The Inventory Control Analysis of Head Truck Spare Parts with Continuous Review Policy in Container Terminal Company

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Abstract

The unavailability of head truck spare parts in container terminal company caused the maintenance operation not to work effectively. The availability of more operating head truck has a negative impact on the loading and unloading activities in the port. This study aims to describe the control of the inventory of head truck spare parts using continuous review policy. Fast moving spare parts of head truck were selected for the purpose of this study. The results show that the safety stock, reorder point, order quantity, average inventory level, inventory days of supply, and total annual cost of 13 fast moving spare parts can be determined. Subsequently, we compare the results of continuous review policy to the company policy. We obtained the continuous review policy decreasing the total annual cost of 16% or USD $ 22,501.77. The continuous review policy study is expected to help companies to control the inventory of head truck spare parts.

Keywords

Inventory control, Continuous review policy, spare parts, head truck, container terminal company

1. Introduction

The availability of head truck spare parts is essential in the container terminal company. As the loading and unloading activities are getting higher, the utilization of head truck to move back and forth from warehouse to jetty or vice versa increases. The maintenance division has the responsibility of head truck preventive maintenance to keep these vehicles operating properly. Otherwise, the corrective maintenance should be carried out as the head truck has a trouble. Therefore, the spare parts availability in the preventive and corrective maintenances is necessary. The unavailability of head truck spare parts impacts to cannibalism of spare parts. If the unavailability of spare parts could not be solved, more head truck will not operate optimally.

There are several strategies for checking inventories such as periodic review and continuous review policies. This study aims to control the inventory of head truck spare parts using a continuous review policy. Continuous review policy is a policy in which the inventory level is reviewed continuously and when the inventory level reaches the

reorder point, an order is placed to the distributor (Simchi-Levi et al., 2008). Several literatures has discussed about continuous review policy. Duran et al (2016) studied the relationship of spare parts continuous review system with total cost of ownership of industrial plants. Yu et al (2017) discussed a continuous review production inventory system with two product types. i.e.: a high end product and a low end product. Saracoglu et al (2014) proposed a genetic algorithm for multi products/period (Q, r) inventory model in a pharmaceutical case study. Perez and Geunes (2014) analyzed a (Q, R) inventory replenishment model with two delivery modes, i.e.: a cheaper, less reliable mode and more expensive but perfectly reliable mode. Massonnet et al (2014) worked the continuous time lot-sizing inventory problem when demand and costs are time-dependents. Zhang et al (2019) proposed the (s, S) inventory policy in the opportunistic maintenance strategy for wind turbines which considered stochastic weather conditions and spare parts management.

This study is motivated by their initiatives. We employed a (Q, R) policy for head truck spare parts inventory management. The fast moving spare parts of head truck is selected in this study. The results showed that the safety stock, reorder point, order quantity, average inventory level, inventory days of supply, and total annual cost of 13 fast moving spare parts can be determined. Subsequently, we compare the results of continuous review policy to the company policy.

The remaining of this paper is organized as follows. Section 2 presents research methodology including the research stages, the data of spare parts, and the continuous review policy. Section 3 discusses the results of continuous review and company policies, whereas Section 4 finally presents the conclusions and future research directions derived from this paper.

2. Literature Review

The continuous review policy means that the inventory is reviewed continuously. Whenever the inventory reaches the reorder point, an order is placed to the distributor. This policy is very appropriate when the computerized inventory system is used (Simchi-Levi, 2008).

Some notations used within the formula of continuous review policy are as follows:

R: Demand (R units/year)

L: Lead time

P: Purchase cost (Rp / units)

C: Ordering cost (Rp / units)

H: Holding cost (Rp / units / year)

AVG: average demand (units)

STD: standard deviation (units)

z: the service factor

Several formulas used in the continuous review policy are as follows:

Average demand during lead time (AVL)

This is the product of average daily demand that the system must cover during lead time. The formula of average demand during lead time is as follows:

$$AVL = L \times AVG$$

Safety stock (*SS*)

Safety stock is the amount of inventory should be kept in order to protect against demand deviations during lead time. The formula of safety stock is as follows:

$$SS = z \times STD \times \sqrt{L}$$

The service factor used in this study is 1.29 with service level 90%.

Reorder level (*ROP*)

The reorder point is the inventory level when an order for Q units is placed. The formula of reorder point consists of average demand during lead time and reorder level as follows:

$$ROP = L \times AVG + z \times STD \times \sqrt{L}$$

Order quantity (*Q*)

The formula of order quantity is as follows:

$$Q = \sqrt{\frac{2C \times AVG}{H}}$$

If there is no variability in demand, the distributor would order Q items when the inventory is at level $L \times AVG$. Otherwise, the distributor places an order Q items when the inventory position is at reorder point (ROP).

Average inventory level (*AVI*)

The average inventory level is the average of safety stock and order quantity Q as follows:

$$AVI = \frac{Q}{2} + z \times STD \times \sqrt{L}$$

Inventory days of supply (*IDS*)

The inventory days of supply is defined as the average period in which the company can operate in its inventory level. The formula of inventory days of supply is as follows:

$$IDS = \frac{AVI}{AVG}$$

Total annual cost (*TC*)

The total annual cost consists of purchase cost, order cost, and holding cost as follows:

$$TC = RP + \frac{RC}{Q} + \frac{QH}{2}$$

3. Research Methodology

3.1 The flowchart of research method

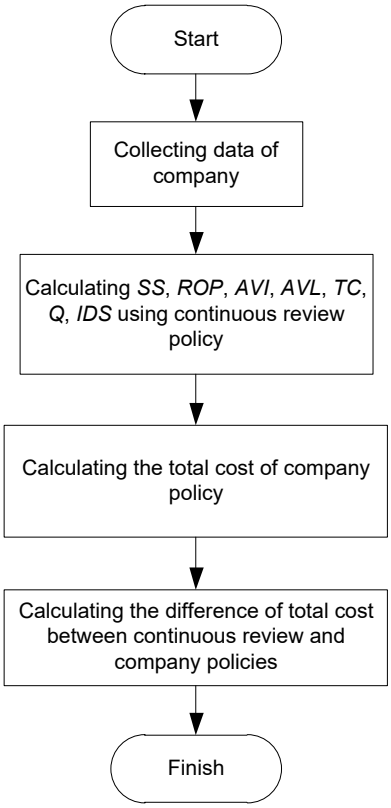

Figure 1. The stages of research

Based on Figure 1, the research is started by collecting demand data on 13 fast moving spare parts. The data is taken from January to December 2016 in container terminal company as shown by Table 1. Demand for one year (R) is obtained by summation of demand in each month. The price for each spare part per unit is also known in Rupiah (IDR). The second stage of Figure 1 is calculating the safety stock (SS), reorder point (ROP), average inventory level (AVI), average demand during lead time (AVL), total cost (TC), quantity (Q), and inventory days of supply (IDS) by using continuous review policy as written in Section 2. The third stage of Figure 1 is calculating the results of company policy and subsequently comparing the result between company and continuous review policies. The final stage of Figure 1 is calculating the difference of total cost between these two inventory policies. When the total cost of continuous review policy is less than the one with company policy, we obtained the cost saving.

3.2 The demand data of fast moving spare parts (Cahyo, 2018)

Table 1: Demand per year for 13 fast moving spare parts

Part name	Price (Rp)	Jan	Feb	Mar	April	Mei	June	July	Aug	Sep	Oct	Nov	Dec	*R*
FILTER OIL ENGINE PN 21707134	179,450	146	134	50	146	0	115	146	134	96	50	549	54	1620
FILTER BY PASS PN 21707132	246,050	65	68	43	65	1	59	65	68	62	43	287	27	853
FUEL FILTER PN 22480372	352,425	69	68	41	69	1	59	69	68	52	41	287	27	851
GASKET PN 20579690	49,950	68	67	61	68	0	58	68	67	62	61	47	69	696
PRIMARY FILTER PN 21380475	670,625	46	38	4	46	2	47	46	38	12	4	180	7	470
Filter Power Steering PN 349619	159,100	16	13	7	16	6	10	16	13	12	7	179	12	307
PRIMARY FILTER PN 20998367	725,200	24	19	16	24	2	11	24	19	14	16	107	19	295
AIR FILTER PN 21743197	435,675	0	3	3	0	54	0	0	3	16	3	174	4	260
Gasket PN 18813	20,000	20	18	15	12	22	20	21	12	13	42	35	25	255
Bulb Long Life PN 990037	398,675	25	38	13	25	4	11	25	38	5	13	13	17	227
COOLANT FILTER PN 22567321	359,825	7	12	14	7	0	38	7	12	16	14	37	44	208
Bolt PN 984758	32,375	0	36	0	0	6	0	0	36	52	0	1	30	161
OIL FILTER PN. 21707133 VOLVO	243,000	0	0	36	0	27	0	0	0	28	36	12	0	139

3. Results and Discussions

In Table 2, we calculated the average demand monthly (AVG), the standard deviation of demand monthly (STDEV), average demand during lead time (AVL), safety stock (SS), reorder point (ROP), order quantity (Q), average inventory level (AVI), inventory days of supply (IDS), and total annual cost (TC) by using formula in Section 2.3. As an example, we describe the first spare part of filter oil engine. The average demand monthly is 147 units. The standard deviation of demand monthly is 139 units. With the lead time for 1 month, the average demand during lead time is 147 units. The safety stock or the amount of inventory should be kept is 179 units. Whenever the inventory position level reaches the reorder point, i.e. 327 units, the company should place an order to the distributor with the order quantity 87 units. The average inventory level of filter oil engine is 223 units. The inventory days of supply in terms of the company can operate filter oil engine inventory level for 1.5 months. Finally, the total annual cost of filter oil engine is Rp. 292,333,248.97. The explanation of other spare parts is very similar to the filter oil engine. The total annual cost of all spare parts using continuous review policy is Rp. 1,737,615,791.76.

In Table 3, we calculated the total annual cost for regular procurement in all spare parts using company policy. Regular procurement means that the company orders regularly to the distributor with certain frequency and order quantity. We discuss the regular procurement of filter oil engine as an example. Company determines that they will order with the quantity of 369 units for 3 times in a year. Therefore, the order quantity in a year is 1107 units and costs Rp. 200,612,470. In the regular procurement, company only set the minimum order quantity for each spare part. In filter oil engine, the minimum order quantity is 221 units. In addition, the total annual cost of regular procurement for all spare parts is Rp. 1,029,691,852.

In Table 4, we explained about the additional procurement made by company. By the regular procurement policy as shown in Table 3, the company could not afford the demand in a year (Cahyo, 2018). Instead, they buy additional spare parts whenever they face shortage of it. Consequently, the price of additional procurement will cost higher than the regular one. For example, the total annual cost of filter oil engine with 646 unit additional spare parts is Rp. 127,288,492. The total annual cost for the rest of spare parts is very similar to filter oil engine. Moreover, the total annual cost for all spare parts in the additional procurement is Rp. 1,035,549,719.

The total cost of company policy is the summation of total cost by regular (Table 3) and additional (Table 4) procurements. By adding these, we obtained the total cost of company policy is Rp. 2,065,241,571. Comparing to the total cost shown in Table 2, the cost of continuous review policy is less than company policy. We can calculate the saving cost as:

$$\text{Saving cost} = \frac{2{,}065{,}241{,}571 - 1{,}737{,}615{,}791.76}{2{,}065{,}241{,}571} = \frac{327{,}625{,}779.24}{2{,}065{,}241{,}571} = 0.16$$

The saving cost in percentage is 16%. If we convert the saving cost in rupiah into USD with 1 USD = Rp. 14,560, we attain 22,501.77 USD.

Table 2: The results of continuous review policy

PART NUMBER	*AVG*	*STDEV*	*AVL*	*SS*	*ROP*	*Q*	*AVI*	*IDS*	*TC* (Rp)
FILTER OIL ENGINE PN 21707134	147.27273	138.9375	147.2727	179.2293	326.5021	87.04443	222.7515	1.51251	292,333,248.97
FILTER BY PASS PN 21707132	71.083333	70.97433	71.08333	91.55689	162.6402	60.4733	121.7935	1.713391	209,924,517.79
FUEL FILTER PN 22480372	70.916667	71.24026	70.91667	91.89993	162.8166	60.40237	122.1011	1.721755	299,913,675.00
GASKET PN 20579690	63.272727	6.574054	63.27273	8.480529	71.75326	57.05426	37.00766	0.584891	34,765,200.00
PRIMARY FILTER PN 21380475	39.166667	48.30365	39.16667	62.31171	101.4784	44.88881	84.75611	2.163986	315,193,750.00
Filter Power Steering PN 349619	25.583333	48.44389	25.58333	62.49262	88.07595	36.27926	80.63225	3.151749	48,843,700.00
PRIMARY FILTER PN 20998367	24.583333	26.69851	24.58333	34.44108	59.02442	35.56315	52.22266	2.124311	213,934,000.00
AIR FILTER PN 21743197	32.5	59.82116	32.5	77.1693	109.6693	40.89041	97.6145	3.003523	113,275,500.00
Gasket PN 18813	21.25	9.176303	21.25	11.83743	33.08743	33.06429	28.36958	1.335039	5,100,000.00
Bulb Long Life PN 990037	18.916667	11.38946	18.91667	14.6924	33.60906	31.19623	30.29051	1.601261	90,499,225.00
COOLANT FILTER PN 22567321	18.909091	13.78009	18.90909	17.77632	36.68541	31.18998	33.37131	1.764829	74,843,600.00
Bolt PN 984758	26.833333	19.55931	26.83333	25.23151	52.06485	37.15499	43.80901	1.632634	5,212,375.00
OIL FILTER PN. 21707133 VOLVO	27.8	9.80816	27.8	12.65253	40.45253	37.81832	31.56168	1.135312	33,777,000.00
Total									1,737,615,791.76

Table 3: The results of regular procurement by company policy

Part name	Qty Order (unit)	Order frequency (year)	Qty Order (unit/year)	Total Cost (Rp)
FILTER OIL ENGINE PN 21 707134	369	3	1107	200,612,470
FILTER BY PASS PN 21707 132	178	4	712	176,614,718
FUEL FILTER PN 22480372	178	2	356	126,176,859
GASKET PN 20579690	134	3	402	20,944,986
PRIMARY FILTER PN 2138 0475	98	3	294	197,860,903
Filter Power Steering PN 349 619	64	3	192	31,085,749
PRIMARY FILTER PN 2099 8367	62	2	124	90,277,613
AIR FILTER PN 21743197	82	2	164	71,865,710
Gasket PN 18813	52	3	156	3,602,571
Bulb Long Life PN 990037	48	2	96	38,582,074
COOLANT FILTER PN 22567321	48	2	96	34,852,474
Bolt PN 984758	68	2	136	4,774,472
OIL FILTER PN. 21707133 VOLVO	66	2	132	32,441,252
Total				1,029,691,852

Table 4: The results of additional procurement by company policy

Part name	Additional procurement (unit/year)	Price (Rp)	Total cost (Rp)
FILTER OIL ENGINE PN 21707134	646	194,000	127,288,492
FILTER BY PASS PN 21707132	266	266,000	72,129,614
FUEL FILTER PN 22480372	573	381,000	220,163,981
GASKET PN 20579690	377	54,000	21,904,213
PRIMARY FILTER PN 21380475	246	725,000	179,532,516
Filter Power Steering PN 349619	143	172,000	25,778,357
PRIMARY FILTER PN 20998367	205	784,000	161,998,763
AIR FILTER PN 21743197	183	471,000	86,957,554
Gasket PN 18813	125	20,000	2,774,368
Bulb Long Life PN 990037	161	431,000	70,601,346
COOLANT FILTER PN 22567321	130	389,000	51,732,142
Bolt PN 984758	70	35,000	3,118,846
OIL FILTER PN. 21707133 VOLVO	46	243,000	11,569,527
Total			1,035,549,719

4. Conclusion and Future Research

We have described the inventory control of spare parts using the continuous review and company policies. The continuous review policy has the lower total annual cost than the company policy. With the saving percentage of 16% and the saving cost of 22,501.77 USD, we can expect that continuous review policy is used to control the inventory level of spare parts. By the continuous review policy, the company order with the quantity, Q, for each spare part whenever the inventory position level reaches the reorder point. The future research could be carried by comparing the performance of continuous review, periodic review, and the combination between continuous and periodic review policies.

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