03. An Inventory System

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An Inventory System of Packaging Materials: Case Study at PT. Djambi Waras Jujuhan

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Abstract. PT Djambi Waras Jujuhan is one of Crumb Rubber Factory which is inseparable of inventory problems. It needs packaging materials for production process, especially in packaging process. Currently, PT Djambi Waras Jujuhan has the problems in controlling inventory system of packaging materials because of one supplier only supplying materials, variation of lead time, high minimum stocks of packaging materials and pile up in the storage. The aim of the research is to propose an inventory system of packaging materials to improve inventory performance considering variations of lead time. The inventory system we proposed consists of four steps. The first step is calculating Inventory Turnover (ITO) to identify how the performance level of the existing inventory system. The second step is determining aggregate planning of packaging materials, classifying packaging materials using ABC analysis and testing distribution of lead time. The third step is determining economic order quantity and order interval, safety stock and reorder point. The fourth step is calculating total annual inventory cost considering safety stock and variation of lead time. Sensitivity analysis is performed to see the effects of changes of input parameters to the decision variables and total inventory cost. Based on analysis we have done, current inventory system of packaging materials at PT Djambi Waras Jujuhan has not been efficient yet that we can see from the value of inventory turnover. From 38 types of packaging materials, 18 types of packaging materials have the value of inventory turnover more than 1 and 20 types have the value of inventory turnover less than 1. The inventory system we proposes in this paper can save 78,46% of total current inventory cost that is Rp.320.728.188,-. Therefore, the inventory system considering variation of lead time we proposed at PT Djambi Waras Jujuhan has increased the inventory performance.

1 Introduction

Inventory is one of the most important factors in logistics management. Inventory planning will determine the smoothness of the production process in the company. Deficiency or excess inventories may cause problems in the company. So, inventory management seeks to achieve balancing between deficiency and excess inventory in a period of planning that involve risks and uncertainties [2]. In addition, each company must be able to maintain the optimum amount of inventory so as to ensure the

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smoothness whole operation of the company in the right quantity, right quality and lowest possible cost.

Inventory problems can be influenced by several parameters such as demand, lead time, holding costs, ordering cost, back order costs and price, which often vary in the real situation. Deterministic models are not sensitive for these changes. To cope their variations, especially variations of lead time and demand, the probabilistic model is characterized by the presence of safety stock that is an important part of the company inventory policies. Safety stock be able to meet the demand during lead time [1,2].

PT Djambi Waras Jujuhan is one of Crumb Rubber Factory that produces natural rubber balles into products such as: SIR-10, SIR-20 and SIR-20 CV. The company needs packaging materials for packaging process. And the company had difficulty to control the packaging materials inventory because the company has only one supplier, varying demand and lead time which varies from 1 day, 3 days, 5 days until more than 1 month, the packaging materials ordered the last period came periodically, minimum stock of packaging materials in warehouses is quite high. Because the existing inventory system for packaging materials in the company has not yet precise and optimal, so the packaging material is damaged and pill up in warehouses. This situation happened because of the size specification of the packaging materials that has been holding in previous period by the company no longer fit the size specifications set by the consumer (buyer), so that situation has explained before happened and the company is loss. Figure 1, 2, and 3 showed the variation of the finished product demand, variation of lead time, and one of the packaging materials inventory.

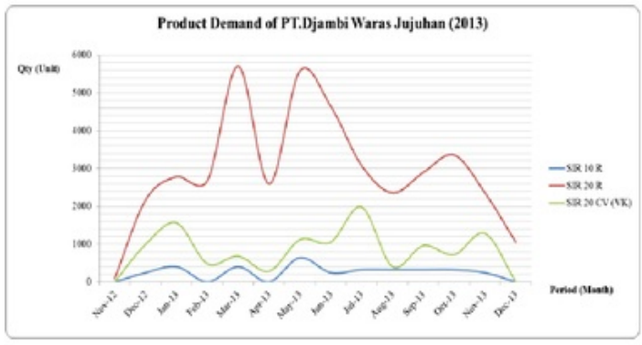

Fig. 1. Graph of Product Demand (SIR) in PT Djambi Waras Jujuhan

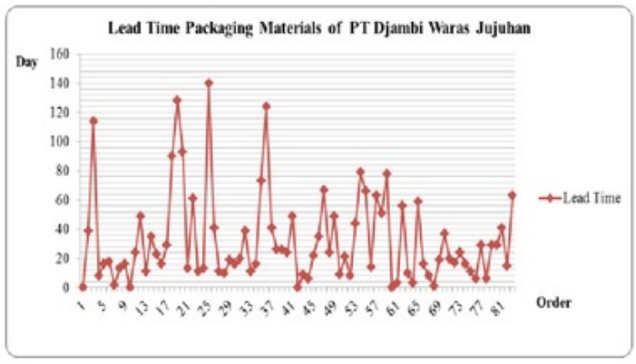

Fig. 2. Graph of Lead Time Packaging Materials in PT Djambi Waras Jujuhan

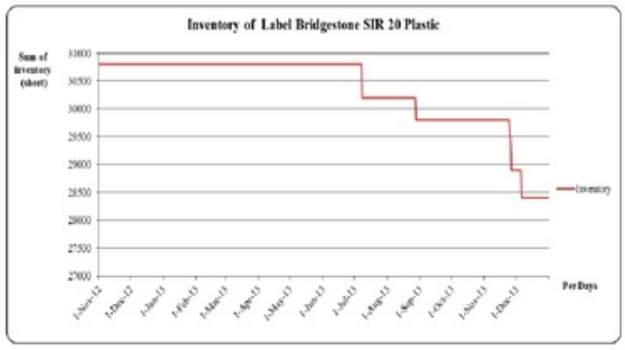

Fig. 3. Graph of Label Bridgestone SIR 20 Plastic Inventory

Examples for safety stock of Label Bridgestone SIR 20 Plastic is 30,000 sheets and changed in October 2013 to be 7000 sheets, though this type of packaging material start in November 2012 until in July 2013 are not used. That type of packaging material used on August 28th, 2013 was 400 sheets. It was concluded that this type of packaging material has a lot of stock and long stored in the warehouse. As a result of too much storage, there are some packaging material that discarded due to damage such as Plastic bags SIR R 20/35 SEU damaged amount of 654 sheets or approximately 27.25 kg and removed from the warehouse on April 10, 2013. In addition, there are some packaging material have not been established safety stock to be provided by the company to cope with demand fluctuations or variations. For example: Label SMPT C 20 UG230 SIR Plastic, Red Plastic, etc.

Consequences that must be accepted by the company because inventory system still doesn't optimal or appropriate is the high inventory cost and inventory policy for safety stock is not accurate that will increase the risk of losses in the future. Now, company management has not been too considering the consequences. Based on the issues that have been disclosed and supporting data of this research to be done so this research to improve the existing inventory system is needs by evaluate inventory system with considering variations of lead time, so the company can make appropriate planning of when order time, optimal quantity order and how much safety stock should be provided for a certain period to anticipate variations of lead time so that inventory cost can be minimized.

2 Literature

2.1 Inventory

According to reference [1] inventory is a number of materials, spare-parts, work in process, finished goods/products or components supplied to meet consumer demand at all times and use an asset that is waiting in a production process. So, basically this inventory is intended to facilitate or expedite the process of the operation in the company.

2.1.1 Inventory Costs

According to reference [1] the elements contained in the inventory can be divided into four groups, that is:

1. Ordering Costs
2. Inventory carrying costs/stock holding cost (%)
   According to Tersine (1994), holding costs are typically at intervals of 20-40% of the investment companies [8].
3. Shortage costs/out of stock cost).
4. Capacity associated costs

2.1.2 ABC Analysis

ABC Analysis is the method to classification material into group based on materials usage during the period of time (price per unit multiplied by the volume of material usage in period of time). ABC classification is using principle 80-20 or Pareto law which about 80% of the total inventory of material represented or represented by 20% of material inventory. Use of ABC analysis is to establish the engineering priority, purchase priority, security, recharging system (replenishment systems), and investment decisions and also can be applied in the company that have various types of inventory materials with different using value.

2.1.3 Probabilistic Models

This model considers all variables have values that are uncertain and one or more variable is a random variable. Parameters such as demand, lead time, inventory costs are varies in the real condition. And deterministic models are not sensitive to such things. The equation used to determine the total inventory cost is using equations Economic Order Interval (EOI)-Multiple Items. The equation is as follows:

1. Total Inventory Cost

$$TC(T) = \sum_{i=1}^{n} P_i R_i + \frac{C+nc}{T} + \frac{TF}{2}\sum_{i=1}^{n} P_i R_i \quad (1)$$

2. Optimum Order Interval (T*)

$$T^* = \sqrt{\frac{2(C+nc)}{F\sum_{i=1}^{n} P_i R_i}} \quad (2)$$

3. Maximum Inventory each items (E_i)

$$E_i = \frac{R_i T}{N} + \frac{R_i L}{N} = \frac{R_i (T+L)}{N} \quad (3)$$

where:

R_i = Demand or requirement per item
P_i = Purchasing cost per item
n = number of items are ordered at the same time
c = additional ordering cost for each item

When the lead time varies, reorder point policies that may set the lead time is the time that the minimum lead time, the average lead time or maximum lead time. With a minimum or maximum limit, then the reorder point should be different. If the reorder point based on a minimum lead time then tend not sufficient, and if the maximum lead time based on the results obtained is excessive inventory levels, so it can not be evaluated statistically, so in practice the reorder point based on the average lead time. The solution in this case is similar to variation demand and constant lead time. The basic difference is the demand during lead time probability distribution is obtained by adding a constant demand during lead time. This case can be seen in Figure 4

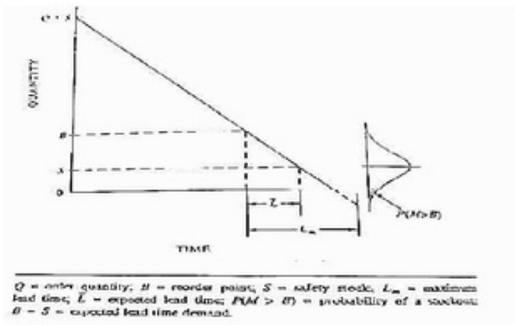

Fig. 4. Constant Demand and Variable Lead Time (Source: Tersine, 1994)

If the lead time is normal distribution, the formulations are used to optimize the reorder point is as follows:

$$B = \bar{M} + Z_{\sigma} = D\bar{L} + ZD\sigma_{L} \quad \textbf{(4)}$$

where:

B = reorder point
D = rate constant demand per period
σ = standard deviation of demand during lead time
σ_L = standard deviation of lead time
$\bar{L}$ = average lead time in the period

2.2 Sensitivity Analysis

Sensitivity analysis is one step of the modeling system in validation the inventory model built or developed. Two important issues in the sensitivity analysis are as follows [3]:

1. Find response of optimal solutions generated to changes in the input values.
2. Find out how the big error occurs (loss of profits or savings).

3 Research Methodology

Research methodology is structured for problems can be resolved with better and more focused. The steps are shown in the flowchart in Figure 5.

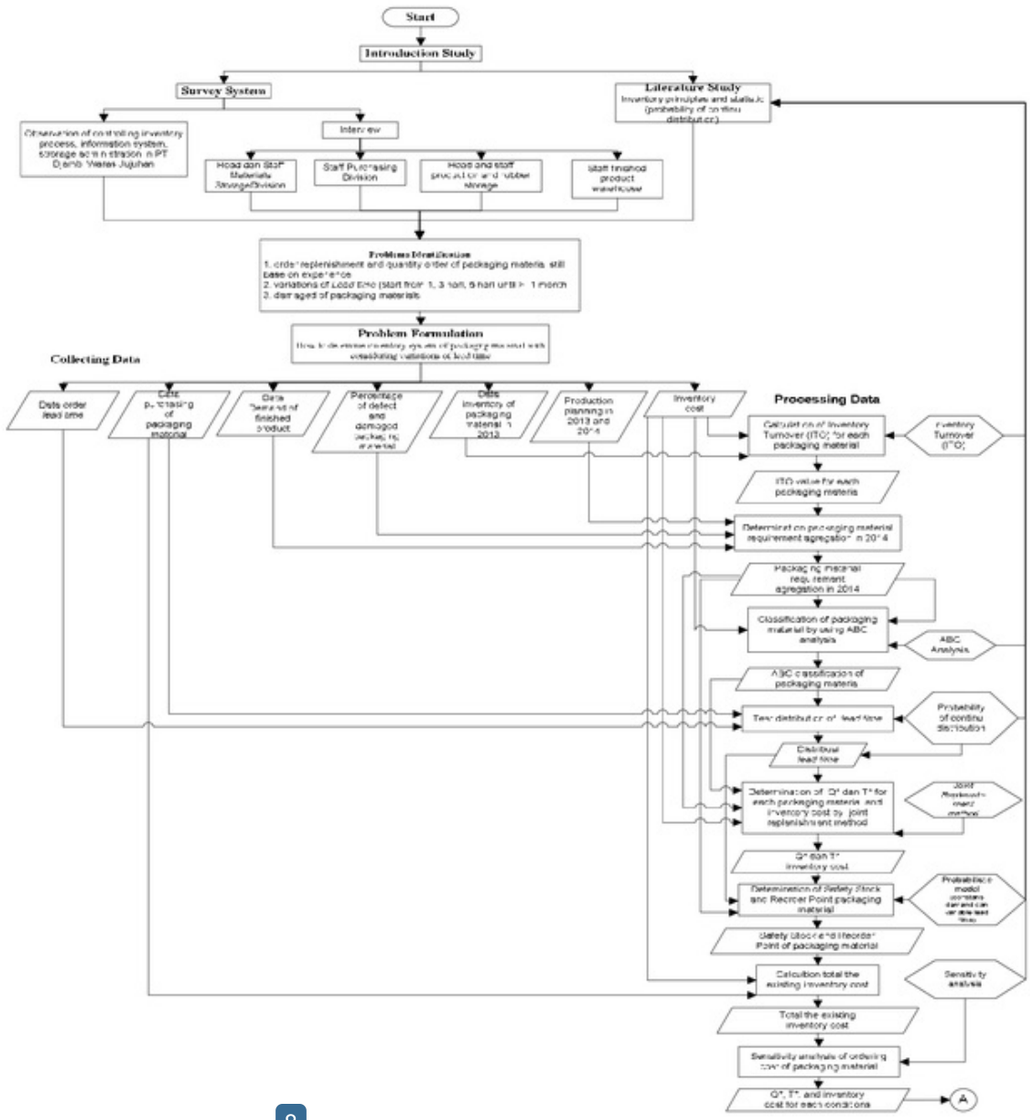

Fig. 5. Flowchart of Research Methodology

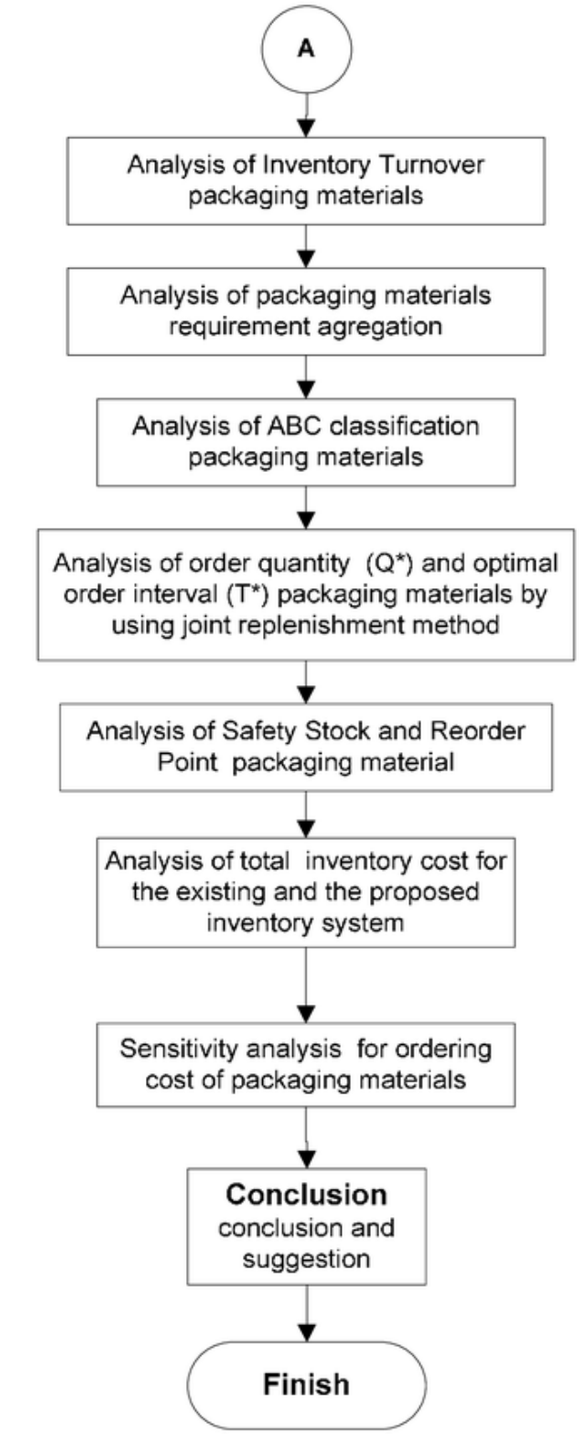

Fig. 5. Flowchart of Research Methodology (continue)

4 Results and Discussion

4.1 Data Collection

The data collected are as follows:

1. Data demand of finished products in 2013
2. Plan production in 2013 and 2014
3. Data supplies packaging materials in 2013
4. Component inventory cost of packaging materials
5. Percentage of defect or damaged packaging materials
6. Data oerder lead time of packaging materials
7. Data purchase of packaging materials.

Ordering costs of packaging material can be seen in Table 1, and transportation cost and PPN can be seen in Table 2, the percentage of defect packaging materials can be seen in Table 3, and data lead time can be seen in Table 4.

Table 1. Ordering Costs of Packaging Materials

Number	Component	Cost
1	Make PR from storage and buy sheet (@Rp. 1000)	Rp 6.000
2	Make an coverring letter (3 pieces) @Rp. 1000)	Rp 3.000
3	Goods Receiving Report 6 pieces (@Rp. 1000)	Rp 6.000
4	Communication Fee via Telephone and email	Rp 30.925
5	Administration Fee	Rp 72.565
6	Goods Receiving Fee	Rp 206.360
Total		Rp 324.850

(Source: Materials Storage and Purchasing Division of PT Djambi Waras Jujuhan)

Table 2. Transportation Costs of Packaging Materials

Number	Component	Cost
1	Transportasi Cost Per Kg	Rp 600
2	Delivery Cost Per Kg	Rp 500
3	Value Added Tax (PPN) % Per Unit	10%

(Source: Purchasing Division of PT Djambi Waras Jujuhan)

Table 3. Percentage Defect of Packaging Material

Number	Code	Type of Packaging Material	Unit	Percentage (%)
1	PLS-0001	Plastic Bag SIR 10 SEUR	Kg	3%
2	PLS-0002	Plastic Bag SIR 20 SEUR	Kg	3%
3	PLS-0003	Plastic Bag SIR 20 SEUVK	Kg	3%
4	PLS-0071	Bridgeston Plastic SIR 20	Sheet	3%
5	PLS-0074	Good Year Plastic SIR 20 NOLO	Sheet	3%
6	PLS-0075	Good Year Plastic SIR 20 SEUNOVOLO	Sheet	3%
7	PLS-0076	Good Year Plastic SIR 10 NIMBO	Sheet	3%
8	PLS-0077	Good Year Plastic SIR 20 SEUCVNIVCO	Sheet	3%
9	PLS-0093	Plastic SIR 10	Sheet	3%
10	PLS-0099	SMPT Plastic C UG230SIR20	Sheet	3%
11	PLS-0163	Shrink Wrapped Plastic 0,25mm x 165 mm x252 mm	Kg	5%
12	PLS-0189	Blank Plastic SIR 20 SEU	Sheet	5%
13	PLS-0195	Blueprint Plastic 0,14mm x 145 x 870 cm	Kg	5%
14	PLS-0199	Blueprint Plastic 0,10 mm x 140 x 160 cm	Kg	3%
15	PLS-0202	Gyo Plastic SR 20 SEUCOOPER TIRE	Sheet	3%
16	PLS-0223	Blank Plastic 0,1 x 140 x 160 cm	Kg	3%
17	PLS-0225	White Blank Plastic 0,1 mm x 125 x 160 cm	Kg	3%
18	PLS-0230	Trapping Band Plastic SMPT	Rol	3%
19	PLS-0253	Wire Plastic MB 0,2mm x 90 x 271 cm	Kg	3%
20	PLS-0296	Red Plastic 0,14 mm x 146 x 340 cm	Kg	3%
21	PLS-0297	Red Plastic 0,14 mm x 146 x 370 cm	Kg	3%
22	PLS-0302	Blue Plastic 0,1 mm x 140 x 170 cm	Kg	3%
23	PLS-0312	Blue Plastic 0,1 mm x 110 x 150 cm	Kg	3%
24	PLS-0326	Sumtomom Plastic	Sheet	3%

(Source: Finished Product Warehouse of PT Djambi Waras Jujuhan)

Table 4. Order Lead Time of Packaging Materials

Order	Lead Time (Days)	Order	Lead Time (Days)	Order	Lead Time (Days)	Order	Lead Time (Days)
1	8	15	13	29	22	43	37
2	16	16	11	30	35	44	20
3	18	17	10	31	24	45	17
4	2	18	19	32	9	46	24
5	13	19	16	33	21	47	16
6	16	20	20	34	8	48	11
7	24	21	11	35	14	49	6
8	11	22	16	36	3	50	29
9	35	23	26	37	10	51	6
10	23	24	26	38	3	52	29
11	16	25	24	39	16	53	29
12	29	26	1	40	8	54	15
13	13	27	9	41	1		
14	11	28	6	42	19		

(Source: Purchasing Division of PT Djambi Waras Jujuhan)

4.2 Results

The following are the results of the calculations have been carrying out.

Table 5. Summary of Packaging Material Requirements 2014

Number	Code	Type of Packaging Material	Unit	Total Requirement (2014)
1	PLS-0001	Plastic Bag SIR 10 SEUR	Kg	4201,73
2	PLS-0002	Plastic Bag SIR 20 SEUR	Kg	59969,25
3	PLS-0003	Plastic Bag SIR 20 SEUVK	Kg	14833,31
4	PLS-0071	Bridgeston Plastic SIR 20	Sheet	2294
5	PLS-0074	Good Year Plastic SIR 20 NOLO	Sheet	17955
6	PLS-0075	Good Year Plastic SIR 20 SEUNOVOLO	Sheet	32398
7	PLS-0076	Good Year Plastic SIR 10 NIMBO	Sheet	9515
8	PLS-0077	Good Year Plastic SIR 20 SEUCVNIVCO	Sheet	43951
9	PLS-0093	Plastic SIR 10	Sheet	1158
10	PLS-0099	SMPT Plastic C UG230SIR20	Sheet	25891
11	PLS-0163	Shrink Wrapped Plastic 0,25mm x 165 mm x252 mm	Kg	25772
12	PLS-0189	Blank Plastic SIR 20 SEU	Sheet	21665
13	PLS-0195	Blueprint Plastic 0,14mm x 145 x 870 cm	Kg	20045,2
14	PLS-0199	Blueprint Plastic 0,10 mm x 140 x 160 cm	Kg	17522,44
15	PLS-0202	Gyo Plastic SR 20 SEUCOOPER TIRE	Sheet	7632
16	PLS-0223	Blank Plastic 0,1 x 140 x 160 cm	Kg	4008,9
17	PLS-0225	White Blank Plastic 0,1 mm x 125 x 160 cm	Kg	1068,48
18	PLS-0230	Trapping Band Plastic SMPT	Rol	1295
19	PLS-0253	Wire Plastic MB 0,2mm x 90 x 271 cm	Kg	41346,84
20	PLS-0296	Red Plastic 0,14 mm x 146 x 340 cm	Kg	3107,52
21	PLS-0297	Red Plastic 0,14 mm x 146 x 370 cm	Kg	3301,74
22	PLS-0302	Blue Plastic 0,1 mm x 140 x 170 cm	Kg	3365,96
23	PLS-0312	Blue Plastic 0,1 mm x 110 x 150 cm	Kg	30789,64
24	PLS-0326	Sumtomom Plastic	Sheet	34491

Table 6. Summary of ABC Classification Based on Usage Value / Demand Packaging Materials

Class	Usage Value	Amount of items	Percentage of items	Total usage value/demand	Percentage usage value/demand
A	>360 million	5	20,83%	Rp 4.226.892.496	79.41 %
B	70 million < usage value < 360 million	4	16,67%	Rp 782.532.795	14,56%
C	< 70 million	15	62,50%	Rp 323.674.462	6,02%
Total			100%	Rp 5.373.099.753	100%

Data collected amount of 80 data and after testing data distribution, data can only 54 data. This happened because there are some data that is too extreme like ordering

lead time is more than 1 month and out of the control limits I-MR control chart. Distribution of lead time obtained is a normal distribution with a mean = 16.2 days (0,044 years) and standard deviation = 8.97 days (0,025 years).

Determination of Q * and T * packaging material the proposed system (2014) by using joint replenishment method

Code material = PLS-0002
Type of material = Plastic Bag SIR 20 SEU R
Unit = kg
Class = A
Total requirement (Ri) = 59.969,25 kg
Price per unit (Pi) = Rp. 27.940, -
S = ordering cost for 1x order = Rp. 324.850, -
k = fraction of holding cost = 0,24

Step to determination Q * and T * are as follows:

Step 1: Calculate annual demand (PiRi)
PiRi = Rp. 27 940, - x 59969.25 kg = Rp. 1.675.540.845, -

Step 2: Total annual demand = Rp. 4.894.941.013, -
Step 3: Economic Order Interval (EOI)

$$T^* = \sqrt{\frac{2(C+nc)}{F\sum_{i=1}^{n} P_i R_i}} = \sqrt{\frac{2(Rp.324.850 + (7x0))}{0{,}24\ x\ Rp.4.894.941.013}} = 0{,}02\ years = 8{,}58\ days$$

That included in Group AB.

Step 4: Optimal Order Quantity (Q *)
Q * = Ri x Q * = 59.969,25 kg x 0,02
= 1.410,28 kg per order

Step 5: Ordering cost (TC_p) Group AB

$$TC_p = \frac{C+nc}{T} = \frac{Rp.324.850 + (7x0)}{0{,}01} = Rp.13.968.562,-$$

Step 6: Holding cost (TC_s) Group AB

$$TC_s = \frac{TF}{2}\sum_{i=1}^{n} P_i R_i = \frac{0{,}01x0{,}24}{2} xRp.4.894.941.013 = Rp.13.813.571,-$$

Step 7: Total Inventory Cost

TC = TCP + TCS
= Rp.13.968.562,- + Rp.13.813.571,-
= Rp. 27.782.133, -

Determination of SS and B for the proposed system (2014)

Code material = PLS-0001
Type of material = Plastik Kantong SIR 10 SEU R
Class = B

Total demand in 2014 (D) = 4201,73 kg
$\bar{L}$ = 16.2 days = 0,044 years
σ_L = 8.97 day = 0,025 years

SS $= ZD\sigma_L$
= 2,33 x 4.201,73 kg x 0,025
= 240,59 kg

B $= \bar{M} + Z_\sigma = D\bar{L} + ZD\sigma_L$
= (4201,73 kg x 0,044 years) + 240,59 kg
= 427,08 kg

Table 7. Summary of Inventory Cost Comparison between The Existing and The Proposed Inventory System in 2013

component of inventory system	existing inventory system	proposed inventory system
ordering cost	Rp 5,522,455	Rp 16,892,214
holding cost	Rp 403,234,152	Rp 71,136,205
total inventory cost	Rp 408,756,607	Rp 88,028,419
save	Rp 320,728,188	
% save	78.46%	

Table 8. Summary Inventory Costs of The Proposed System with Considering Safety Stock (SS) in 2014

component of inventory cost	proposed system 2014
ordering cost	Rp 19,815,867
holding cost	Rp 94,877,098
total inventory cost	Rp 114,692,965

Sensitivity analysis performed two conditions of ordering cost are:
Initial condition = Rp. 324 850, -
Condition 1 booking fee up to 30% = Rp. 422 305, -
Condition 2 booking fee rise 50% = Rp. 487 275, -

Table 9. Summary of Inventory Cost Comparison between Initial Condition, Condition 1 and 2

component of inventory cost	initial condition (proposed 2014)		sensitivity analysis			
			condition 1		condition 2	
ordering cost	Rp	19,815,867	Rp	22,804,489	Rp	24,363,771
holding cost	Rp	19,368,350	Rp	22,083,316	Rp	23,721,287
total inventory cost	Rp	39,184,216	Rp	44,887,805	Rp	48,085,057
% increasing TC				14.56%		22.72%

4.3 Analysis

4.3.1 Analysis of Inventory Turnover (ITO) of Packaging Materials

The purpose of determination ITO value was to know how quickly turnover of packaging materials in the company and how much the company invested to inventory. Inventory management of the company will be efficient if ITO value more higher. Based on the results that have been obtained from 38 types of packaging material, just only 18 types of packaging material that has ITO value > 1, its means that 18 types of packaging material is changed at least once time for a year. For example, Plastic Bag SIR 20 SEU Plastic have ITO value = 10.28 x turn of the year,

Table 10. Inventory Turnover Value (ITO) of Proposed Inventory System

Number	Code	Type of Packaging Material	Unit	Class	ITO
1	PLS-0002	Plastic Bag SIR 20 SEUR	Kg	A	58.46%
2	PLS-0253	Wire Plastic MB 0,2mm x 90 x 271 cm	Kg	A	58.46%
3	PLS-0163	Shrink Wrapped Plastic 0,25mm x 165 mm x252 mm	Kg	A	58.46%
4	PLS-0312	Blue Plastic 0,1 mm x 110 x 150 cm	Kg	A	58.46%
5	PLS-0195	Blueprint Plastic 0,14mm x 145 x 870 cm	Kg	A	58.46%
6	PLS-0199	Blueprint Plastic 0,10 mm x 140 x 160 cm	Kg	B	58.46%
7	PLS-0003	Plastic Bag SIR 20 SEUVK	Kg	B	58.46%
8	PLS-0001	Plastic Bag SIR 10 SEUR	Kg	B	38.55%
9	PLS-0223	Blank Plastic 0,1 x 140 x 160 cm	Kg	B	38.55%
10	PLS-0302	Blue Plastic 0,1 mm x 140 x 170 cm	Kg	C	38.55%
11	PLS-0297	Red Plastic 0,14 mm x 146 x 370 cm	Kg	C	38.55%
12	PLS-0296	Red Plastic 0,14 mm x 146 x 340 cm	Kg	C	38.55%
13	PLS-0077	Good Year Plastic SIR 20 SEUCVNIVCO	Sheet	C	27.69%
14	PLS-0230	Trapping Band Plastic SMPT	Rol	C	27.69%
15	PLS-0326	Sumtomom Plastic	Sheet	C	27.69%
16	PLS-0075	Good Year Plastic SIR 20 SEUNOVOLO	Sheet	C	27.69%
17	PLS-0225	White Blank Plastic 0,1 mm x 125 x 160 cm	Kg	C	27.69%
18	PLS-0099	SMPT Plastic C UG230SIR20	Sheet	C	24.54%
19	PLS-0189	Blank Plastic SIR 20 SEU	Sheet	C	24.54%
20	PLS-0074	Good Year Plastic SIR 20 NOLO	Sheet	C	24.54%
21	PLS-0076	Good Year Plastic SIR 10 NIMBO	Sheet	C	24.54%
22	PLS-0202	Gyo Plastic SR 20 SEUCOOPER TIRE	Sheet	C	24.54%
23	PLS-0071	Bridgeston Plastic SIR 20	Sheet	C	8.53%
24	PLS-0093	Plastic SIR 10	Sheet	C	8.53%

its mean that packing material turn over 10 times a year and inventory control for this packaging materials quite good compared with other types of packaging materials. Meanwhile, 20 types of packaging material has ITO value <1 and ITO value = 0 as Label Good Year 10 VK / Nevo Plastic, Pink Plastic 0.1 x 150 x 880 cm, etc. That is happened because packaging materials not changed in one year.

If ITO value of the existing inventory system compared with the proposed inventory system in Table 5.1, so ITO value of the existing inventory system is still not optimal or it can be concluded that inventory turnover is still relatively slow if it compared with the proposed inventory system has been considering with variations of lead time. Based on these conditions, the company should improve the existing inventory system and implement the proposed inventory system that can reduce average inventory of packaging materials in warehouses. So turnover of packaging materials can be faster than the previous inventory system.

4.3.2 Analysis of Packaging Material Requirements Aggregation

Existing packaging material requirements planning is still not well arranged and has not been integrated with the demand of finished product, it still based on previous usage, so the risk of stock out or over stock becomes larger. To solve this problem, the company must plan for packaging material in 2014 so that the risks can be minimized.

Packaging material requirements planning is done based on production plan in 2014. The result of this packaging material requirements planning is aggregation of packaging materials. Packaging material requirements planning has been undertaken to consider the percentage of defects or damage of the packaging material during the production process or after production during for a year. Production planning of packaging material in 2014 use for another step for evaluation and give recommendations inventory system for this company.

4.3.3 Analysis of ABC Classification Packaging Materials

Condition of packaging material inventory systems in PT Djambi Waras Jujuhan still not grouping and ordering process in the company is done if inventory of packaging material has reached the minimum stock. So, if there are several types of packaging material has reached the minimum stock of packaging materials will be immediately ordered to suppliers. In this research, packaging materials will be grouped into three classes using the ABC analysis.

Data packaging materials in that company amounted to 38 types. But just only 24 types are used and classify by ABC Analysis because only 24 types of packaging material that has required in the year 2014. Packaging materials are not grouped into packaging material requirements planning in 2014, the inventory system is specific policy based on historical data of the company.

ABC analysis performed in this research is based on value usage criteria of the packaging material and the result showed that 5 types of packaging materials are in A class, 4 types of packaging materials are in B class, and 15 types of packaging materials are in C class. Packaging materials including into A class with usage percentage 79.41% and its annual usage value more than Rp. 360 million, B class with usage percentage of 14.56% and its annual usage value is above Rp.70 million - under Rp.360 million, and C class with usage percentage 6.02% and its annual usage valua is under Rp.70 million.

The high demand value of packaging material is influenced by price per unit and the number of demand for a year. If price and amount of usage per year increase, so packaging material can classify into A class. And if one of two factors that mentioned before is low, so possibility of the packaging material can classify into B or C class. The situation also happened of packaging material in PT Djambi Waras Jujuhan. For example, Plastic Bag SIR 10 SEU has a high price but low annual usage for a year, so this type classify into C class.

The results of ABC classification will be using for packaging material inventory system in PT Djambi Waras Jujuhan in 2014. A class of packaging materials should be given the main focus in the Materials Storage and Purchasing Division. Although B and C class are focus of attention quite normal and enough, but for certain types of packaging material still needs to be given more attention than the other types that are same class because there is a packaging material that has a rapid rate of usage in the class. The results of ABC classification is also used as the basis for ordering process the packaging material to suppliers.

4.3.4 Analysis of Optimal Order Quantity (Q*) Order Interval (T*) of Packaging Materials by Using Joint Replenishment Models

Order interval for every group is different. The differences happened are because of the influence from purchasing cost, ordering cost, fraction of holding cost and requirement of packaging material. The higher of demand and purchasing cost, so order interval will be smaller. This means that company is increasingly often an order to the supplier. For example, the actual order interval C order 1 that is 59 days so actual order frequency is 11 times not 10.95 times as the result of the calculation. This is done so that demand can be met during the year.

Thus, in the decision-making process should consider order interval and order frequency so that a more optimal decisions compared just only one factor to consider. For example, when a decision is taken only consider order interval there was a risk that order made by the optimal quantity will exceed demand for a year, and it will increase order and holding cost. This problem happens if packaging materials has great demand. Optimal order quantity (Q *) is different for every item in the group, depending on the needs of the packaging materials and purchasing cost. Q * will be greater if demand is high and purchasing cost of packaging materials is low. Conversely, if purchasing cost of packaging materials is high so Q * will become smaller. Recommended for the proposed system, the company would choose the actual order frequency because the company only adds one order.

4.3.5 Analysis of Safety Stock (SS) and Reorder Point (B) Packaging Materials

Based on the results of the calculations have been done SS obtained is smaller than the SS set by companies today. It is shown that the the proposed system has a better inventory system inventory systems inventory now because a given proposal already has the optimal ordering quantity (Q*) with optimal ordering interval (T*) for each packaging material, although given the the proposed inventory system has messaging costs are greater because the frequency of ordering frequently. However, packaging materials stored in the warehouse a little more and have faster inventory turnover compared to the current inventory system. So the risk of damage or loss due to specification changes the size of the packaging material can be reduced in the the proposed inventory system.

Safety stock provided by the company is still greater when compared with the results of calculations performed, but this time the SS policy is much better than the company's policy before the month of October 2013 as the SS set is much larger than the current inventory system. Reorder Point (B) packaging materials are obtained from calculations carried out amounted to two times of the safety stock is obtained. This occurs because the service level that is 99% larger.

4.3.6 Analysis of Current and Proposed Inventory System

Calculation of total inventory cost for the the existing and the proposed inventory system 2013 was conducted to determine the proposed inventory system is feasible to be implemented or not. The proposed inventory system that given was feasible to implement because: a) it can save total inventory costs up to 78.46% or Rp.320.728.188,- fr[illegible] total inventory cost of the existing inventory system, b) ordering costs of the proposed inventory system is greater than the existing inventory system because ordering frecuency more often done by considering the optimal quantity of packaging material, purchasing of packaging materials, ordering costs holding costs, c) holding costs of the propose[illegible] inventory system is smaller than the existing inventory system because average inventory and safety stock packaging materials is smaller than the existing inventory system. In the existing inventory system, average inventory and safety stock is higher when it compared with the the proposed system, its meaning that company save many packaging materials that resulted turnover of stock to be slow.

4.3.7 Sensitivity Analysis for Ordering Cost of Packaging Materials

Based on result from calculation, it showed that condition 1 when ordering costs increased up to 30%, so total inventory costs increased up to 14.56%. Meanwhile, the condition 2 ordering costs increased up to 50% so the total inventory cost increased up to 22.72%. It can be concluded that the response given the optimal solution or the total inventory costs if ordering costs chaged so total inventory costs chages less than increase of ordering costs, this can be interpreted that propose or recommendations inventory system feasible to implement in the company. In addition, if ordering costs increase so order interval and order quantity will be increasing too. That mean, time period between the previous order to the next order increases because ordering quantity increase or it can be said ordering frequency reduced for a year.

5 Conclusions and Suggestions

5.1 Conclusions

Conclusions derived from this research include the following:

1. Packaging materials inventory systems in PT Djambi Waras Jujuhan still not optimal if their compared with the the proposed inventory system because of from 38 types of packaging materials holding in warehouse just only 18 types of packaging material that has a value of ITO > 1 and 20 types of packaging material has a value of ITO < 1 and ITO = 0. While the value of

the the proposed inventory system of order class AB has a value of ITO = 58.46 x turn of the year, order class BC has a value of ITO = 38.55 x turn of the year, order class C 1 has a value of ITO = 27.69 x turn of the year, order class C 2 has a value of ITO = 24.54 x turn of the year, and order class C 3 has a value of ITO = 8.53 x turn of the year. This happens because the company has an average inventory and safety stock is high. Solution for this problem is the company can reduce the average inventory in the warehouse so risk of damage or change the size specifications of packaging materials can be minimized.

2. Proposal or recommendation packaging materials inventory systems will give for the the existing inventory system, are:

   a. Planning or aggregation of packaging material needs for a year using a production plan that has been made by considering the percentage of defect packaging materials.
   b. Grouping of packaging materials using ABC analysis based on rate of using criteria ordering process and the controlling.
   c. Determination of the optimal order quantity (Q*), optimal order interval (T*), and frequency ordering (f) by using Joint Replenishment Method.
   d. Determination of safety stock and reorder point of packaging materials by considering variations of lead time.
   e. Calculate the total inventory costs during for a year.

5.2 Suggestions

Suggestions given to the company and further research are:

1. The company may implement the packing material inventory systems is the proposed that the the existing inventory system becomes more accurate and optimal.
2. Future research could design an application or information system for inventory planning of packaging materials, so that company can plan packaging materials inventory system for the next period to more easily and quickly and also can be used by stakeholders. In addition, data inventory or inventory reports more accessible.
3. Future research may develop or make a new model inventory system of packaging materials which more appropriate and more sensitive if one of the components inventory system in the company changes, so optimal solutions that result by the model more optimal.

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References

1. Assauri, S.: Production and Operations Management. Revised Edition 2008. Economic Faculty of Indonesia University, Jakarta (2008)
2. Bowersox, D.J.: Logistics Management. Systems Integration - Management Physical Distribution Systems and Materials Management, vol. 1. Bumi Aksara, Jakarta (2002)
3. Daellenbach, H.G.: Systems and Decision Making: A Management Science Approach. John Wiley & Sons Ltd., England (1995)
4. Fogarty, et al.: Production and Inventory Management, 2nd edn. South - Western Publishing Co., Ohio (1991)
5. Gaspers, V.: Production Planning and Inventory Control: Based Integrated Systems Approach Towards MRP II and JIT Manufacturing 21. PT Gramedia Pustaka Utama, Jakarta (1998)
6. Isaac, A.: Operation Manajemen, 1st edn. Graha Ilmu, Yogyakarta (2010)
7. Walpole, R.E., Myers, R.H.: Probability & Statistics for Engineers and Scientists, 4th edn. Bandung Institute of Technology, Bandung (1995)
8. Tersine, R.J.: Principles of Inventory and Materials Management, 4th edn. Prentice Hall International, New Jersey (1994)

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