IMPLEMENTATION OF THE LEAN PRODUCTION APPROACH TO PRODUCTION PROBLEMS IN A PROCESS AT TOYOTA MOTOR MANUFACTURING TURKEY

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Abstract. *In all industrialized countries, the automotive sector is regarded as the locomotive of economy in terms of its contribution to economy and pioneering of the other sectors today and it is of great economic importance thanks to the value added it creates, its contribution to employment, its tax revenues, and its demand creating state in many sectors. In this sector, competition among firms is increasing rapidly and such elements as an increase in productivity, the efficient use of resources and administrative and technical organization gain great importance accordingly. To obtain a competitive advantage, it is necessary to keep up with the dynamic structure of the age and be open to change and innovations. That's why enterprises must adapt the new systems, techniques, and technologies to themselves. Based on continuous improvement and aiming at continuous development and elimination of waste, lean production is a production system which contains no unnecessary element in its structure and in which such elements as error, cost, inventory, workmanship, the development process, production area, wastage, and customer dissatisfaction are minimized. This study describes the improvement activities in the conveyor line at Toyota Motor Manufacturing Turkey where the outer body parts of vehicles are assembled in line with the understanding of lean production. Within this scope, it is aimed to determine the standards of the conveyor line specified by the automotive factory and ensure that the operators work in conformity with these standards; to increase the network rates in processes and process productivity by making detailed work analyses of the processes in the line; and to create the flexible workforce line characteristics which will enable the processes to work with complete productivity.*

Keywords: *Lean production; productivity; work analysis.*

Introduction

With globalization, customer-oriented production is becoming one of the most important issues of firms in both the production sector and the service sector. Therefore, establishments try to implement different strategies and innovations to continually improve their processes. Lean production is a management philosophy which aims to reduce costs and waste, to enhance productivity, and to produce quality products and maintain their continuity.

Lean means less of many things: less waste, shorter cycle times, fewer suppliers, and less bureaucracy. Lean also ensures being institutionally more agile, an increase in productivity, more satisfied customers, and long-term success (Ertuğrul, Özveri & Gündoğan, 2013).

Lean philosophy emphasizes total system efficiency, continual improvement, value-added activity, and respect for people (Standard & Davis, 2000). Lean production is considered part of the 'lean thinking' system. Being the basis for the lean production system, lean thinking is a skeptical philosophy which questions all generally accepted and valid rules and principles and which does not consider any established view absolute. A lean system, order or organism means a structure which only possesses the elements it needs and which can act quickly and flexibly as it does not carry any unnecessary weight (Metinkaya, 2003, p.3).

Lean Production**,** also known as the Toyota Production System, means doing more with less – less time, less space, less human effort, less machinery, and less materials – while giving customers what they want (Dennis, 2007) The system focused on pinpointing the major sources of waste, and then using tools such as JIT, production smoothing, setup reduction and others to eliminate the waste (Abdulmalek & Rajgopa, 2007).

The current state of a process in the assembly line at an automotive company is examined and the improvement of the process with the lean production system as a result of specific analyses is described in this study.

The Toyota Production System (TPS)

The Toyota Production System was developed and promoted by Toyota Motor Corporation and adopted by many Japanese companies in the aftermath of the 1973 oil shock. The main purpose of the system is to eliminate through improvement activities various kinds of waste lying concealed within a company (Monden, 2012). The main objectives of the TPS are to design out overburden (muri) and inconsistency (mura), and to eliminate waste (muda). The most significant effects on process value delivery are achieved by designing a process capable of delivering the required results smoothly; by designing out "mura" (inconsistency). It is also crucial to ensure that the process is as flexible as necessary without stress or "muri" (overburden) since this generates "muda" (waste). Finally the tactical improvements of waste reduction or the elimination of muda (waste) are very valuable. There are seven kinds of muda (waste) that are addressed in the TPS: Waste of over production (largest waste), waste of time on hand (waiting), waste of transportation, waste of processing itself, waste of stock at hand, waste of movement, waste of making defective products (Taiichi, 1998).

The goal of the Toyota Production System is to provide products at world class quality levels to meet the expectations of customers, and to be a model of corporate responsibility within industry and the surrounding community

Components of the Toyota Production System

Two pillars of TPS are Just in Time (JIT) and Jidoka (Autonomation). Each element fits in its position to make a complete symbol of a house and is important in the development of TPS (Nicholes, 2011).

Just in Time: "Just-in-Time" means making "only what is needed, when it is needed, and in the amount needed." Just-in-time production relies on finely tuned processes in the assembly sequence using only the quantities of items required, only when they are needed (Toyota Material Handling Europe, 2010, p.8). The key benefits of Just In Time area: low inventory, low wastage, high customer, high quality production. The Just In Time strategy; by taking a JIT approach to inventory and product handling, companies can often cut costs significantly. Inventory costs contribute heavily to the company expenses, especially in manufacturing organizations. By minimizing the amount of inventory you hold, you save space, free up cash resources, and reduce the waste that comes from obsolescence (James, 2015).

Kanban: Kanban again is a Japanese term and means card or sign (Lindenau, 2011). Kanban is a system to control the logistical chain from a production point of view, and is not an inventory control system. Kanban was developed by Taiichi Ohno, at Toyota, as a system to improve and maintain a high level of production. Kanban is one method to achieve JIT (Ohno, 1988).

Heijunka; Heijunka sets the pace of flow in production and product withdrawal (Luyster & Tapping, 2006). Heijunka allows line loads to be smoothed by mixing the order of product manufacture. This assists stability and standardisation of work. The second objective of Heijunka is to assemble different models on the same line while eliminating Mudas (wastes) by standardised work. The application of

Heijunka allows production in the same order as customer demand. The Heijunka practice distributes and balances production over all available means, rather than allowing dedicated resources to suffer from sudden fluctuation in demand (Vision lean, 2015).

Kaizen; The term Kaizen means continuous improvement and also it is a process of making incremental improvements, no matter how small, with the goal of eliminating waste that adds cost without adding a value (Nicholes, 2011).

Jidoka; Jidoka is the principle of stopping work immediately whenever a problem or abnormality occurs. Toyota production equipment is designed to stop automatically if an error is detected, and workers are expected to halt the line when defects are suspected (Black, 2008).

Poka-Yoke: Successive, self, and source inspection can all be achieved through the use of poka-yoke methods. Poka-yoke achieves 100 percent inspection through machinal or physical control (Shingo & Dillion, 1989).

5S**:** The 5S program focuses on organizational cleanliness and standardization to improve profitability, efficiency and safety by reducing waste off all types. It gives organizations the five keys to a total-quality environment. The name “5S” comes from five Japanese words all beginning with S, namely Seiri (Sort, organization), Seiton (Set in order, neatness), Seisou (Shine, cleaning), Seiketsu (Standardize), and Shitsuke (Sustain, discipline) (Moulding, 2010).

Standard Work: Standard work describes the key formulas for calculating tact time, determining work sequence, standard work-in process, and work area staffing through line balancing (Jackson, 2011). Standard work supports the lean system of continuously improving capacities and efficiencies by defining 5 critical elements for every person doing the work. The customer demand, the most efficient work routine (steps), the cycle times required to complete work elements, all process quality checks required to minimize defects/errors, the exact amount of work in process required (Raution & Michael, 2015).

A case study on the implementation of the Lean Production System at Toyota Motor Manufacturing Turkey

Toyota Motor Manufacturing Turkey

Toyota Motor Manufacturing Turkey (Toyota Turkey) is one of Toyota's vehicle production bases in Europe. Located in the northwestern Anatolian province of Sakarya, Toyota Turkey currently manufactures Corolla and Verso model. The majority of the plant’s production is exported to more than 50 countries. These include Western and Eastern European countries, as well as the Middle Eastern, North African and Central Asian countries. Today, with its annual production capacity of 150,000 units, Toyota Motor Manufacturing Turkey is the third largest production plant of Toyota in Europe, and is also one of the largest carmakers in Turkey.

Dedicated to top quality production with the contribution of all its members, Toyota Turkey has been successfully applying the Toyota Production System (TPS) to its manufacturing processes since the start of its operations.

Toyota Turkey registered rapid growth with the start of its export activities in 2002. The company’s production and number of employees have multiplied in line with increasing investments. Today, Toyota Turkey has invested EUR 1.4 billion since its establishment, and currently has 3,300 employees. 10 percent of the employees speak Japanese, while majority of the office employees speak English. Since 2002, Toyota Turkey’s accumulated exports have totaled USD 19 billion. Toyota Turkey’s cumulative production is over 1.3 million units in total, while more than 85 percent of its production is allocated for exports. Toyota Turkey has become one of the largest exporters in the

Turkish automotive sector and other industries in the country. Turkey's geographical location with its young, disciplined and capable workforce, has made the country the right place for Toyota's investments. Toyota is pleased to have invested in Turkey and will continue to produce and export high-quality products (Investment Support and Promotion Agency, 2015, p.1).

Automobile body production processes

In order for the body of a vehicle to be formed, the body of a vehicle is processed in 3 different regions. These working regions are called the Under Body, the Upper Body, and the Shell Body. Bottom parts of the body are produced in the Under Body; the parts on the top and lateral surfaces of the body are produced in the Upper Body; and the bottom parts produced in the Under Body and the top and lateral surface regions are assembled and turned into the main body. The outer assembly of the body is performed in the Shell Body. The production flow and the operation regions are shown in Figure 1. The current situation of the hood process in the shell body conveyor line was examined with a video analysis, a standard work analysis, a standard work combination form, a standard work form, Yamazumi, conveyor line fundamentals, the Houjun Koujun Kukuri Map, and operation analyses. The problems in the hood process were detected through each analysis performed. When the problems are considered in general, it is seen that they are caused by mudas (wastes). The presence of mudas (wastes) at the production stages is among the undesirable cases in the Toyota production system, for mudas (wastes) are non-value added activities. They reduce the production rate, lead to delays, negatively affect the network, reduce quality, and cause the cost to increase. It was found out that there were mudas (wastes) of walking, waiting, unnecessary operations, and stocking in this process under examination. These problems are elaborated further.

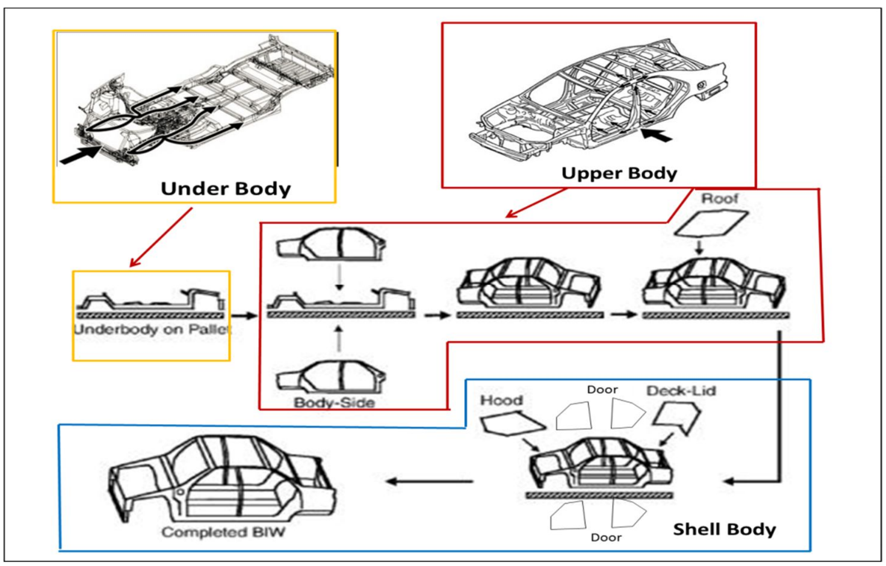

Figure 1. The production flow and the operation regions

Determination of production problems by analyzing the current state of the hood process

The apparent problems in the hood process were detected by examining the Shell Body Line. Various analyses were made in order to examine and improve the current state. These analyses and the ways and purposes of making the analyses are as follows:

1. Video Analysis: It is an analysis which is performed to find out the starting and finishing times of the operations by dividing the operations carried out by an operator into small parts. It is made in order to be able to instantaneously capture the tasks performed by an operator and see the performed tasks more clearly. The video analysis form contains the sequence number of the task, the name of the task performed, its starting time, its finishing time, the difference in time between the tasks, the manual time, the automatic time, and the walking time, and the total time is found depending on them. To

observe all operations performed by the operator in the hood process for the Corolla model, video shooting is performed for 10 cycle times. The video shot is loaded into the Avidemux program; the video is broken down for 10 cycle times; and the data are entered into the video analysis form one by one.

2. Standard Work Analysis: With this analysis, all tasks performed by an operator are determined step by step. The times generated in the video analysis form following the video analysis are transferred to the standard work analysis form. The total times and max and min times of the 10 cycle times are determined, and the time which most repeats after the min time is considered the takt time. All operations performed in the process are considered standard work.

3. Standard Work Combination (SWC): It allows an examination of the state of movement of an operator on the layout**.** A second-based graph is created according to the takt time determined in the standard work analysis and the operations performed. This standard work combination encompasses the operations performed, the operation number, manual work, automatic work, walking, periodic work, the takt time, the takt time of the real line, operator's cycle time, and operator's waiting time. The cumulative graph of the next operation is created by entering the times of the performed tasks according to the manual, automatic, and walking work types. All these steps are performed for the most ideal takt time, and the takt time of the real line, operator's cycle time and operator's waiting time are determined on the graph.

4. Yamazumi Creation: It is the workload which is created by adding the tasks for the products produced with different variations one on top of the other. This analysis aims to determine the occupancy rates of the operator and of the process within the framework of the takt time specified. This analysis is formed by writing the sequence numbers of the operations, the names of the operations, the operation times, and the takt time respectively, with the first operation performed by the operator being at the bottom and the last operation performed by the operator being at the top. It is created by entering into this analysis the sequence numbers, the names of the operations, and the operation times according to the takt time specified in the standard work analysis.

5. Conveyor Line Fundamentals: It is an analysis of the fundamentals of the conveyor line. This analysis enables one to determine the Flowrack standards, the coincidences of operators while performing their operations, operator's shutting between the vehicle and the parts maximum once, visualization of the starting and finishing points of the standard work, the criteria for extrinsic intervention in case of a delay in the work, and the fact that the number of the sections where the operator will work (bui) will be a maximum of 3 when a vehicle is divided into 24 equal parts.

6. Houjun Koujun Kukuri Map: The purpose of this analysis is to ensure that the indivisible tasks in the conveyor line are shown. It states that the tasks performed in the line and the equipment items follow each other respectively and that some tasks and equipment items are visually inseparable.

7. Opr Analysis: It is the productivity analysis of the line. The Opr analysis enables one to determine how many times and how long the line stopped, how many times and why the andon was pulled, the extra extrinsic interventions made in order for the line to work appropriately, and the problems which led to the unproductiveness of the line.

To observe all the operations carried out by the operator in the hood process, video shooting is performed for 10 cycle times. The video shot is loaded into the Avidemux program; all the operations performed are determined by breaking the video down into small parts for 10 cycle times; and the data are entered into a different video analysis form for each cycle time. To find the standard time in the hood process, the data in the video analysis form are transferred to the standard work analysis form. The total times and the maximum and minimum times of 10 cycle times are determined; the time which most repeats after the minimum time is considered the tact time; and all the operations performed at that tact time are considered standard work. The amounts of manual work, automatic work, walking, and tasks of the operator in the hood process are determined by transferring the standard time and operations found into the standard work combination form. Yamazumi Creation is formed in order to find out the occupancy rates of the operator and of the hood process within the framework of the tact time determined in the standard work combination and in order to control the continuity, administration, and whole process of the work items. After this analysis, Conveyor Line Fundamentals are analyzed and the working zone of the hood process, the movement of the operator between the vehicle and the parts and the working standards in the hood process are determined. On the Houjun Koujun Kukuri Map, a change is made considering the indivisible tasks when making a change in combinations in the operations in the hood process by finding the indivisible tasks of all processes. Finally, an Opr Analysis is made and the productivity of the process is measured. Thanks to this, it is ensured that the productivity of the hood process is measured both before and after making an improvement.

With the analyses described above, it was observed that there were problems in the hood process – the 8th process of the Shell Body Line – and the problems existing in this process were specified as follows:

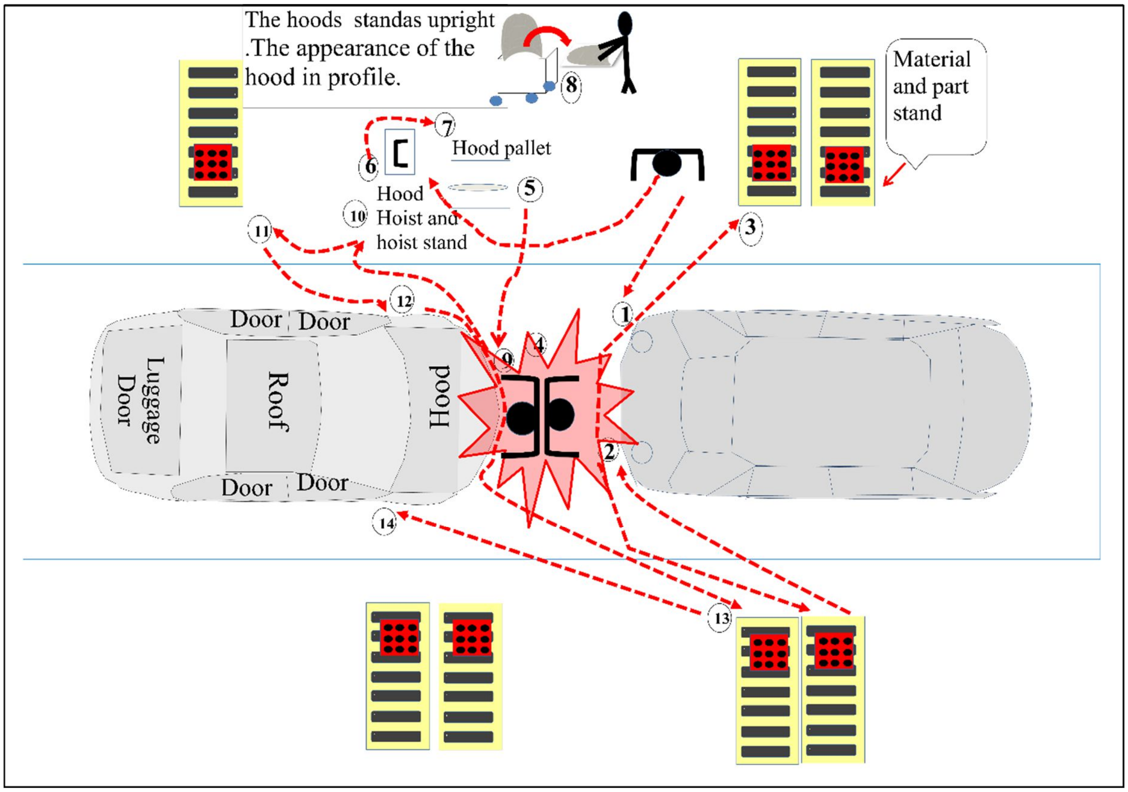

Figure 2. The problems in the hood process

The current state of the hood process is seen in Figure 2. The problems detected as a result of the analyses performed are indicated with numbers in Figure 2. These problems are described below:

1. The operator is on the left-hand side of the line. He walks to the body in order to complete the operation at the bottom left-hand corner of the body.
2. Having completed his operation at the bottom left-hand corner of the body, the operator goes to the pallet on the right-hand side of the body, takes the material, and moves towards the body again in order to perform the operations of fastening at the bottom right-hand corner of the body. He performs more than one walking movement for a single operation.
3. After the operator has finished the operation on the right-hand side of the body, he walks to the left in order to leave the fastening gun and gets the fastening gun with a different cap.
4. The operator who performs the operations of fastening of the body in the 8th process and the operator who works at the back of the body in the 9th process coincide while performing their operations.
5. The hood comes with a carrier and an extra logistic operator works.
6. When more than one hood comes with a carrier, they wait on the pallet.
7. The operator walks to the hoist tool and the hood in order to get the hood.
8. In order to get the hood by means of a hoist, he walks to the lateral side of the hood pallet.

9. He passes to the left-hand side of the hood pallet and lifts and turns the hood by means of the hoist. Since he repeats the operation of turning daylong, ergonomic problems are experienced on his wrists.
10. Since the hood remains far from the body, he walks with the hoist in order to set it on the body.
11. In order to leave the hoist in its place, the operator walks to the hoist stand.
12. In order to set the hood, the operator walks to the flowracks to get the material.
13. To perform the operations of fastening for the right-hand side of the hood, the operator walks to the right-hand side of the body from the material site.
14. The operator works in the 8th and 9th processes, i.e. in two processes. That's why he walks a lot while making a transition from one process to the other.

Improvement of the production problems of the hood process with the Lean production technique

As a result of all these analyses, the Kaizen implementation was used to produce solutions to the problems in the current state and to eliminate the problems. With the Kaizen implementation, problems are determined by monitoring the production line and considering all the analyses performed above. Later on, the problems are improved by producing solutions to these problems. Karakuri (energy-free motion) is used when carrying out Kaizen.

The improvements made against the problems detected in the process during the analyses performed to examine the current state of the hood process are described.

The improved state of the hood process is seen in Figure 3. The improvements made against the detected problems are indicated with numbers in Figure 3. The improvements made against these problems are described below:

1. The operator had been making mudas of walking to the body so as to perform the operations in the line. To reduce operator's walking to the body, it was ensured that the operator worked only on the left-hand side of the body.
2. The material sites were brought closer to the body, and the operator was constrained from walking to the material site.
3. The operator was assigned operations in which a single fastening gun would be used. The changing of fastening guns was eliminated.
4. Changes in the work combinations were made in order to prevent the operators from coinciding.
5. The bringing of the hoods by means of carriers was cancelled. The hood process was carried to the 1st process. It was ensured that the hood operations were performed in the 1st process in order for the hood to be close to the area where it was produced as a semi-finished product and to be carried one by one with the AGVs. The work of the logistic operator was cancelled.
6. It was ensured that the hoods were brought one by one at the time of the operation by means of the AGVs. Waiting by the hood was eliminated.
7. It was ensured that the hood was brought to the closest distance to the body by the AGV. Karakuri was utilized while carrying out this study. To bring the hood closer to the body, the bottom floor where the hood was placed was built with a sliding system. When the AGV arrived at the edge of the conveyor line, the barrier found at the bottom opened the pawl of the sliding system of the hood and enabled it to flow to the body.
8. A hoist was located to the point where the AGV arrived, thereby preventing the operator from walking to the hoist.
9. By ensuring that the hood was brought to the body in a horizontal position, the operator was prevented from turning the hood by means of the hoist and from experiencing an ergonomic difficulty.
10. By lifting the hoist a little upwards, the hoist was enabled to be more active. In this way, the Hoist stand and the carrying of the hoist to its stand were cancelled.
11. The operator was enabled to work in a single process only.
12. Entry into the line was facilitated by organizing the edges of the conveyor line. It was ensured that the line was convenient for 5S.

The analyses used to determine the problems in the current state were performed again for the improved process, and the analyses of the improved state were also created. Thanks to these analyses, the improved state was examined and whether these improvements caused new problems in the process in the improved state, a comparison of the states of the new and old processes and how much profit was gained through the improvements were determined. With the final analyses on the improved state, it was observed that no new problem arose and that the problems in the hood process were improved.

Conclusion

Today, when customer expectations are continually multiplying, the automotive sector – a customer-oriented sector – must continually renew and develop itself so as to surpass customer expectations, to enhance quality, to ensure profitability, to enhance its competitiveness, and to become sustainable.

First developed and implemented by Toyota, Lean Production is a systematic approach which purifies the processes from waste, reduces cost and the production time, and enhances quality by making efficiency and productivity analyses.

At Toyota Motor Manufacturing Turkey (TMMT), the current state in the production line was examined and the problems in the line were determined via various analyses. To eliminate the problems in the production process, solutions were produced with the lean production techniques which were among the process improvement techniques. Such methods as Just-in-time, Kanban, heijunka, jidoka, poka-yoke, and 5S, included in the Toyota production system, are continually being employed at TMMT. The processes are continually being improved with these methods and thanks to this, the processes are purified from unnecessary operations and such elements as error, cost, inventory, workmanship, the development process, production area, wastage, and customer dissatisfaction are minimized.
The improvement activities in the conveyor line at Toyota Motor Manufacturing Turkey where the outer body parts of vehicles were assembled with lean production were described in this study. It was ensured that the conveyor line standards specified at the automotive factory were drawn up and that the operators worked in conformity with these standards. By making the work analyses of the processes in the conveyor line, the network rates in the processes and process productivity were increased. The flexible workforce line characteristics to enable the processes to run with full productivity were created.

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