal operations. Parts shortage and longer lead time may not happen if dealers know the demand for each day and prepare the effective staff and parts in advance. Furthermore, dealers can arrange the time slot to move the congestion in the workshop especially the period of 7.00-11.00 a.m to the afternoon session by offering a discount for customers who make pre-appointment during that period [12].

V. CONCLUSION

Enhancing the standard and procedure of the service centres in Thailand by reducing engine oil changing service time is the highest expectation of this research. Having examined the VSM, the overview of the service process is shown and the non-value activities in the current operations are identified. After the analysis, the maintenance phase has the longest service time which impacts the overall lead time. The time consumed by this phase is up to 30%-50% of the whole process. This value impedes the service centre of the company from effectively competing with other branded and non-branded garages in the market. The non-value activities come from the analysis of VSM which uses the secondary repair history service, brainstorming among the team member, and service manager surveys. These sources of information show issues on different sides. After the wasteful factors are notified from the VSM, the outcome is summed up by utilizing the inductive methodology. Three significant reasons are revealed for excessive engine oil change lead time, namely the inefficiency of the SA, poor workshop management, and ineffective parts management. Overall, for the improvement, it can be reduced the range of engine oil changing service time to only 1.1-2.6 hrs. from 1.3-3.3 hrs. for non-appointment customers and only 0.9-1.8 hrs. from 1.2-2.5 hrs. under the utilization of dual mechanics and a fast track lane for appointment customers leading to higher customer satisfaction.

REFERENCES

[1] Marklines. (2019, Aug 10). *Thailand - Flash Report, Sales volume, 2018*. [Online]. Available: https://www.marklines.com/en/statistics/flash_sales/salesfig_thailand_2018

[2] Marklines. (2020, Apr 10). *Thailand - Flash Report, Sales volume, 2019*. [Online]. Available: https://www.marklines.com/en/statistics/flash_sales/salesfig_thailand_2019

[3] MarketLine. (2020, Jun 30). *Thailand - Car Manufacturing 2020*. [Online]. Available: https://0-advantage-marketline-com.pugwash.lib.warwick.ac.uk/Analysis/ViewwasPDF/thailand-car-manufacturing-98454

[4] J. L. Mfwaya, "Lead Time Management and Customer Satisfaction in the Telecommunication Industry in Kenya," M.S. thesis, Dept. BA. Eng. University of Nairobi, Nairobi, Kenya, 2013.

[5] S. Igor, S. Darko, and N. Aleksandar, "Setting the After-Sale Process and Quality Control at car Dealerships to the Purpose of Increasing Clients Satisfaction," *Journal of Applied Engineering Science,* vol. 11, no. 2, pp. 81-88, May. 2013.

[6] Y. Han and X. Zhu, "Research on Optimisation of Production Process and Warehouse Management System," *Revista de la Facultad de Ingenieria,* vol. 32, no. 15, pp. 36-41, Sep. 2017.

[7] T. Desai and R. Shrivastava, "Six Sigma - A New Direction to Quality and Productivity Management," in *Proc. The World Congress on Engineering and Computer Science,* 2008. pp. 74-134.

[8] S. A. Irani and J. Zhou. (2020, Jun 23). *Value Stream Mapping of a Complete Product*. [Online]. Available: http://www.lean-manufacturing-japan.com/Value%20Stream%20Mapping%20of%20a%20Complete%20Product.pdf

[9] S. Nallusamy and M. A. Adil Ahamed, "Implementation of Lean Tools in an Automotive Industry for Productivity Enhancement - A Case Study," *International Journal of Engineering Research in Africa*, vol. 29, pp. 175-185, Mar. 2017.

[10] H. Abdulmouti, "Benefits of Kaizen to Business Excellence: Evidence from a Case Study," *Industrial Engineering & Management*, vol. 7, no. 2, pp. 1-15, Jan. 2018.

[11] N. Mandahawi, O. Al-Araidah, A. Boran et al., "Application of Lean Six Sigma Tools to Minimise the Length of Stay for Ophthalmology Day Case Surgery," *International Journal of Six Sigma and Competitive Advantage*, vol. 6, no. 3, pp. 156-172, Apr. 2011.

[12] N. Slack, A. Brandon-Jones, and R. Johnston, *Operations Management*, 7th ed., London, UK.: Pearson Education, 2013, pp. 4-713.

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