IMPACT: International Journal of Research in Engineering & Technology (IMPACT: IJRET)
ISSN(E): 2321-8843; ISSN(P): 2347-4599
Vol. 2, Issue 1, Jan 2014, 7-14

THE SPARE PART INVENTORY MANAGEMENT SYSTEM (SPIMS) FOR THE PROFOUND HERITAGE SDN BHD: A CASE STUDY ON THE EOQ TECHNIQUE

NOOR-AJIAN MOHD-LAIR[1], FAQIH-ANAS MUHIDDIN[2], SAIMON LAUDI[3] & FADZLITA MOHD-TAMIRI[4], BIH-LII CHUA[5]

[1]Senior Lecturer, Mechanical Engineering Program, School of Engineering and Information Technology, Universiti Malaysia Sabah, Malaysia

[2]Student, Mechanical Engineering Program, School of Engineering and Information Technology, Universiti Malaysia Sabah, Malaysia

[3]Mechanical Engineer for Profound Heritage Sdn Bhd. Malaysia

[4,5]Lecturer at Mechanical Engineering Program, School of Engineering and Information Technology, Universiti Malaysia Sabah, Malaysia

ABSTRACT

The inventory management is an important part of supply chain management, which protects the schedule of production or maintenance towards any type of disturbance. This research emphasized on the development of the Spare Part Inventory Management System (SPIMS) for the Profound Heritage Sdn Bhd (PHSB), which is currently adopting the manual Kadex method. This automatic software used the Economic Order Quantity (EOQ) in the periodic review environment to control the inventory and the software was written using the Microsoft Visual Studio 2012. Therefore, this research will not only helps the PHSB but also increased literature on the actual implementation of the EOQ technique in the periodic review environment. This newly developed SPIMS have the ability to keep the spare parts transaction records, calculate the EOQ for each part and remind the user to purchase more spare parts at its dedicated “When to Order” date. The developed SPIMS performance was then evaluated by comparing it to the current Kadex or manual method.

The method, which produced the lowest average inventories, is considered as the best method. Comparison across the overall average inventory indicated that the EOQ with zero opening balance (which represented a system that start with zero opening inventories) performs better than the Kadex method. However, the Kadex method is found to perform better than the EOQ when current opening balance is considered. The deterioration in the EOQ performance, when current opening balance is considered, is due to the fact that more data and longer time for observation is required before the EOQ reached its steady state. However, it is expected that the result similar to the EOQ with zero opening balance will be observed when the EOQ (with opening balance) reached it steady state. In addition, the EOQ also produces some shortages on the stock, which is nonexistent in the Kadex method. This problem is caused by the EOQ inability in detecting any shortages as the inventory will only be checked on a specific time interval called the “when to order” date. Due to this, an improvement on the SPIMS is needed. Rather than reviewing the inventories periodically during the “when to order” date, it is suggested that the SPIMS should adopt the continuous review/monitoring environment to optimize its performance.

KEYWORDS: Spare Part Inventory Management System, Economic Order Quantity, Profound Heritage Sdn Bhd, Power Plant, Inventory Control

INTRODUCTION

Inventory management is related to the question of how much stock of materials is needed to buffer against the change of state in forecast, customer demands and supplier deliveries. In inventory management, stock, which is the expensive asset, is replaced with a less expensive asset called “information”. This management leads to cost saving.

However, to ensure this management successful, the information must be timely, accurate, reliable and consistent [1]. Inventory is an idle resource of an enterprise [2]. It is the stock of items, which are either stocked for sale or currently in the process of manufacturing or items that is not yet utilized. Inventories are to be kept in order to stabilize production because the item’s demand went up and down depending on various factors, such as seasonality, production schedule and in this case, how often it used to replace a broken parts. Therefore, inventory is necessary in order to prevent any stoppage in production due to shortage and also making it smooth all the way to the end. Sometimes, inventory is also used to take advantage of price discounts, where manufacturers usually offering a discount for a bulk purchases. By buying the items in bulk, the price will be reduced and thus inventory exists as a result of economy in purchasing. Inventory can also buffer against sudden increase in prices, which may result in spending more on the inventory [2]. Therefore, the inventory management’s objective is to give the desired level of customer service, to make operations cost-efficient and to keep the inventory investment as low as possible.

Spare parts inventory management plays an important role in supporting maintenance operations and to protect against equipment failures [3]. In this project, the Profound Heritage Sdn Bhd (PHSB) was used as a case study. PHSB customer is the Sabah Electricity Sdn Bhd (SESB). Every month, PHSB has a specific wattage that needs to be delivered to SESB. Without the spare parts, the engines can’t be running continuously, thus stopping the production of power. Cost-efficient operation is desired by every company in this world, and it starts from their inventory management. If the inventory is fully managed and timely ordered, it can reduce the buffer rate and work can go on as usual. Inventory turnover can be used to measure their minimum inventory investment. A company is considered to be using its inventory effectively when its inventory turnover’s number is high [4]. For PHSB, the spare part inventory management ensures breakdown can be repaired on time and long shut down may be prevented.

One of the popular techniques in inventory management is the Economic Order Quantity (EOQ). This research will not only improve and automate the PHSB inventory management system but also will increase further literature in the actual implementation and utilization of the EOQ technique in the periodic review environment. Therefore, this research expands more Mohd-Lair et al. [5] by exploring the EOQ technique in the periodic review environment.

LITERATURE REVIEW

This research centers on development of spare part inventory management system. Current researches in spare part inventory management include by Li & Kuo [6], Porras & Dekker [7], Vereecke & Verstraeten [8], Baron et. al. [9], Dekker et al. [10], Aronis et al. [11], Jin & Liao [12], Cobbaert and Qudheusden [13], Kattan and Adi [14], Chou and Huang [15], and Mohd-Lair et al. [5].

Li & Kuo [6], in their journal titled Automobile Spare parts in a central warehouse, used the Enhanced Fuzzy Neural Network (EFNN) and Enhanced Fuzzy Neural Network with randomly initialized connection weights (EFNNR) as their inventory control method. They compared the two techniques to see their differences. They found that the EFNN is much better than EFNNR because it avoids out of stock at the price of least stock cost.

Porras & Dekker [7] said that ex-ante is more relevance than ex-post, which is hard to be implemented. They used the Willemain’s bootstrap method, Empirical distribution of lead time demand, Normal Distribution, Poisson Distribution and (s,nQ) inventory model. They found that the inventory models can save money and improve service levels. Vereecke & Verstraeten [8] used integration of inventory model with two demand classes (r, r, Q) model with poisson distribution.

This research used service level, average demand, costs and lead time as their performance measure. They found the reorder point that gave satisfying result in term of the service levels.

Baron et. al. [9] used the stochastic (s, S) approach in their research. They considered the problem with perishable items (i.e. medicine or food with expiration date). The performance of the above approach was measured using costs and lead time of the inventories. The numerical study on the heuristics shows that they are accurate. When the exact analysis is not possible and the lead time is relatively short, they recommended the used of this heuristics.

Dekker et al. [10] and Aronis et al. [11] used the same method which is the (S-1,S) inventory model. Dekker et al. [10] proposed this inventory model to control the inventory of spare part based on equipment criticality. They found that this model gave a high service level for the critical demand of spare parts and the method is cost effective too. Aronis et al. [11] conducted a case study of applying Bayesian approach to forecast demand and determine the parameter S of the (S-1,S) inventory model for controlling spare parts of electronic equipment. In their research, the Bayesian approach results in lower total stock for achieving the required level of service. This is a more accurate determination of stock levels required to fulfil the service level to the users of the equipment.

Jin & Liao [12] used the Weibull failure time, exponential failure time and stock level to measure the performance of their (Q, r) inventory model. This inventory model was solved using a multi-resolution approach. They found that this model can be used for products with generic lifetime distributions. It also can be extended to more general inventory control systems involving multiple types of parts. This inventory model also has a better performance in terms of reducing the total inventory cost and number of stock outs expected by controlling the resolution according to the maintenance demand.

Among the techniques, the EOQ technique is continuously getting attention due to ease in implementation. Cobbaert and Qudheusden [13] presented the inventory models for fast moving spare parts subject to unexpected obsolescence. Their results showed that ignoring the obsolescence component of 20% will increase the overall cost by approximately 15%.

Kattan and Adi [14] divided their research into two main parts which are material classification and inventory models. They used the combination of ABC and 123-analysis to classify 2-dimensionalmaterial and Economical Order Quantity (EOQ) as the inventory model. They found that this method give saving of 42% in the total inventory cost over a period of 3 years for the inventory management of spare parts and tools of a company.

Chou and Huang [15] used an inventory model with two demand classes (r, r, Q) and compares it with a continuous review inventory models with lost sales and inventory rationing (c,s,Q) and Economic Order Quantity (EOQ). In this journal, cost was used as the performance measure. They found that the EOQ is not the optimal solution for the model and convergence could not be proven. On the other hand, the model relevant cost function is convex and from the numerical examples, the optimization procedure yields in most practical cases is found to be optimum.

Mohd-Lair et al. [5] developed the Computerised Inventory Management System (CIMS) for the maintenance team at Weida Integrated Industries Sdn. Bhd., which used the basic Economic Order Quantity models (EOQ) to control the inventory. The CIMS developed is unique as it has the ability in handling inventories in multiple-storage locations. They found that the overall average inventory level currently at the factory is lower than the expected overall average inventory level produced by the CIMS. This is due to the fact that the CIMS was unable to consider the opening stock in ordering the inventories.

This research is similar to Mohd-Lair et al. [5], Cobbaert and Qudheusden [9], and Kattan and Adi [10] in using the EOQ technique. However, this research is different as it extends Mohd-Lair et al. [5] on the multiple-storage locations into the periodic review environment.

The Case Study

The Sutera Harbour Resort is a renowned world class resort situated along the coastline of Kota Kinabalu, Sabah. The resort consists of a 27-hole championship golf course, a yachting marina and club, residential housing comprising of 150 bungalow lots, two blocks of condominiums, a 500-room business hotel and a 450-room resort hotel. The 384 acres of reclaimed land is situated about 1.5km from the main city of Kota Kinabalu and only 3km from the Kota Kinabalu International Airport. A co-generation facility was constructed on the reclaimed land to ensure a reliable source of electricity supply for the entire area. The 38-MW co-generation plant occupies about 1.449 acres of the area. This co-generation plant is managed by the Profound Heritage Sdn. Bhd. (PHSB). Environmental impact consideration and cost optimization leads to brilliant design of the co-generation plant. Thru this plant, the PHSB is also responsible for the supply of steam through waste heat recovery boilers for the two 5-star hotels and a laundry complex located within the premise. Exploiting the steam absorption chillers, the steam is used for air conditioning, laundry facilities and other hot water heating for both hotels.

Similar to other power plant, PHSB too have its own storage to store any spare parts inventories to be used during maintenance. The storage consists of more than 1000 different inventories. Currently, the PHSB is using the manual way called “Kadex Method” in order to manage their inventories. Kadex Method is known as the Card Index method, which had been invented by Carl Linnaeus around 1760. This method is very time consuming because every month the person in charge must reviewed every index card in the storage room and update the existing record in the Microsoft Excel. Not only that, they also need to make a summary of the inventories to be placed in the department monthly report. This method has been practiced for more than 10 years.

The Spare Part Inventory Management System (SPIMS)

The developed SPIMS is able to handle the basic inventory management and integrated the EOQ techniques to control the inventories. The SPIMS was developed by following the flow of architecture as presented in Figure 1. This SPIMS starts with the software execution and right after that, the database for the current month was loaded. If the day of the execution is at 1st January in any year, the Economic Order Quantity (EOQ) will be calculated. Upon completing its calculation, the respective parameters that are related to the EOQ will be displayed. After that, the database is then saved and when the time comes, the software will automatically remind the user to purchase a number of spare parts.

The formulas used in the EOQ technique are shown in Eq 1 to Eq 3. The periodic review environment requires fixed dates to review the inventory. The dates are estimates using either Eq 4 or Eq 5. In addition, the performance of the system is evaluated based on the overall average inventory as shown in Eq 6. System with the lowest average inventory is considered as the best system.

$$EOQ = \sqrt{\frac{2DS}{P^{*}K}} \qquad (1)$$

$$= \sqrt{\frac{2DS}{H}} \qquad (2)$$

$$Q = \sqrt{\frac{2k\lambda}{IC}} \quad (3)$$

$$r = \lambda\tau \quad \text{(yearly)} \quad (4)$$

$$r = dL \quad \text{(daily)} \quad (5)$$

Where;

Q = Optimal order quantity

D = Annual demand

S = Ordering cost

H = Holding Cost

P = Price per unit

K = Carrying cost

I = Inventory Cost

C = Purchasing Cost

r = Reorder Point

τ = Lead Time

λ = Demands Per year

d = Average daily demand

L = Lead time in day

$$\text{Overall Average Inventory} = \left(\frac{\Sigma \text{ Average Inventory (For each items)}}{\text{Number of Items}} \right) \quad (6)$$

THE SPIMS PERFORMANCE: RESULTS AND DISCUSSIONS

Using the SPIMS, the EOQ ordering parameters for all five items were calculated as shown in Table 1. However, the EOQ parameters such as ordering cost and carrying cost are assumed to be RM1 as these two values were not provided by the company due to confidentiality of the information.

It is important to notice that, by using the SPIMS, ordering or purchasing of items only takes place when the balance falls under the reorder level on the estimated “When to Order” date.

Under the EOQ policy, whenever the inventory drops below the reorder level, one must order the estimated quantity of EOQ to prevent any shortage in inventory. Order frequency in the table above representing the number of times the item should be purchased.

And lastly, when to order is the estimated date the item should be purchased calculated from the beginning of the year (i.e 1st Jan 2011 and 1st Jan 2012).

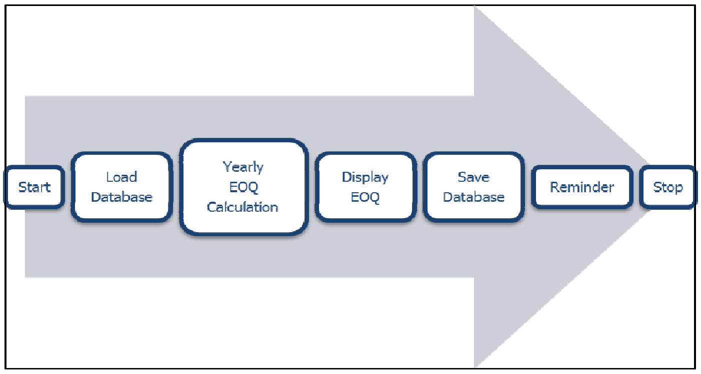

Figure 1: SPIMS' Flow Chart

Table 1: The EOQ Parameters and Ordering Parameters

Part Name	Year	Ordering Cost (RM)	Carrying Cost (RM)	EOQ	Order Frequency	When to Order (Days)	Reorder Level
Filter Element	2011	1	1	1.15	0.58	623	0.67
	2012	1	1	0.82	0.41	881	0.33
Gasket Airhead	2011	1	1	1.15	0.58	623	0.67
	2012	1	1	2.45	1.22	294	3
Gasket Airhead Center	2011	1	1	1.15	0.58	623	0.67
	2012	1	1	2.16	1.08	333	2.33
Spring Valve	2011	1	1	2.45	1.22	293.94	3
	2012	1	1	2.94	1.47	244.57	4.33
Oil Seal	2011	1	1	0	0	0	0
	2012	1	1	0	0	0	0

Using the estimated EOQ parameters and actual demands, the monthly average inventory levels for the last 2 years (from 2011 until 2012) were estimated as summarised in Table 2. Basically, Table 2 showed the EOQ's Overall Average Inventory with zero opening inventories is lower than the current Kadex's method. However, the Kadex method shows better performance than the EOQ technique when the current opening balance is considered by the system. The reason for the inconsistence performance by the SPIMS, which used the EOQ technique, is due to the fact that the EOQ took longer time to reach its steady state when the current inventories opening balance is taken into consideration. In the EOQ technique, the amount to be ordered is estimated based on the historical demands and patterns. In this case, the estimations were based on demands from the last 3 years (2008 until 2010). The estimation were made yearly at the beginning of the year. This estimation of the amount to be ordered did not considered the opening balance or the amount of inventory currently in the system. Therefore, if the estimation of expected demands is accurate, then the amount ordered will always fulfil the anticipated demands. As a result, none of the stocks in the opening inventory was used. This stock was carried throughout the year and lead to high average inventory levels. This incident was also observed in research by Mohd-Lair et.al [11].

On the other hand, the Kadex method utilises the storekeeper experience and judgement in ordering the stock. Basically, an order will be produced whenever the inventories fall to zero. This prevents accumulation of inventories as occurred in the EOQ technique. In order to prevent the accumulation of the inventory, the SPIMS improves the adopted EOQ by estimating the reorder levels for all the stocks. Orders will only be produced whenever the inventories fall below the reorder levels. The implementation of the reorder levels allows the SPIMS to eventually reduce the inventories. However, as shown in this research, the duration of 2 years is too short for the SPIMS to reduce the inventories to as minimum as possible required to cover the demands or in other words to reach it steady state. The SPIMS steady state performance was clearly illustrated by the EOQ with zero opening inventories. Without the opening inventories, only the effect of the EOQ with reorder levels technique was observed in controlling the inventories. Therefore, it can be concluded that the SPIMS with the EOQ technique, which produces lower overall average inventory, is more effective than the Kadex method in controlling the inventories.

Table 2: Average Inventory for 2011/2012 and Overall Average Inventory

	2 Years Average		
	EOQ		Kadex Method
	Zero Opening Inventories	Consider Current Opening Balance	
Average Closing Balance			
Filter Element	1.375	1.875	1.875
Gasket Air Head	1.834	0.375	1.125
GAHC	0.959	1.542	1.500
Spring Valve	1.292	2.000	0.792
Oil Seal	0.000	4.084	4.084
Overall Average Inventory	**1.092**	**1.975**	**1.875**

Observation across the SPIM also exposed occurrences of several part shortage such as on Gasket Airhead, Gasket Airhead Center and Spring Valve. One of the reason leading toward the shortage is inconsistency in demands. The EOQ assumed that this year demands are the same as from previous year. Changes in demands lead to inaccuracy in this year predicted demands. This leads to the shortage in the spare parts. At the same time the SPIMS is designed to operate within the periodic review environment. In the periodic review environment, the stock levels are reviewed or check only during the specified date, which in this case during the "when to order" date. Therefore, if shortage occurred before the "when to order" date, then the shortage will go unnoticed until the "when to order" date arrived. Judging from this incident, a system, which able to review progressively throughout the year, is necessary to eliminate shortage from occurred.

CONCLUSIONS

The developed Spare Part Inventory management System (SPIMS) for the Profound Heritage Sdn. Bhd. can perform the basic tasks such as input and output, tracking inventory movement in details and it can be performed much faster than the manual Kadex way. This software also adopts the Economic Order Quantity (EOQ) inventory management technique to estimate the amount of quantity and when to order. The results showed that the EOQ without considering opening balance performs better with lower average inventory level than the Kadex method. However, the Kadex method performs better than the EOQ as followed;

- Decision making is made by the store keeper. Any shortages in items quantity will be purchased as soon as possible to prevent any shortages in spare parts.
- Inconsistency in demands leads to inaccuracy in predicting the EOQ demands.

Based on these reasons and weaknesses, modification towards the SPIMS is necessary for future research and it is a must to prevent any shortages. One way to tackle the shortage issue is to move the SPIMS from the periodic review environment into the continuous review environment. This adjustment will enable the system to review the inventory level automatically anytime. As a result, the SPIMS inventory will always be enough to fulfil any demands because when the stock falls under the reorder level, the system will automatically remind the person in charge to purchase more of the respective items. In addition, prediction technique also needs to be improved. In this case, assuming that the previous year demands will be the same as the current year might not be accurate. This inaccuracy leads to impreciseness in forecasted demands.

ACKNOWLEDGEMENTS

The authors would like to acknowledge the Malaysian Ministry of Higher Learning for the FRGS grant awarded for this project.

REFERENCES

1. J.D. Viale, Basics of Inventory Management: From Warehouse to Distribution Center. Crisp, USA, 1996.
2. Kumar, S. A., Suresh, N. 2008. Production and Operations Management (2nd ed.). Bangalore, India: New Age International (P) Limited.
3. W.J. Kennedy, J.W. Patterson, L.D. Fredendall, An overview of recent literature on spare parts inventories, Journal of Production Economics, 76 (2002) 201-215.
4. R. D. Reid, N. R. Sanders, Operations Management, fourth ed., John Wiley & Sons, Inc. USA, 2011.
5. N.A. Mohd-Lair, C. K. Pang, W. Y. H. Liew, H. Semui, Z.Y. Loh, An EOQ Based Multi-Storage Location of Spare Part Inventories: A case study. Applied Mechanics and Materials. 315 (2013) 733-738.
6. S.G. Li, X. Kuo, The inventory management system for automobile spare parts in a central warehouse. Expert Systems with Applications 34 (2008) 1144-1153.
7. E. Porras, R. Dekker, An inventory control system for spare parts at a refinery: An empirical comparison of different re-order point methods. European Journal of Operational Research 184 (2007) 101-132.
8. A. Vereecke, P. Verstraeten, An inventory management model for an inventory consisting of lumpy items, slow movers and fast movers. Int. J. Production Economics 35 (1994) 379-389.
9. O. Baron, O. Berman, D. Perry, Continuous review inventory models for perishable items ordered in batches. Mathematical Methods of Operations Research 72(2) (2010) 217-247.
10. R. Dekker, M.J. Kleijn, P.J De Rooij, A spare parts stocking policy based on equipment critically, International Journal of Production Economics, 56-57 (1998) 69-77.
11. K. P. Aronis, I. Magou, R. Dekker, G. Tagaras, Inventory control of spare parts using a Bayesian approach: A case study. European Journal of Operational Research 154 (2002) 730-739.
12. T. Jin, H. T. Liao, Spare parts inventory control considering stochastic growth of an installed base. Computers & Industrial Engineering 56 (2009) 452-460.
13. K. Cobbaert, D.V. Oudheusden, Inventory models for fast moving spare parts subject to “sudden death” obsolescence, International journal of Production Economics, 44 (1996) 239-248.
14. I.A Kattan, A. Adi, Multi-criteria decision making on total inventory cost and technical readiness, International Journal on Interactive Design and Manufacturing, 2 (2008) 137-150.
15. P.L. Chang, Y. C. Chou, M.G. Huang, A (r,r,Q) inventory model for spare parts involving equipment criticality. Int. J. Production economics 97 (2005) 66-74.