

# An Implementation of Set Parts Supply System in the Malaysian Automotive Industry

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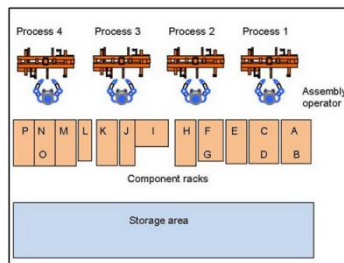
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## Graphical abstract



## Abstract

The automotive manufacturers are facing a challenge in producing variety of products to fulfill the customer demand. A large number of different types of parts forces manufacturers to improve the method of supplying parts on the assembly line. This paper presented an innovation system of supplying parts called Set Parts Supply (SPS) which has been implemented in a mixed-model assembly line. The basic idea of SPS is the process of selection parts and assemble parts are done by different operator at different area. This research is concentrated on the activities in SPS implementation and the design consideration for the equipment through a case based approach. After the implementation, it can be ascertained that the inventory has been reduced, the reduction of waste can be achieved and the shop floor are well-organized.

**Keywords:** Set parts supply; kitting; material supply system; assembly lines; just in time

## Abstract

Keadaan pasaran yang semakin sengit terhadap permintaan pelbagai variasi kereta merupakan suatu cabaran bagi pengeluar kereta. Pelbagai jenis komponen dalam jumlah yang besar mempengaruhi kaedah penghantaran barang ke baris pemasangan. Kajian ini membentangkan suatu penambahbaikan yang dilakukan di baris pemasangan pelbagai model dikenali sebagai sistem penghantaran komponen secara set. Secara umumnya, dalam sistem ini, proses pemilihan dan pemasangan komponen dilakukan secara berasingan oleh operator yang berbeza pada tempat yang berbeza. Kajian ini memfokuskan aktiviti semasa pelaksanaan sistem serta kriteria yang diambil kira semasa merekabentuk kelengkapan yang diperlukan untuk sistem ini melalui pendekatan kajian kes. Setelah sistem penghantaran komponen secara set ini dilaksanakan, ia didapati dapat mengurangkan inventori, mengurangkan pembaziran dan menjadikan lantai pengeluaran teratur.

**Kata kunci:** Set komponen; sistem penghantaran barang; baris pemasangan; tepat pada masa

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## 1.0 INTRODUCTION

In the present scenario of highly demanding customers in the automotive sector, production has become more complex, requiring system innovation and technological integration to compete in the globalize markets. To meet the demand for different models of vehicles with different variants and colours consisting of different types of parts from the supplier such as a variety of speakers, door locks and door handles, manufacturers are faced with the need to effectively manage thousands of parts on the shop floor. The production needs to be properly planned with the Just-In-Time practice. Otherwise, the final assembly will run out of parts and the downtime will increase.

In order to cater for the fluctuating demand, manufacturers have to implement innovation strategies for driving high

performance in the assembly system. Thus, within the constraints of an unpredictable situation, adapting Just-In-Time becomes more challenging. This will also affect the method of supplying materials and material handling on the assembly line [1-2]. The wide variety of parts also causes an excessive inventory, limited storage space and a poor picking system [3]. To meet customer satisfaction, this pressure allows manufacturers to create an innovation which in turn, improve production performance. As an example, Toyota introduced a new system of supplying materials to the assembly line which is called Set Parts Supply (SPS) which has been adopted in the Toyota Tsutsumi plant in Japan [4].

### 1.1 Set Parts Supply (SPS) System

There are two main jobs in SPS, *Erabitori* and *Kumitsuke* [5]. The first job i.e. *Erabitori* or selection is a process in which each part of the different models is selected. The second job *Kumitsuke* or assembly is a process in which the parts are assembled on the car body. The selection process is done by a shopping operator in an area called the supermarket. The job focuses on the selection of the needed parts, removing the unnecessary materials and placing the selected part on the box. The box is then placed on the wagon and supplied to the assembly line. The second job is done by an assembly operator at each workstation on the assembly line. The assembly operator will pick up the parts one after another from the box for the related assembly process and assembled them on the car body.

In SPS implementation, the starting point of *kanban* is moved from the assembly line to the supermarket area [5]. There is no *kanban* between the assembly line and the supermarket. The job in the supermarket is synchronized with the assembly line which is planned by the production planning department. This means that there is no order for supplying parts from the assembly line to the supermarket. The instruction to supply parts for the selection process also comes from the management. Therefore the shopping operator will concentrate on the selection process and the assembly operator will focus on assembling the parts. This make it easy for the unskilled worker to understand and the time to train a new assembly operator can also be reduced [6]. It seems that implementing SPS requires more jobs to be done albeit with some additional labour cost.

SPS is also known as the kitting process in Swedish companies [7]; however there are certain elements that make SPS different from kitting [8]. SPS and kitting seem to be beneficial to solve space utilization and material handling problems but the kitting process is less understood in terms of flexibility, quality and cognitive. Wang *et al.* [9] found that SPS can eliminate 158 m<sup>2</sup> of distribution area and save about 96% for the logistic area at the line side assembly line. However, the preparation for the kitting process needs more space and a temporary storage area [10]. Kitting requires all the components or subassembly collections to be completed before being delivered to the assembly line. Otherwise, kitting will lead to poor quality and increase the lead times due to the rework process.

SPS is better than the traditional method because it can reduce the distance of the parts supplied by three percent and the total time for part arrangement by four percent [11]. Kitting also can be very useful to reduce the time spent searching for parts and provides a quick response to quality control [12]. However, when designing the system, the choice of design depends on the location of the selection process, arrangement of parts on the component racks, material handling equipment, layout design, and picking information system [13]. If the system is designed properly, it will be an advantage for the assembly process performance or else it will just increase the cost of investment [14]. In order to choose the appropriate design system for the supply of materials to the assembly line, Caputo and Pelagagge [3] suggested a methodology as an alternative to return the investment of the manufacturer.

The raising in different models with huge variants will create a difficult environment on the assembly line. SPS is one of the reasons to create a simple, slim and easy system for materials supply. With the synchronized workstation and balancing line, SPS implementation builds high quality into the product and is able to create a better working environment. The other reason for introducing SPS to the assembly line in Japan was the increase in the average age of assembly operators [8]. Therefore, by replacing the ‘senior’ operators on the assembly line and letting them select

the parts, it is easier for them to focus on their job. Moreover, assembly operators have to memorize many job processes each time a different model arrives at the workstation. Therefore, the implementation of SPS balances the job of selection and the assembly of parts.

To date, there have been very few studies of SPS in the literature. However the existence of kitting is often discussed in the research on the implementation, design, operation and evaluation as a method of material supply to the assembly line [10, 13, 15]. Although, kitting has many uncertainties regarding the application and design of the system, the research on kitting is wide spread. For that reason, the exploration on SPS study is crucial to obtain a definitive picture of SPS. This study discusses on how the implementation of SPS in the Malaysian automotive industry. The study also focuses on the scenario before the implementation and after the implementation of SPS. The phase of implementation and activities that support the Just-In-Time practice will also discussed.

### 2.0 METHODOLOGY

The case study was conducted at Perusahaan Otomobil Nasional (Proton), leader of Malaysian national car manufacturer which has produced over a dozen car models since 1985. At Proton, mixed-model production is the practice where different model and variant is produced on the same assembly line. In order to gain multiple sources of data to triangulate the findings, one of the researchers was attached to the Industrial Engineering Department for three months. The information was gathered through the SPS project team members. The qualitative data was collected through observations and interviews by attending the meetings, discussions and fabrication works and were analyzed to achieve a deeper understanding about the Set Part Supply. The documents included official records, minutes of meetings, technical drawings and other related items which were also examined to gain insights relevant to the research questions.

### 3.0 PHASE OF IMPLEMENTATION

The case study of SPS implementation was done at the door assembly line with an area of approximately 812.5 m<sup>2</sup>. There were eight workstations on both the left and right side. The assembly line was about 22.5 m with sixteen assembly operators. There were component racks alongside the assembly line on both sides. The storage area was about 100 m<sup>2</sup> which contained medium and small parts, and the distance was 2 m from the right side component racks. There were two ‘supply operator’ supplied parts to the storage area from the incoming station and to the component racks at the line side from storage area. The Figure 1 below shows the layout of the case study before the implementation of SPS.

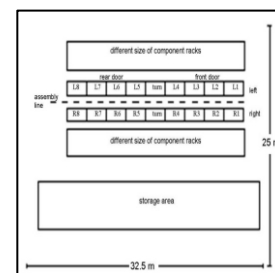


Figure 1 Layout of the case study at door sub assembly line

Before implementation, the management found that a lot of waste arises when the variety of parts was placed at the assembly line with the floor constraints. From the interviews and observation, the waste has been defined and summarized in Table 1.

**Table 1** Identified waste in the case study

Type of waste	Description	Cause
Waiting	Assembly operator had to wait for 'supply operator' supply parts from storage area.	Poor pull system Excess workload
	Assembly operator had to wait due to late assembly of prior process.	
Unnecessary transport	Forklift and towing truck moved along improper route.	Poor layout
Excess inventory	A lot of inventory at storage area and component racks. It was like there were two storage areas.	Poor pull system Poor workplace management
	Many poly boxes with parts on the shop floor due to not enough space to locate. The shop floor was congested, crowded and an unfriendly environment to implement 5S.	
Unnecessary movements	Assembly operator had to remove the Non- Value-Added (NVA) such as rubber, plastic, paper and rope that were used to tie the materials or to protect the materials from being scratched.	Excess workload Poor material supply
	Assembly operator had to walk 11 m to replace racking that contains door glass.	Poor material supply
	Assembly operator had to spend 2 minutes to replace door trim racking.	
Defects	Wrong place replenishment due to a lot of parts.	Poor material supply
	Wrong parts assembled and missing assembly process	Excess workload

As the *kaizen* effort to reduce and eliminate waste, the phase of SPS implementation was approved by management. The feasibility study was done as the first step to make the project visible. The current situation and all the capabilities were studied, including the total process, Work In Process (WIP), equipment, inventory, manpower and plant layout. The actual data and supply routes were checked and analysed to provide the best decision. The explanation, discussion and classroom training were the next step concerning the preparation of the training material. To build up the confidence level, presentations to the management, users and suppliers about the goals and benefits were done to spread the

responsibility setting and job allocation. After that, the design and fabrication phase was done to complete all the equipment needed in SPS implementation. It was a difficult process to determine the appropriate design that contributes to the workability and efficiency. For SPS implementation, three main items equipment are important to ensure the SPS system works properly:

- (i) component racks
- (ii) small parts racks
- (iii) trolleys

There are certain criteria and elements that contribute to the development of the equipment as shown in Table 2. The engineers chose which elements are better and more suitable for the design phase. After the materials were ordered and supplied, the fabrication phase took a few weeks to finish.

**Table 2** Considerations in the design phase

Type of equipment	Type of consideration	Element
Component racks, small parts racks & trolleys	Data of Parts Supply	Size of container Quantity per container Method of supply in container Material of part
	Concept of Supply	<i>Minomi</i> (parts only) Synchronize and synchronize Container
Component racks & trolleys	Concept of racking	Flow racks Flow racks with <i>minomi</i> Special design of <i>minomi</i>
	Workability	Movable or fixed First In First Out (FIFO) Ergonomic Visualization
Component racks, small parts racks & trolleys	Materials and size	Cost Durability Stability

The next step was to rectify all the equipment in proper sequence on the shop floor and test the workability of all the equipment and methods within the process flow. After that, improvement activities were done to add value to the implementation process, simplify the equipment handling and eliminate the unnecessary waste according to the SPS concept and production orientation. After compliance with the regulations and conditions, full SPS implementation was done with direction and manual guidance. The monitoring process took a few days to control the productivity before the process became standardized.

4.0 SPS IMPLEMENTATION

4.1 Before Implementation

Figure 2 shows the layout of process 1 until process 4 as an example of the whole case study. Before implementation, the component racks of different heights, lengths and widths were located at the line side assembly line. The parts with multi variants and models were put on the component racks using different methods; container, *minomi* (parts only), or poly box. The parts were placed followed by the sequence number of the assembly process. For instance, an assembly operator at process 1 will take materials A, B, C, D and E to complete his job. Since the space was very limited, only three to four empty containers or poly boxes could be put in the racking which resulted in many returnable containers on the shop floor. The small parts such as bolts, nuts and clips also were placed next to the component racks. The assembly operators have to walk and turn back each time they need the small parts and tools. The storage area for the reserve materials from the supplier was located behind the component racks. The storage area was full of the containers and poly boxes. The shop floor was congested, crowded and an unfriendly environment to implement 5S.

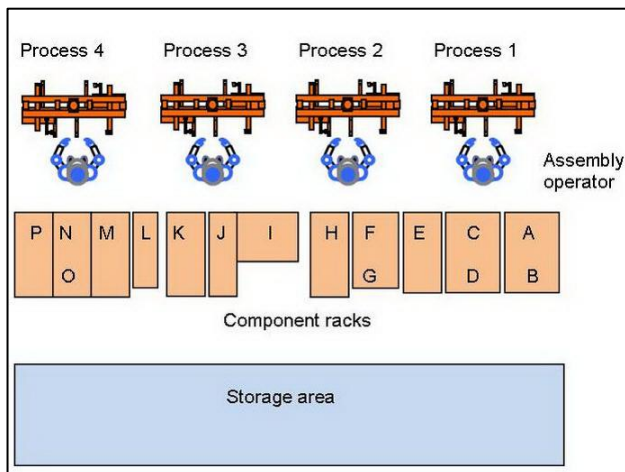


Figure 2 Layout before SPS implementation

4.2 After Implementation

A number of new racks were designed to ensure the parts were arranged correctly. The parts were arranged in consideration of the size of the container and poly box without following the sequence number of the assembly process as shown in Figure 3. The new arrangement of parts reduced the space area and it is easier for shopping man to search and pick the required parts. The small part racks also were designed and placed next to assembly operator to allow picking tools and small parts become easier. This can reduce the walking step and time to pick up.

The new design of the component racks can locate more empty containers and poly boxes than before SPS implementation. The returnable empty containers and poly boxes were put on the top of the racking. The height of the racking is reduced to 1.5 m. It also makes the shop floor looks clear and wide. Some of the parts were changed to *minomi* as a method of supply. The usage of containers and poly boxes was reduced. By using *minomi*, it really eliminated the NVA activities such as removing plastic,

walking to bin, pick up the containers and arrange the empty containers. The quantity parts per supply also increased.

The storage area was eliminated after the implementation of SPS. The component racks were moved to 4 m from assembly line. The assembly operator can be seen clearly in a better environment and ventilation. In order to increase the working efficiency, the job of assembly and selection are done by different operators. By adding two additional operators to do the selection job, they focus on selecting and picking parts from the component racks after they read the information sheet.

The shopping operator need to ensure the parts are in good quality and meet the requirement before selecting the parts and filling up the empty trolley. After the trolley complete with 'set of parts', it was pushed to the process 1. The set of parts that only needed for the process is one to one approach either it just hanging with customized hook, hanger or lay down on the roller, or just stand and resting on the trolley with specific design. The trolley will flow along the assembly line using a rail guide to protect the trolley from moving around. The assembly operator will pick up the required parts and push the trolley to the next station. At the end of the assembly process, the empty trolley is pushed to the shopping operator, and then the process of selection will repeat again.

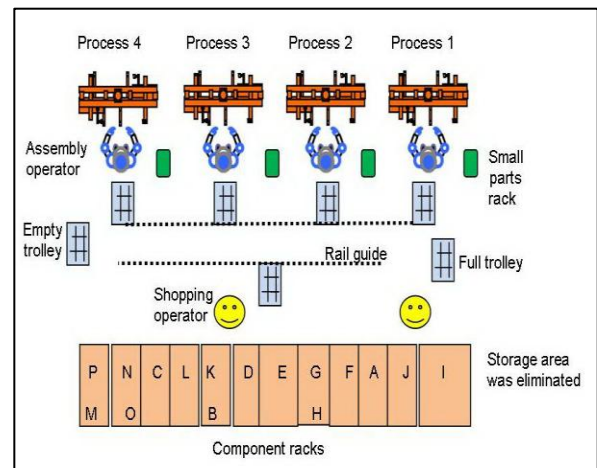


Figure 3 Layout after SPS implementation

The results of SPS implementation at the assembly line can be summarized in Table 3. The result was supported by the Just-In-Time activities that will be discussed below.

Table 3 Results of implementation the set parts supply system

	Before Implementation	After Implementation
Component racks	Different sizes with maximum 1.8 m height.	Standard size with 1.5 m height.
Storage area	100 m <sup>2</sup>	Eliminated
Supermarket area	No supermarket area, the line side was congested with component racks.	Supermarket area is 4 m from assembly line. There are SPS trolleys along the line side.

Material A (per supply)	Supplied using container with polystyrene, bigger size, limited to supply only 6 containers.	Supplied using corrugated board as a partition, much smaller, can supply up to 10 containers.
Material F (per supply)	Supplied using poly boxes up to a quantity to 40.	Supplied using <i>minomi</i> up to a quantity of 90. Poly boxes eliminated.
Material G	Supplied using poly boxes. A lot of NVA had to be removed.	Supplied using <i>minomi</i> . NVA eliminated.
Material I	The walking distance was 11 m to replace the empty rack, the job was done by the assembly operator, the material was supplied by forklift and difficult to handle.	The walking distance is 5 m to replace the empty rack, the job is done by the shopping operator, the material is supplied manually and easy to handle.

## ■ 5.0 ACTIVITIES IN SPS

### 5.1 Pull System

The first step of the SPS system is receiving signal demand from the production control that was printed in the shopping area on an information sheet. The shopping operator will take the information sheet and place it on the trolley to make it easy to select the needed parts. The set of parts can only be supplied to the assembly line if there is any demand on the information sheet. The information sheet on the trolley must be in sequence with the model on each workstation on the assembly line. In this case, the pull system is transferrable and it is easier for the assembly operator to focus on assembly parts of good quality.

The concept of supplying parts to the shopping area also uses the pull system. The signal order comes from manufacturer using Manufacturing Execution System (MES) which is visible to the supplier. The supplier will supply the parts needed as planned by the MES with the just in time concept. The SPS implementation disciplines the supplier and manufacturer to only be concerned with accurate information. However, if there is any problem such as quality or supply of wrong parts, the shopping operator will quickly respond before the models arrive at the workstation.

### 5.2 Synchronization

With the commitment of the supplier, some of the parts supplied are synchronized with the production schedule. Therefore, the job of the shopping operator is much easier. As a result, the wrong pick up and installation have been eliminated. The synchronized parts also reduce the space of the inventory and reduce the number of racking.

### 5.3 Minomi

Although the concept of *minomi* has never been clearly defined in the existing literature, Hanson [16] in his study defined *minomi* as a unit load without container. Liker and Meire [17] simplified *minomi* as the ‘peanut without shell’. In this case study, *minomi* means the parts are put on the racking or trolleys without poly boxes or containers which are visible to anybody. The concept of visualization allows the tracking of parts with real time information and a quick response to product quality verification such as defective or missing parts. By using *minomi*, the

characteristics of poka yoke have also been implemented in designing the racking or trolleys to prevent mistakes during the handling of materials. For the best results, the supplier or operator can only put the right parts in the right place on the racking or trolleys which have been designed specifically for the parts with the help of a tagging card and picture. The parts can also be easily picked up and the time for searching parts is reduced. The engineer considers the size of the part, the type of material and the characteristics of the part and whether the part is easy to scratch or breakable.

### 5.4 Workplace Organization or 5S

The implementation of SPS is also considered as a way to extend the 5S concept, the workplace organization methodology that refers to cleanliness, tidiness and discipline which is the simplest tool in lean activities to reduce waste. By removing the unnecessary or NVA items, it also helps to reduce time of searching, sorting, picking, and also decrease the defects during material handling. After the replacement of new racks, the line side was clear and created a safer environment for operators. The management and supervisor, at a glance will obtain the information directly if things are not well-ordered, misplaced materials or parts and also the working condition of the operator without verbal communication.

### 5.5 First In First Out

The concept of ‘parts only’ is to design materials supplied to assembly line with high safety features and complete with FIFO concept as an approach to control the inventory. Parts that enter the racking first are the first to be picked up. The shopping operator must take parts systematically, one by one, and follow the sequence especially when the part is already synchronized with production. This method is easy to understand. The advantage of this method is the parts are issued on the recent purchase. It is very useful when the prices are falling or fluctuating. It also helps in tracing quality issues especially when a quality problem occurs in an assembly line, as it is easier to isolate the parts. The replenishment of parts separately from picking can also reduce inventory misplacement and reduce inventory loss. This is because the supply operator only supplies in one direction and puts the parts on the racks. The workplace also looks organized because there is one entrance to pick up as the loading parts always at the back.

## ■ 6.0 CONCLUSION

One of the good things in SPS system, it comes as a complete set of parts that supplied as a unit loads which can be easily seen by the operator. As a new concept for material handling system, SPS is one of the alternatives in Just-In-Time practice used to improve inventory control. SPS can reduce the number of defects and the ultimate goal is cost reduction. The damaged materials and part shortage can be identified earlier by creating an efficient and orderly workplace. Although the implementation of SPS increased the number of manpower, but the reduction of inventory is more important to cost savings, improve stock accuracy and enables efficient inventory tracking. In addition, by implementing SPS, it is much easier to implement 5S. SPS also maximize the benefit of workplace management and visualization by designing the appropriate component racks and using *minomi* method in supplying materials.

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