

# Just-In-Time (JIT) - Pull System Approach on A Malaysia Rubber Production Company

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## ABSTRACT

*The JIT-pull system is one of the lean tools which can reduce and eliminate all the wastes created in the production system. Seven waste elements which have been identified are transportation, waiting, over-production, defects, inventory, motion and excess processing. Currently, a rubber company has been alarmed on the wastes created in their production system as the production is running in push system mode. The wastes lead to high inventory costs, over-production, the requirement of large inventory spaces and inefficient products and materials flow. Hence, this project takes into account the situation and generates ideas which emphasis on the implementation of the Just-In-Time (JIT)-Pull System in term of changing the push system. The main objective of this study is to design and analyze the JIT-pull system in the rubber production system. The results showed that the JIT system design is capable of reducing inventory quantity, minimize the inventory costs, reduce requirements of large inventory spaces and also provide efficient communications in the production.*

**Key Words:**, *Design and analysis of JIT-pull system, Push system, Wastes elements.*

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## 1. INTRODUCTION

There are two methods of production system, namely push production system and pull production system. Push system means make-to-stock in which the production is not based on actual demand whereas pull system means make-to-order in which the production is based on actual demand. On the push production system, the production is based on the scheduling where the process begins with forecasting, thereby establishes the main production process and then implements manufacturing management and control [1]. MRP (Materials Requirements Planning) is the classic push system. MRP combines the calculations for financial, operations and logistics planning [2]. The MRP system computes production schedules for all levels based on forecasts of sales of end items. Once produced, subassemblies are pushed to next level whether needed or not.

JIT (Just-In-Time) is the classic pull system. The basic mechanism is that production at one level only happens when initiated by a request at the higher level. That is, units are pulled through the system by request. The main advantage of JIT over MRP is that JIT reduces inventories to a minimum. In addition to saving direct inventory carrying costs, there are substantial side benefits, such as improvement in quality and plant efficiency. JIT philosophy was introduced and developed in Japan by Taiichi Ohno in early 1970s throughout the automotive industries. The JIT concept was developed to improve Toyota's competitiveness in the global market and soon it was adopted by many Japanese industries [3]. Nowadays, JIT has become as one of the most effective management system in manufacturing. By implementing JIT, Toyota has become world best manufacturer. Based on Toyota Production System (TPS), there are three elements should be considered in order to implement JIT which are continuous flow, takt time and pull system [4]. Just-In-Time (JIT) manufacturing is a Japanese management philosophy applied in manufacturing which involves having the right items of the right quality and quantity in the right place and the right time [5]. The core principle of a pull system is that any activity should only be performed when it is needed [6].

The goal is to keep inventory levels to a minimum by only having enough inventories, not more or less, to meet customer demand. The JIT system eliminates waste by reducing the amount of storage space needed for inventory and the costs of storing goods [7]. The implementation of JIT System are capable to increase utilization of machinery and equipment, reduced investment in inventory, improvement in the quality of product or service, reduction in space requirements of the firm, reduction in production cycle time, zero inventory storage and maintenance costs, closer relationship with suppliers, and higher involvement of employees [8]. JIT works in the three types of inventories which raw materials, work-in-process and finished goods [9]. The most apparent goal of the JIT system is, thus, to minimize work-in-progress (WIP) inventory. However, the purpose of reducing WIP inventory is two-fold which are reducing the carrying cost and improve quality and productivity. Perhaps the greatest benefit of minimizing WIP is the vastly improved visibility of problems in the manufacturing process. Problems which contribute to consistently low quality, high rework, large inventories, and low throughput. Over production occur when there are weak control rate of production that cause massive flow of product that are not suitable to market demand. It also increase the number of product kept in stock which results to the increase of production and inventory cost. Large amount of uncompleted product happened when there are unsmooth on material flow in certain department or division affects the production system.

### 1.1 Push System VS Pull System

Currently, push system is the most familiar system in producing products. As known as producer-centric, in push system, goods are manufactured in anticipation of customer orders. In other words, the manufacturer will determine what to manufacture and in what quantities after judging true customer needs. The push system of inventory control involves forecasting inventory needs to meet customer demand. Companies must predict which products customers will purchase along with determining what quantity of goods will be purchased. The company will in turn produce enough products to meet the forecast demand and sell, or push, the goods to the consumer. Disadvantages of the push inventory control system are that forecasts are often inaccurate as sales can be unpredictable and vary from one year to the next. Another problem with push inventory control systems is that if too much product is left in inventory. This increases the company's costs for storing these goods [10]. An advantage to the push system is that the company is fairly assured it will have enough products on hand to complete customer orders, preventing the inability to meet customer demand for the product.

An example of a push system is Materials Requirements Planning (MRP). MRP combines the calculations for financial, operations and logistics planning [2]. It is a computer-based information system which controls scheduling and ordering. Its purpose is to make sure raw goods and materials needed for production are available when they are needed. JIT may be thought of as a 'pull' activity based on customer demand rather than pushing products based on projected demand. Thus pull system is a tool of JIT practices where pull system is a manufacturing methodology that controls production from the end of the process. Pull system reduces waste by limiting overproduction and inventory in a systematic way. In the pull system each process or customer takes the product or the parts from the previous process as and when they are needed. In this way, a work or service center only works when the next process communicates to it the need to do so. One advantage to the system is that there will be no excess of inventory that needs to be stored, thus reducing inventory levels and the cost of carrying and storing goods [11]. This system uses Kanban in order to function. Kanban is the authorization to produce or adjust stock, at the same time providing control and information [12].

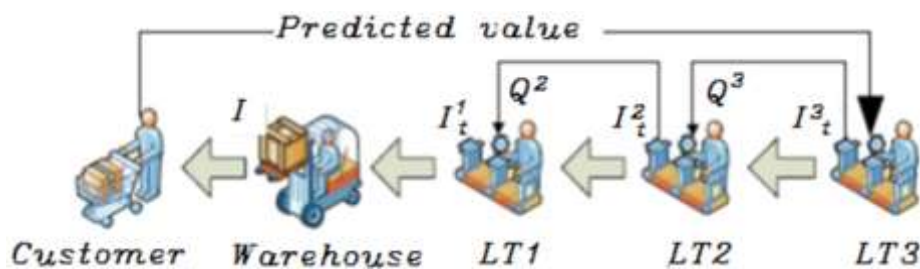
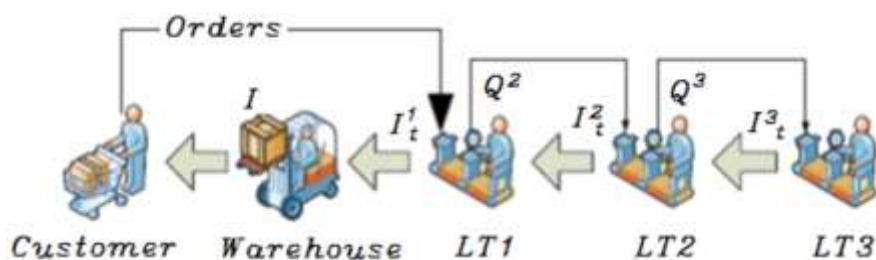


Figure 1: Simplified push production system



**Figure 2: Simplified pull production system**

The comparisons between pull system and push systems are throughout five criteria such as in Table 1 [13]:

**Table 1: Comparisons of push and pull system**

	<b>Push System</b>	<b>Pull System</b>
<b>Driving mode</b>	Production Plan	Customer Orders
<b>Scale &amp; Flexibility</b>	Mass production, Low-cost	Customization production,
<b>Inventory</b>	Higher inventory level	Low inventory levels
<b>Order completion time</b>	Lower response time	A certain delay
<b>Equipment utilization</b>	Higher capacity utilization	Customer order-related

## 1.2 Kanban

In JIT-pull system, kanban controls the production process and also the flow of materials. A Kanban is a card on which certain information for the pulling of material is printed where it serves as a communication tool to start production of next unit and to pull processed item between production stages [14]. The word Kanban is Japanese for instruction card or sign board. The Kanban is used to signal the need for replacing or refilling materials necessary for production. There are a variety of ways that the signal can be sent. In order to keep track of current inventory, the cards that accompany goods though the production process can be used. Kanban coupled with a pull system is a means of implementing JIT and that is why it has been widely used in many manufacturing systems, assembly systems, and supply chain systems [15].

Kanban is a flow control mechanism for pull-driven Just-In-Time production, in which the upstream processing activities are triggered by the downstream process demand signals [16]. The kanban system allows to produce according to the demand and to limit work-in-process in each stage [17]. With the utilization of kanban in pull system, it creates an environment of make-to-order production instead of make-to-stock production ([18]. The withdrawal kanban authorizes the movement of production. This card is sent to the supplier or manufacturing unit when the material or product is taken from the inventory to the customer or production purpose. It controls the material flow from the supplier or manufacturing unit to the downstream manufacturing phase. As the materials are consumed and new product is taken into use, the kanban card is released and sent to upstream operations [19]. In a Kanban system, the main design parameters are the number of Kanbans and the lot size. Thus the formula in calculating the number of kanbans and the lot size are as follows [15]:

- a) Total Required Inventory (TRI) = Weekly Part Usage x Lead Time x Number of Location for Stock
- b) Number of Kanban = TRI / Capacity of each location

## 1.3 Issues on the Rubber Company

In a rubber industry production system, the current push system is creating lots of problem especially on the high inventory costs, high production quantities (over-production), high inventory spaces requirements and inefficient materials flow. According to the second quarter production report 2013 of the rubber company, the total production was increased (as shown in Figure 3) in second quarter 2013 starting from week 14 to week 26. This brought to the increment of 82.86% in inventory costs starting from week 14 until to week 26. The Figure 4 shows the weekly inventories costs from week 14 to week 26. As there is increasing concern in the inefficiencies of the production system, a solution of improvement needs to be identified and implemented. An improvement in their production system to reduce waste, smoothen the production flow as well a satisfying their customer by having on time delivery which results in higher profitability.

Since the management is aware of the concepts of lean and JIT, and their advantages, the management would like to change the production system from push to the pull system. Thus, this study was conducted to investigate the feasibility of changing the production system from push to pull.

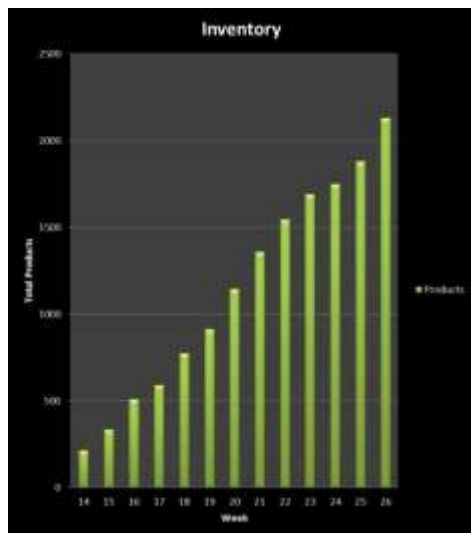


Figure 3: Production (week 14 to week 26)

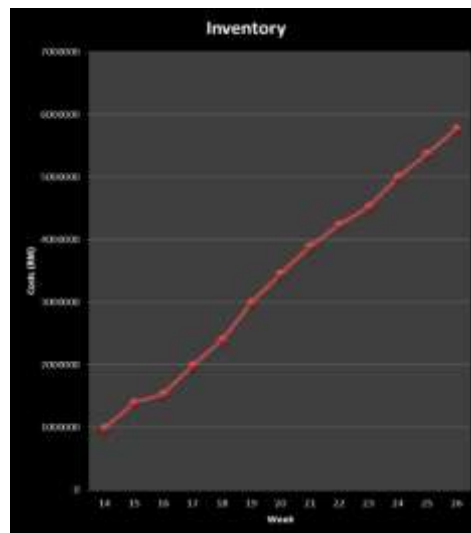


Figure 4: Inventory costs (week 14 to week 26)

## 2. CURRENT PRODUCTION SYSTEM (PUSH SYSTEM)



Figure 5: General production system

Based on the Figure 5, currently the rubber company is using push system as the production system methods in producing the rubber products. Generally, the push system is based on the raw materials in the storage tank or warehouse. The production will push the products to the warehouse while the warehouse will push the products that been stored to the supply chain department. For any demands from the customers, the supply chain will push to the customer based on the quantity purchased. Figure 6 shows the details of the push system production flow that currently use in the rubber company production system. As the schedule plan released by the supply chain department, CRP will starts the production of uncured compounds where each uncured compound is 10kg of weight. The finished uncured compounds are then being pushed to BUP and CPP. BUP and CPP will then run the productions of pressing the uncured compounds into rubber sheets. At BUP, in order to produce a 30mm rubber sheets, 7 pieces of uncured compounds will be pressed within certain periods while at CCP, 4 pieces of uncured compounds are pressed within certain periods for producing a 12mm rubber sheets. The finished rubber sheets are then been sent out to the bulk store for the temporary storage. The bulk store will transmit the rubber sheets in batch for the SBB production. SBB will continuously proceed with the production through slit and buff processes.

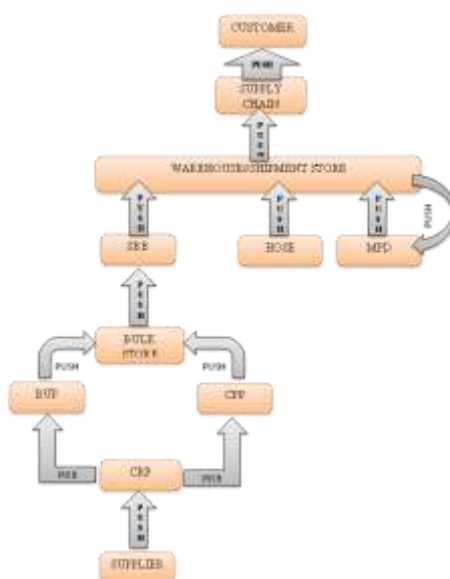


Figure 6: Flow of push production system at the rubber company

Upon completing the slit and buff processes, SBB push or sent off the products to the warehouse/shipment store. The warehouse/shipment store will collect the rubber sheets and stack it into the storage bins. For any purchase from the customers, the products will be prepared and gather in the marshaling area at the warehouse/shipment store. Before shipment, the packaging will be done as per purchased quantities. The remaining rubber sheets are considered to be the inventory stocks and also raw materials for the MPD and Hose production.

As MPD and Hose department are running the production based on the schedule plan, the warehouse/shipment store sent the rubber sheets as the raw materials of both productions. MPD are using Linatex 6.35 and Linatex 9.53 rubber sheets in producing Valve PPV 3T and Cavex 1T while Hose are using Linatex 3.18 and Linatex 4.76 rubber sheets in producing Freeport hose and Sweeper hose. The end products of both departments are then been push to the warehouse/shipment store for storage and shipment activities.

In the warehouse/shipment store, all the data of productions, inventory and demands can be obtained. The total amount of productions are able to be identified as the warehouse/shipment store mainly provide service in products storage, products shipment and materials deliveries to necessary departments. Table 2 shows the total productions of all departments that been stored in the warehouse/shipment store within week 36 to week 47.

**Table 2: Total production of all departments from week 36 to week 47**

Week	36	37	38	39	40	41	42	43	44	45	46	47
<b>Linatex 3.18 (40kg)</b>	45	45	45	45	45	45	45	45	45	45	45	45
<b>Linatex 4.76 (40kg)</b>	44	44	44	44	44	44	44	44	44	44	44	44
<b>Linatex 6.35 (70kg)</b>	42	42	42	42	42	42	42	42	42	42	42	42
<b>Linatex 9.53 (70kg)</b>	44	44	44	44	44	44	44	44	44	44	44	44
<b>Freeport Hose</b>	75	75	75	75	75	75	75	75	75	75	75	75
<b>Sweeper Hose</b>	45	45	45	45	45	45	45	45	45	45	45	45
<b>Valve PPV 3T</b>	12	12	12	12	12	12	12	12	12	12	12	12
<b>Cavex 1T</b>	15	15	15	15	15	15	15	15	15	15	15	15

The calculation on the total amount of weekly total in-hand inventory can be calculated by:

$$\text{previous week inventory} + [\text{amount of productions} - (\text{demands} + \text{usage})]$$

- a) Previous week inventory is the last week stocks remaining in the current week at the warehouse/shipment store
- b) Amount of productions is the number of productions in the current week
- c) Demands depends on the quantities of purchase by the customer
- d) Usage is quantities of materials used (only for calculating rubber sheets inventory because MPD and Hose are using rubber sheets as the raw materials; otherwise usage = 0)

Thus, the results of weekly in-hand inventory are as presented in Figure 7. Based on the track records of warehouse/ shipment store, the results of total weekly in-hand inventory were similar to records of weekly inventory inspection and audits. Thus, the results were tally with the quantities of stocks in the storage location.

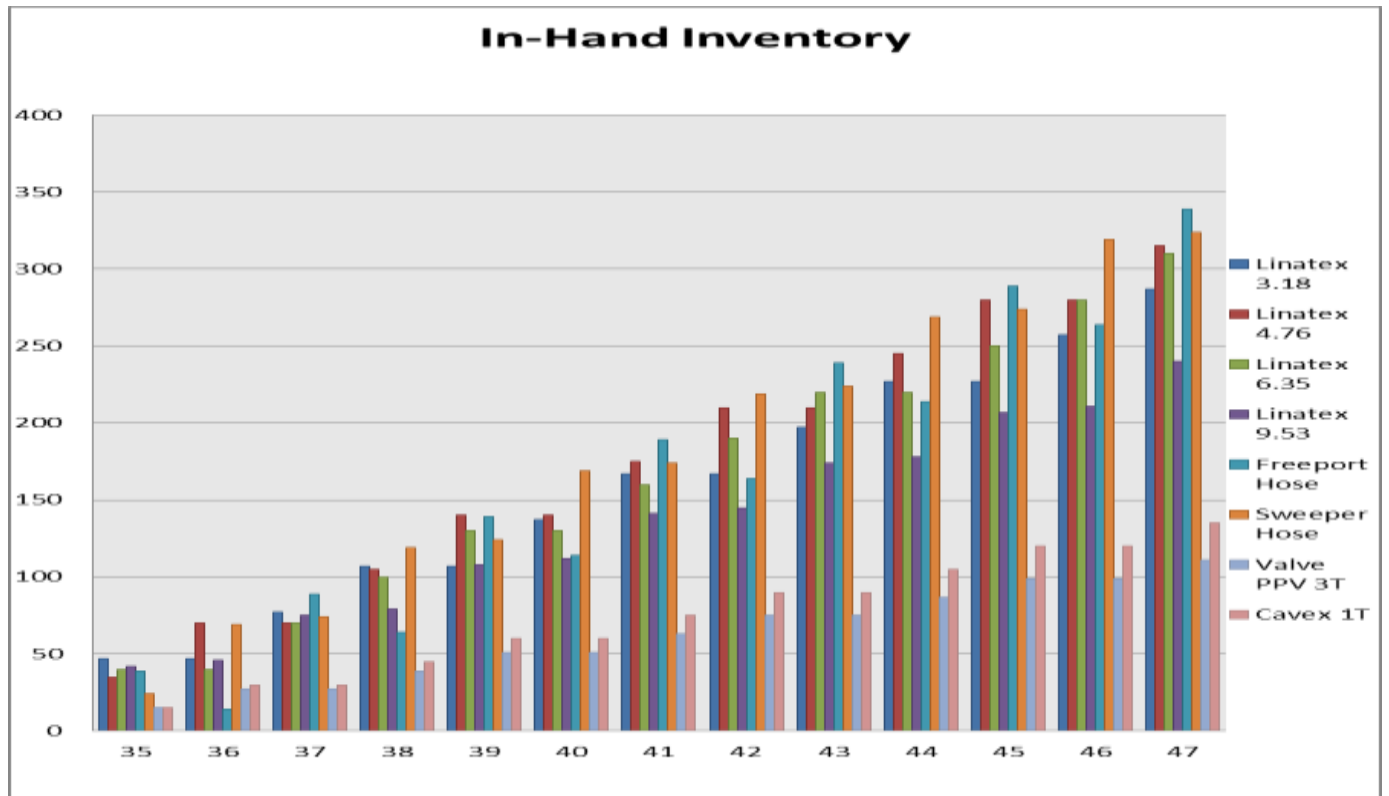


Figure 7: Weekly in-hand inventory

As the inventory cost for each product is obtained as in Table 3, the total inventory is calculated and as shown in Figure 6. Based on the calculations of the inventory costs (as in Figure 8), week 47 stated the highest of inventory cost which is RM 5,350,870. This is because of the high stock level on that week where the stocks in week 47 are above the ceiling.

Table 3: Inventory cost (per unit)

Product	Linatex 3.18	Linatex 4.76	Linatex 6.35	Linatex 9.53	Freeport Hose	Sweeper Hose	Valve PPV 3T	Cavex 1T
Unit Price (RM)	2,380	2,930	4,400	6,750	590	620	1,370	1,540

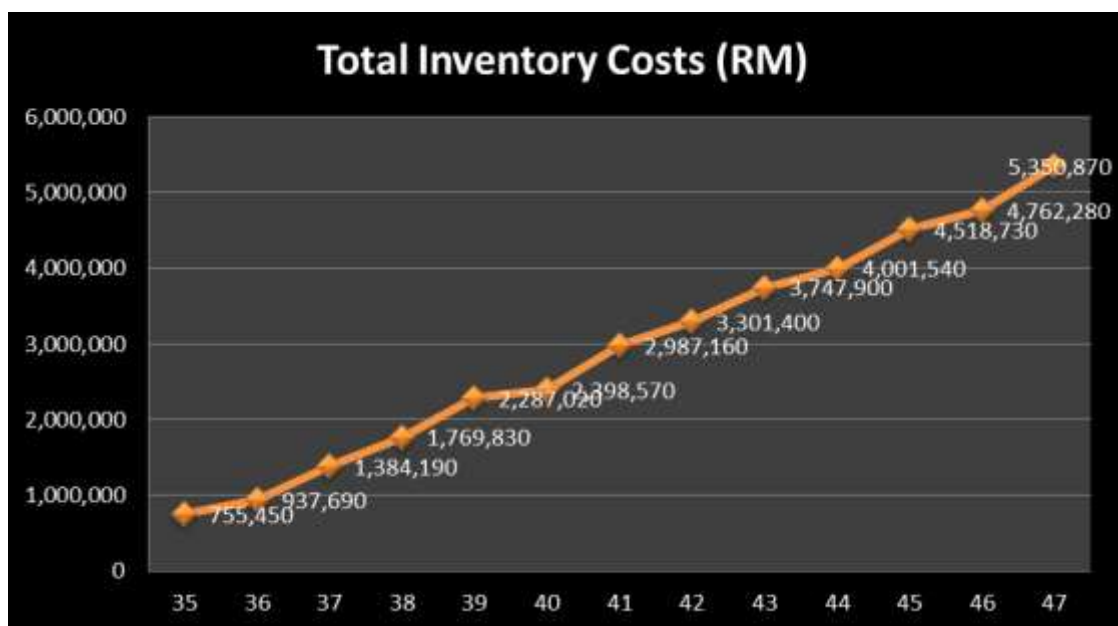


Figure 8: Total weekly inventory cost –from week 36 to week 47

The cycle time is the maximum time allowed at each workstation to perform assigned tasks before the work moves on. With the formula of cycle time calculation, the cycle time of weekly production can be calculated and presented in Table 4.

Formula:

$$\text{Cycle time} = \frac{\text{Operating time per day}}{\text{Desired output rate}}$$

SBB, MPD and Hose department are working 6 days per week with 6 hours per day. As the total production shown in Table 2, the cycle time can be calculated as in such example: For the first example; for Linatex 3.18, the operating time per day is 360 minutes and the desired output rate is 45 units / 6 days = 7.5 units. Thus the cycle time is 360 minutes/7.5 units = 48 minutes. Second example; for Valve PPV 3T, the operating time per day is 360 minutes and the desired output rate is 12 units / 6 days = 2 units. Thus the cycle time is 360 minutes/2 units = 180 minutes.

Table 4: Product cycle time

Product	Linatex 3.18	Linatex 4.76	Linatex 6.35	Linatex 9.53	Freeport Hose	Sweeper Hose	Valve PPV 3T	Cavex 1T
Cycle Time (minutes)	48	49	51	49	29	48	180	144

For the summary of the current production system analysis, several issues occur especially on the inventory. The issues are mainly on the effects of high inventory and also over-production through the streams. In term of using the push system, an improvement on the production has been designed and analyzed with may give the impact with efficient inventory level and production flow.

### 3. DESIGN OF JIT-PULL SYSTEM



Figure 9: General pull system design for the rubber production company

When there is order from the customer, the order placement will be done at the sales department (supply chain) which means the customer will pull from the sales department (Flow 1). Thus supply chain will pull the products from the warehouse/shipment store (Flow 2). With the inventory of kanban stocks, the warehouse/shipment store will ship the products to the customer (Flow 3). At the same time, warehouse/shipment store will pull the products from the production for replacement as the kanban stocks were pulled by customer (Flow 4). As production departments received kanban requisitions, the production departments will pull the raw materials from supplier and warehouse (Flow 5). Once receiving the raw materials, the production departments run the production as per plan and schedule. Finish products are then sent to the warehouse for the stocks refill (Flow 6). The details operation of the products and materials flow in the new design is as in Figure 10.



Figure 10: Pull (kanban) production system

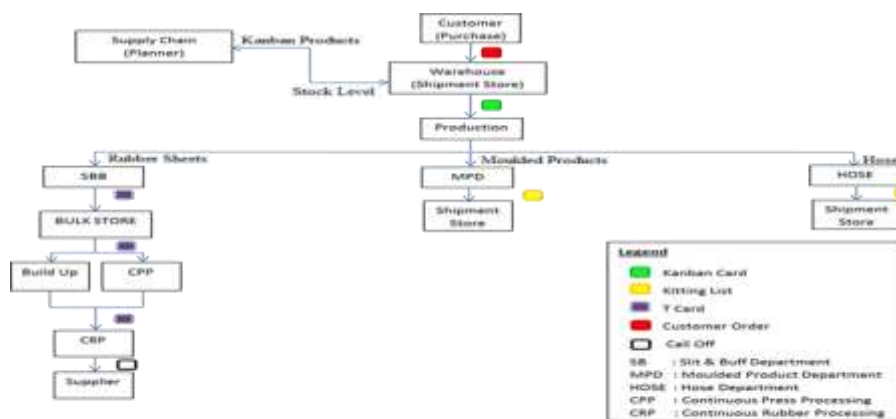


Figure 11: Pull system cards

From the design of pull system of the rubber production company as in Figure 11, the flow of materials is through the moving cards. As the customer place the order through the purchase order, the warehouse/shipment store will sent out the products which are the kanban stocks from the kanban bins. In order to replace the stocks that have been taken out, warehouse/shipment store will withdraw the kanban cards to the production departments. The kanban cards indicate the signal of quantities that need to be produce for replacing or refill the kanban bins. In SBB stream (from SBB to CRP), transaction cards (T-cards) will be used for the productions. The transaction cards from SBB to the bulk store will indicates the quantites of rubber sheets needed by the SBB to run the production.

While the T-card from bulk store indicates the quantities of rubber sheet that the BUP or CPP need to produce. Same situation goes to the T-card from BUP or CPP to CRP. The T-cards indicate the amount of compounds needed to produce the rubber sheets that has to be sent out to the bulk store. On the MPD and Hose stream, whenever these both departments received the kanban card from the warehouse/shipment store, both departments will be preparing the kitting list. Kitting list is the list of raw materials needed to run the production. The kitting list will be sent out to the warehouse/shipment store. By receiving the kitting list, the raw materials will be sent to MPD or Hose department. Once completing the production, the product will be sent off to the warehouse/shipment store.



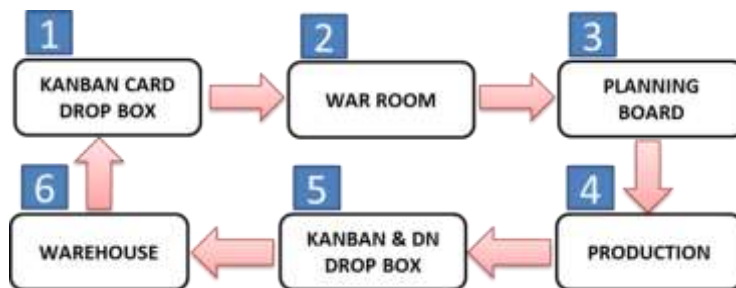


Figure 12: Kanban card flow

Base on the Figure 12, the warehouse personal will issue the kanban card at the kanban drop box placed in front of every department office. According to the kanban quantity and the used of War Room, production schedule is planned. The productions details will then be displayed at the planning board. With the planning, the production runs. Once production completed, finishing personal will open the delivery note and take the kanban card from the war room and move it to kanban and DN drop box at the outbound area (finishing area). Finally, warehouse personal will be informed to collect the product. Upon collecting, the person in-charge will check and verify the product and kanban card quantity. Once agreed, the delivery note will be sign off and the kanban card returned to the warehouse/shipment store together with the finished products.

#### 4. JIT-PULL SYSTEM ANALYSIS

The comparison on the total production within 12 weeks (from week 36 to week 47) of every product has been derived. The total productions of both push system and pull system are presented as in Figure 13. As the pull system are reducing the production of every product within week 36 and week 47, this can conclude that the reduction of production gives the impacts in reducing the cost itself. Thus, by improving the production quantities, this may help the rubber company to save up the production costs.

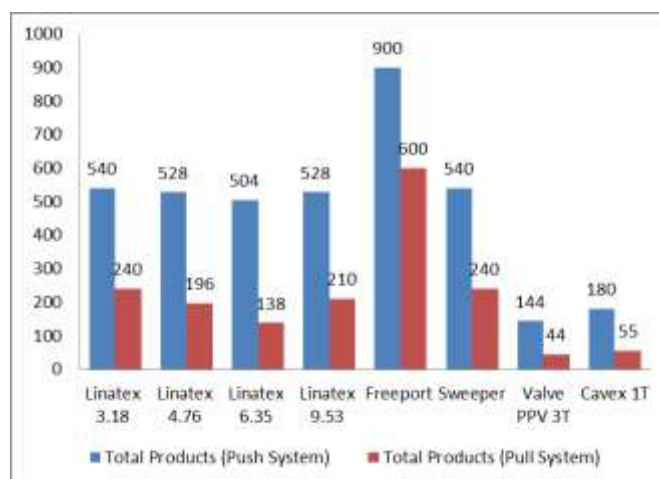


Figure 13: Comparison on production quantities within week 36 to week 47

As the production quantities have been reduce by implementing the pull system, the total cycle time will also be reduced. The cycle time is calculated according to the cycle time on current production system (push system) and also the cycle time on the new production design (pull system) as presented in Table 5.

Table 5: Comparison on product cycle time within week 36 to week 47

Products	Push System			Pull System		
	Total Products	Cycle Time Per Unit (minutes)	Total Cycle Time (minutes)	Total Products	Cycle Time Per Unit (minutes)	Total Cycle Time (minutes)
Linatex 3.18	540	48	25920	240	48	11520
Linatex 4.76	528	49	25872	196	49	9604
Linatex 6.35	504	51	25704	138	51	7038
Linatex 9.53	528	49	25872	210	49	10290

Freeport	900	29	26100	600	29	17400
Sweeper	540	48	25920	240	48	11520
Valve PPV 3T	144	180	25920	44	180	7920
Cavex 1T	180	144	25920	55	144	7920

Through the pull system, the inventory cost is as show in Figure 4.14. From the graph, it shown that week 35 stated the highest inventory costs as all locations of the products are fully occupied. This means that, whenever the kanban stocks of all products in the warehouse/shipment store are in the sufficient quantities, the inventory cost is RM 1,530,980.



Figure 14: Pull system inventory cost on week 35 to week 47

The calculation of the improvement on inventory cost is taken at week 47 (cumulative inventory). By implementing the pull system, the rubber company may improve the inventory costs by 76% as in the following calculation.

Current Inventory Cost (push system) on week 47 : RM 5,350,870  
 Inventory cost (pull system) on week 47 : RM 1,286,390

Thus,

$$\frac{RM\ 5,350,870 - RM\ 1,286,390}{RM\ 5,350,870} \times 100 = 76\%$$

## 5. CONCLUSION

This study is mainly for the production system improvement of the rubber company. In implementing the push production system, currently that company is facing few issues that been disturbing the top management and also the staffs. The push production system mainly created several wastes that cause high inventory costs, low storage spaces, over-production and inefficient communications. Hence, with the design of pull system for the rubber production company, it is proven that this pull system able to reduce inventory costs, reduce work in process (WIP), increase storage space with proper arrangement, eliminate over-production instead maintaining fixed production quantities and created an efficient communications throughout the production stream. In addition, with the implementation of kanban system in the production stream, the materials flows will be more smoothly compared to the push system practices. Besides that, the kanban system help to ease the monitoring and control the production flow including the inventory. Therefore, the pull system completely able to reduce overall inventory, improve cash flow and also provide improvement in customer satisfaction for rubber company by minimize the presence of non-value-adding operations and non-moving inventories in the production line.

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