IOP Conference Series: Materials Science and Engineering

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To cite this article: M Z M Ismail *et al* 2019 *IOP Conf. Ser.: Mater. Sci. Eng.* **469** 012086

A mini review: Lean management tools in assembly line at automotive industry

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Abstract. Malaysia is active in automotive manufacturing activity for decades. The needs in continuing development of lean manufacturing tools are not exempt to be pressurised, which enable the regional demand for vehicles. Several research studies clearly indicate significant opportunities for efficiency improvement in the automotive industry through implementation and a higher level of lean management utilization. Apparently, there is still a small number of study for Lean Management Tools in a Malaysian Automotive Assembly Line. The emphasis for the study is to investigate practices of lean tools applied in the production line and proposing an implementation of lean management tools available to apply in the Malaysian automotive production line work practice. A review study of literature from different journal publication sources related to lean management tools was made to understand more on how to best identify practices of lean tools. From this literature study review, three lean management tools have been investigated and identified such as 5S, Value Stream Mapping (VSM) and Work Standardization are to be studied for proposed application in the Malaysian automotive assembly production line. The impact of implementing lean tools is studied based on the results gathered from previous studies related to 5S, VSM and Work Standardization. The conclusion of this paper is to investigate the practices and implementation of Lean Management Tools in the Malaysian Automotive Assembly. It is to be suggested that a future case study on the proposed lean tools using time study and observational survey to be implemented in Malaysian automotive assembly line and measuring the improvements gained from utilizing the selected lean tools. The result from this review is that among the lean tools highlighted here, 5S is applied everywhere in an automotive assembly line, supported by VSM with its overview of the whole process and also Work Standardization to standardize the method and flow of work in an assembly line and improve the consistency of work. Therefore, concluding this study would be the importance of 5S, VSM and Work Standardization as the implemented tools in an automotive assembly line, in view of overcoming the challenges of the constant change in customer demand.

1. Introduction

The concept of Lean Management was derived from the Toyota Production System (TPS), developed in the early 1950's by Taiichi Ohno. Lean management is universally recognised as an interpretation by western researchers based on the Japanese concept. The principle of lean is to constantly produce better quality, delivery, safety, as well as cost by means of eradicating waste and generating simple and clear

IOP Conf. Series: Materials Science and Engineering 469 (2019) 012086 doi:10.1088/1757-899X/469/1/012086

process flow to meet the demands of customers [1],[2],[3]. The concept of lean management, its core values and practices were initiated in 1988. The lean concept was defined by Womack as an internal philosophy of the organization in 1990. A few years later in 1996, he anticipated key changes in the production process for the companies due to changes in the type of orders from the customers and that they would have to become accustomed to the change. He emphasised that the era of standard mass production had ended and that they were now in the period of small quantity and a large variety of orders [4].

Nowadays, there are highly competitive manufacturing market automotive companies in Malaysia and the Asia Pacific region that forces them to be more innovative and efficient way of conducting businesses. In North America, there have been efforts to establish new strategies in manufacturing management for the last two decades, in order to meet the increasing demands of their customers. With the establishment of lean management tools, it has improved the efficiency of labour at one of the famous Big North American automotive companies, involving Chrysler, General Motors, and Ford [5]. The challenge of the automotive industry at present and in future is to meet customer demand while balancing profit and efficiency. Customer demand changes frequently and the unpredictability of their choices caused automotive manufacturers having to predict, adapt and implement a strategy to overcome the customer demands. Therefore, lean management tools are one of the ways to help manufacturers to not only meet the demand of customers but also achieve reduced waste and decent profit in operating its operations.

2. Lean Management Tools

In this study, the lean management tools contributing to the research are 5S, visual stream mapping (VSM), and work standardization. These are only a part of tools available in lean management concept. The other lean management tools not selected to be used for this study are explained later in a separate topic section of the literature review.

2.1. 5S

The concept of 5S is a workplace organisation technique that originates from Japan as a result due to the implementation of the philosophy of kaizen [6]. This concept offers a template at the workplace as a method to transform in what manner individuals would manage the devised future state [7], [8]. 5S is a straightforward and influential quality process routine. The 5S technique assists everyone to recognise and eradicate waste at the place of work [9],[10]. 5S also support creating and preserving a positive and refined atmosphere in the workplace. The components of 5S are listed below:

i. Seiri (Sort)
ii. Seiton (Set)
iii. Seiso (Shine)
iv. Seiketsu (Standardize)
v. Shitsuke (Sustain)

Veres (Harea), Marian, Moica, & Al-Akel [11] made a study regarding 5S implementation in Hirschmann Automotive. Hirschmann Automotive is an Austrian automotive company that makes automotive parts. The parts are made in several countries including Romania, Mexico, Morocco, Czech Republic and China. The 5S is implemented as an integral part of the company's managerial culture and production process. Every Hirschmann Automotive worker must go through preparatory training with Hirschmann School in order to be well aware of the company's vision, expectations, Lean principals and its components, 5S and other related information applicable to the company. Every month, a progress audit for 5S is conducted for everything inside the company and to empower employees to support 5S, they are provided with salary bonuses if they maintain the standard processes. Another study in India by Shaikh, Alam, Ahmed, Ishtiyak and Hassan [12] in regards to 5S application in a company that manufacture filters, time was wasted in preparation of machine than time of machine usage. What had happened throughout the study was the implementation of 5S at the workplace. As a result, the 5S application had not only improved efficiency of work and effectiveness, but also tidiness, working conditions and standard of safety and health.

After reviewing several journals for 5S, the findings showed that this particular tool is implemented in most industries, including automotive. 5S is a core tool of Lean for organizations in ensuring cleanliness, standardizing and sustaining a methodical order of management, especially in an automotive assembly line where individual parts are sorted according to its specific workstation.

2.2. VSM

Value stream mapping (VSM) is a visual tool for lean management. VSM helps organisations to detect the origin of waste. As a visual tool, it highlights and enhances inventory flow while providing the required information by using arrows, symbols, and metrics as a guide [13]. To create VSM, there are two steps that must be followed for proper visualisation of flow and the information related to the process involved. The first step of VSM requires drawing a current state map in order to identify the source of waste and the opportunity to apply applicable lean tools. The identification of value-added activities in a value stream and the removal of non-value added activities is assisted by using the visual illustration of VSM [14]. The second step of VSM requires a future state map to be designed, based on a plan for enhancing the process flow. The accessibility of the information provided in VSM should certify the resolution to apply the lean management tools and also encourage the organization throughout the actual application so that the targeted outcomes are attainable. The information shown visibly in VSM include process flow in order to identify as well as resolve bottleneck cycle time against Takt time, number of inventory, lead time, waiting time, and process time [15].

VSM is a critical instrument for implementing lean management tools. Numerous uses of VSM technique in various production sections have discoursed in articles from several types of research [9,10,11]. Therefore, applying and supporting the lean approach at organisations using VSM as the chosen ideal approach [19]. Applications of VSM in automotive manufacturing can be referred to a study by Vamsi Krishna Jasti & Sharma [20], as VSM was used to map current state with specific VSM symbols, and identify needed areas of improvement in terms of cycle time, lead time and work in process from current state mapping. Their findings have brought out helpful influence in regards to TAKT Time, process inventory level, reduced manpower, total lead and process time, line speed and process ratio. With VSM, the company was able to satisfy their customers based on cost, delivery and quality. To further investigate the benefits of VSM, Rahani & Al-Ashraf [21] carried out the study on the use of VSM in improving the approach of lean production initiatives. They found out that not only it helped improve the lean production initiatives from revealing visible and non-visible waste, but also highlighted economic benefits from time optimization resulting in cost reduction due to less rate of rejection.

Rohac & Januska [17] sees VSM as an analysis tool to provide the urge to identify the specific origin of causes in problems arising across the value chain. They noted the fact that VSM is only an analytical tool and it does not eradicate complications on its own. Once the complications have been identified, they can be fixed by using other lean management methods or tools.

On top of creating current and future state maps with special symbols, there are also calculations involved as well. They are listed below:

i. Takt Time

The definition of takt time is described as the rate of demand and subsequently the time to complete a finished product from the manufacturing line. For manufacturing systems, takt time plays an important role. Takt time helps to simplify the capability of calculation in a challenging flow. Furthermore, the required machine speed and other related tools were chosen. With the help of takt time, it is easier to estimate the smallest batch sizes when changeovers are required [22]. To obtain the takt time, the following Equation (1) is used:

$$Takt\ Time = \frac{Available\ minutes\ for\ production}{Required\ units\ of\ production} \quad (1)$$

ii. Cycle Time

The cycle time is the amount of time needed for a workstation operator to complete each of their specified parts of work before performing the work again. [13]. It can be explained that the decisive contribution towards improving customer demand is due to the reduction in cycle time [23]. The Equation (2) used to calculate cycle time is:

$$Cycle\ Time = \frac{(PT)(P)}{(PQ)(Res)} \tag{2}$$

*PT represents process time, P represents a number of matching parts/finished product, PQ represents process quantity, and Res represent the number of resources.

iii. Lead Time

Lead time is a form of data in production about the period of time needed for a product to undergo the entire production line, from start to finish [24]. The Equation (3) used to calculate lead time is:

$$Lead\ Time = \ Processing\ Time + \sum Inventory\ lead\ time \tag{3}$$

iv. Processing Time

Processing time provides workers and production planners information of a product for the amount of time taken to process a piece during its production activity. [24]. The Equation (4) used to calculate processing time is:

$$Processing\ Time = \sum Cycle\ Time \tag{4}$$

The various study of VSM by many researchers especially by Rohac and Januska state the benefits of it such as identifying the origin of causes in problems arising but as an analytical tool, it is not able to eradicate complications on its own. As a tool, VSM provides the researcher and organization with the benefit of having a general overview of the whole process, but as stated above it can combine with 5S, Work Standardization and other tools for better analysis process and result.

2.3. Work Standardization

Work standardization is one of the lean management tools. It can be defined as system standardization and implementation of tasks assigned at every single workspace. As a result, the processes are conducted consistently the same, irrespective of which worker is involved in that particular situation and process [25]. Through appropriate application of standards, defects can be prevented during manufacture of the product. On top of that, procedures are created to avoid the event of other errors occurring that may possibly have an influence on production activity. Therefore, work standardization helps in defining the best possible practices for work to be carried out efficiently and safely. The goal of this tool is to carry out the job correctly for the first time beyond any mistake, and minus undesirable consequences on individuals and also the environment. When the standard is improved further, the newly created standard will become the baseline for future improvements [9].

El-khalil & Zeaiter [5] made a case study for implementing several lean tools in an automotive assembly plant. The study was focused on improving and optimize each station in the study area. In order to achieve highest utilization and efficiency, work standardization is utilized amongst the other tools to provide changes in technician's process sequence, station layout, tools and fixture and how they communicate to their supervisor or inspector-in-charge. Johansson, Lezama, Malmsköld, Sjögren, & Ahlström [26] claims that although the concept of work standardization has been present for a period of time, there is still the possibility of improvement opportunities in this study scope. They noted that the use of work standardization differs from company to company, different industries, and even between normal automotive manufacturing and truck manufacturing. Critical features such as the process of assembly should be able to repeat continuously. The conclusion from their study was that implementing work standardization provide positive effects but also requires the definition of requirements in order to carry out work standardization effectively in the assembly line.

The three key components of standardization are standard work-in-process inventory, standard work sequence, as well as takt time [27]. The key components are explained further:

i. Takt Time

Takt time is one of the components of work standardization. It can define as the maximum amount of time for production of a product to be produced against the demand of customer orders. Ensuring work is completed to takt time standard keeps the production meeting the target for customer demand. By following takt time, the production will produce a steady and smooth flow of goods. Takt time is not made through observation or measurement, but by calculating the proportion of available time by output required. Managing manufacturing process with takt time allows detection of any irregular state and rectify the condition as a result. Several definitions need understanding in describing and calculating rate production: total cycle time, operation cycle time, machine cycle time, end-of-line rate, takt time and pitch. Total cycle time is the time from as soon as raw material arrives at a plant up until a finished product is sent to the customer [27]. The Equation (5) used to calculate takt time is:

$$Takt\ Time = \frac{(Available\ working\ time\ in\ period)}{(Customer\ demand\ in\ a\ period)} \tag{5}$$

ii. Standard Work Sequence

Standard work sequence is one of the other components of work standardization. This component focuses on standardizing the order in which the tasks are done in a certain process. It represents the safest and best way to do it. Each worker executes these tasks repeatedly and constantly over time, making it better organized and reveals extra enhancement openings. To allocate work uniformly, line balancing is prepared to decide the number of workers required on each line or cell to follow the takt time. Line balancing also helps to ensure that every worker is optimised evenly, preventing the occurrence of some workers are not doing too much in comparison to others and preventing downtime from happening [27].

iii. Standard work-in-process Inventory

Standard work-in-process inventory is also one of the components of work standardization. It runs the least quantity of inventory to sustain the pace of production in a continuous flow and without idle time. The Kanban system assists in reducing the inventory to the least number of amounts. Excessive inventory causes slowing down of the parts and workers will struggle to keep up. The same scenario will happen to the workers again if the inventory is insufficient. In both circumstances, there will be a decrease in productivity as a result [27].

Application of work standardization in automotive assembly line helps operators to work more consistently and establish a standard level of performance required from the operators in the assembly line. Although this tool is already established for a long time, as Johansson, Lezama, Malmsköld, Sjögren, & Ahlström highlighted, there is indeed an opportunity in improving in this study method. The study analysis can be made using only this tool or also in combination of other lean tools for a better data analysis and reasoning, as different companies have different implementation of work standardization.

3. Other Lean Management Tools

Lean management has remained until today as one of the most common thinking in waste eradication, especially in the service and manufacturing industry. Therefore, countless organisations have taken the opportunity to seize the advantages of practising lean management in order to improve value and efficiency [28]. The other lean tools identified during this study include Wastes in Lean Management, Kaizen, Kanban, Single Minute Exchange Dies (SMED), Jidoka, and Just-in-Time (JIT).

3.1. Wastes in Lean Management

The fundamental concept of lean is about eradicating waste and non-value added activity involving a series of activities or solutions. Waste is defined as the resources used in any activity other than generating value for the customer [29]. Waste can be divided into two different types, known as type 1 waste and type 2 wastes. Type 1 describes enabling activities that do not generate direct value yet required to assist the creation of value, normally with the administration, mandatory testing, management, and others. Type 2 describes pure waste that exists in production is generally broken down into seven subgroups, comprising of overproduction, excessive motion, waiting, transportation, processing, defects, and inventory [30].

For any organizations, identifying waste frequently occurs in their process and differentiate these wastes into two separate types, type 1 waste and type 2 waste. Organizations usually want to reduce the type 2 waste as they do not assist in the creation of any tangible value. In order to sustainably reduce the waste, other lean tools are applied to assist in meeting this goal in organizations such as 5S, Work Standardization and VSM.

3.2. Kaizen

Kaizen is one of the lean management tools used by many companies around the world. The word kaizen is of Japanese origin. It can be plainly translated as change for improvement. One of the problems with kaizen is that it has existed for so long, there is a misunderstanding that appeared throughout its existence, that kaizen and continuous improvement (CI) are the direct alternative expression of each other and they can be interchangeable. Nonetheless, it is not the case especially when kaizen is just the CI characteristic surrounded by lean management [31]. The philosophy of Kaizen comprises a number of recognized methods for improving the quality of implementation. Kaizen encompasses customer orientation, Total Quality Control, Kanban, Just-in-Time, Quality Improvement, Zero Defects, Robotics, and Automation etc. Various attributes that explain what Kaizen is, identified here as long-term benefits, small footsteps of continuous improvement, having the involvement of the whole organization, and culture of maintaining and enhancing [26].
As for this case, Kaizen is only similar to continuous improvement and the difference is that Kaizen promotes lean management in a continuous manner with the aim of achieving superior results in the company's practices. Promoting Kaizen as a work practice will not only improve the automotive assembly process but also influencing the activities of the workers on a daily basis in a positive effect.

3.3. Kanban

Kanban is one of the tools of lean management, originating from Japan. When it literally translated, it actually brought the meaning of "visible part" or "visible record". Usually, it is a signal reference used in manufacturing plants to help reducing waste. It is often referred to as Kanban cards at the production line [3]. Kanban is an approach intended for monitoring levels of inventory, the making and allocation of parts. The purpose of indicating conveyance and manufacture, Kanban can be categorized into the dual card Kanban system. For the period of unpredictable market requirement, it is necessary to retain safety stock in order to equalize the flow of production plus Kanban system rearrangement for inventory reduction. As a result, the Kanban system offers organizations the flexibility of assembling assorted models as well as maintaining an optimum level of inventory. With the flexibility afforded to the manufacturers, it points to lead time reduction for delivering goods created as well as the efficient deployment of assets such as man, equipment, and etc [15]. The principle of Kanban is that apart shall not be manufactured or flow through the production line up until the next customer sends the indication to collect the part. Currently, most organizations have established various techniques and approaches in order to achieve manufacturing excellence, while ensuring dynamic and functional manufacturing processes. In Japan, most of their companies have already applied Kanban for the reason that it reduced costs through decreasing the amount of scrap and waste, workstations are designed to be flexible, abolishing overproduction, reduction of logistics costs and waiting times, thus decreasing the level of stock in inventory and expenses on overhead. To guarantee the success in implementing the system of Kanban, several elements have to be taken into account, for example, the involvement of supplier and vendor, enhancements in quality, better control of quality, inventory management, and last but not least assurances from the employee and top management [3]. According to Ahmad, Dennehy, Conboy, and Oivo [32], the advantages of implementing Kanban in production processes consist of observing and regulating of process in production, restricting work in progress (WIP), flow improvements, reaction to changes, visual scheduling, assisting in high production, preventing overproduction, improving capacity utilization, and reduction in manufacturing time.

As assembly lines become more adaptable to customer demands, Kanban is crucial in helping operators and line leaders to keep track of parts movement throughout the assembly process. The ease of tracking the parts help them in identifying the production progress and also detect defective parts from being processed further in the line itself.

3.4. Single Minute Exchange of Dies (SMED)

Single Minute Exchange of Dies (SMED) is another tool of lean management. SMED was first introduced by Toyota, with the objective set for handling the difficulties of manufacturing, which has many variations, while the quantities are fewer, inventory reduced, in addition to enhancing the production system's capability to provide a quick response. The advantages of SMED includes not only the ability to reduce required time for attachment of equipment and mould, but it is also able to change plan for the production line at any moment, enabling the production plant to meet the various requirements from the market [33]. On the contrary, a majority of the companies as anticipated did not receive the effect of SMED in the real world. The lack of effect could be caused by certain reasons, for instance, the layout of the workshop is inflexible, improper stages of manufacturing, the unfamiliarity of procedures by the operators [34]. The name of SMED derived from this approach, whereby this approach's objective is to cut down time needed for setup or setup time to a single digit, which means it has to be completed less than ten minutes. SMED's fundamental aim is to minimize the waste of time in several stages during the changeover by carrying out several activities as much as possible even though the machine is in operation, making things easier and rationalize the other stages in making the production flow more smoothly [33].

Consequently, SMED is crucial in minimizing setup time in less than ten minutes. SMED helps reduce waste in form of time during a changeover in operation. This eventually translates into smoother assembly flow at the assembly line and reduce the operator's exposure to danger in risk of machine handling during operation.

3.5. Jidoka

Jidoka is a term that originated in Japan. The rough translation of Jidoka is the "production problem warning system that alerts everyone". The theory of Jidoka is for ceasing the completely manufacturing line when there is a problem been discovered. The rationale for ceasing the whole line is the prevention of risk for adding value to substandard parts. Meanwhile, Fekete & Hulvej [35] clarifies that the principle of Jidoka or autonomation was to attach a machine with a device that is capable to identify on its own if a machine has performed an operation correctly and as a result, a product was manufactured with the proper quality standard or if some defect has occurred. In case of defects occurring, the device will proceed to automatically end the machine to prevent more defects from being produced. In this scenario, the worker does not need to observe when the machine completes an operation properly. Therefore, the workers should be able to handle more machines, rather than just a machine to handle. In that situation, a worker can be separate from work at an operation and from a machine work. It was a revolutionary step by Toyota at that period of time that guaranteed improved quality and production. In the past, operators attended only one machine and had to watch every machine if it performs smoothly before Jidoka came along into the process. Furthermore, jidoka uses tools such as andons, which is basically a visual control system, and poka-yokes to reduce quality defects [36].

Jidoka serves as the visual warning device to inform problems or defects that have happened during the assembly process. Without Jidoka, an operator would only be able to handle one machine at the workstation at that time and required them of their constant attention. With the addition of Jidoka, the operator may be able to observe the process as a whole in the workstation and enable them to observe other potential error and defects in the process.

3.6. Just-in-Time (JIT)
Just-in-Time (JIT) is a concept of producing products when it is only needed [37]. As one of the tools in lean management, it is supported by the act of effective preparation and implementing the crucial actions required to manufacture a finished product. The vital aim of JIT is to make available only one part for every single workstation at a time, as soon as the part is required at the workstation. The vital parts of JIT include decreasing buffer sizes, reduction of lot sizes, and minimizing order lead times [2]. The objective of JIT is to help the manufacturer's ambition in enhancing its processes, in order to be more aggressive. Products are produced through a method that reduces the time used to send the completed products, minimizing requirements of labor and workspace, and products are produced at the lowest cost possible and also the best quality. In order to survive in the rapid worldwide market progression, the application of JIT must be put into practice for every single part of waste reduction so as to improve cost efficiency. There are five key benefits in utilizing JIT, and the benefits include a decrease in inventory, quality enhancement, advancing efficiency, a higher margin of profit, and higher position amongst the competition. The benefits of JIT are obtainable only under a JIT production environment. The JIT tool act as a blueprint for applying the JIT control methods and enhancement for the atmosphere of JIT. An effective JIT system will be more influential in reducing waste when process control is shifted to a greater degree [38].

Therefore, with the application of JIT automotive assemblers is able to adapt to the demand of customers and the production of vehicles is only required when there is demand. After receiving a certain number of demand from customers, the assembly line will produce them only according to the requested demand and specification, thus reducing the possibility of overproduction, excessive utilization of parts and workers.

4. Recommendations and Implications
The paper discussed the lean tools applied in industry, specifically 5S, VSM and Work Standardization. Utilizing lean tools was proven capable of delivering the improvement to the companies, in terms of utilization, quality, cost and delivery. Although the improvements were visible, there are still further improvements that can be made, especially towards specific areas in the automotive production line. One of these tools was also used as performance motivators for employees to perform better with incentives when there is an improvement.

The recommendation is to study the level of implementation and the parameters to establish the validity of the effectiveness of the lean tools in a case study. The case study should include time study and observational survey. The relevant components that assessed are VSM and Work Standardization, as well as the use of 5S in the workplace. The case study will help in determining the impact of lean tools and the relevant governing equations associated with quality, profit/cost, and worker efficiency and worker satisfaction at the production plant. The use of data collected from the survey is to support the theoretical parameters highlighted earlier in this study. Results of this study should reflect that with utilizing lean tools at the assembly line, there is a positive impact and tangible result shown in reality.

Therefore, a case study of the theoretical parameters highlighted in this review would apply to an actual situation in the Malaysian automotive industry. The case study proposed is to provide evidence that lean tools actually have an impact on utilization, quality, profit/cost, worker efficiency, worker satisfaction and delivery to customers.

5. Conclusion

The result derived from this review is that from the assorted list of lean management tools reported in this study, 5S is one of the lean management tools applied everywhere in an automotive assembly line and also in other different industries as well. It is supported by VSM with its concept of having a clear and detailed overview of the whole process. Work Standardization as another lean management tool is used in organizations to standardize the method and flow of work in an assembly line and improve the consistency of work. As the study went deeper, it can be taken into consideration that although each of the lean tools is capable to be used for analysis on its own. But the analysis in the automotive assembly line would be better if several tools are used together to create a more detailed and wholesome analysis result. In order to anticipate future change in customer needs and demands for different vehicle types, as well as the anticipation of digitized economy and trading, the automotive industry itself could use some of the tools as a combination to analyse its capacity to react efficiently and productively against said challenges without having to suffer additional waste that is unproductive to the industry itself.

Therefore, concluding this study would be the importance of 5S, VSM and Work Standardization as the implemented tools in an automotive assembly line, in view of overcoming the challenges of the constant change of customer demand and the digital world impacting the industry.

Acknowledgements

Authors wishing to acknowledge the encouragement from colleagues, special work by technical staff support from organizations for their assistance in reviewing this research study. This work financially supported by the Internal Research Grant Scheme (IRGS) vote 11000 under DRB-HICOM University of Automotive Malaysia. We are also thankful to all participant involved from Hicom Automotive at Pekan, Pahang for an endless support and cooperation during the research study.

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