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Spare parts Inventory Management by using EOQ Model

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Abstract: This paper is analysed on the basic of Economic Order Quantity (EOQ) model and designed to enhance efficient management of modern industry and the company's current forecasting model and recommending an inventory control model to help them solve their current issue. As a result, an Economic Order Quantity (EOQ) and a Reorder Point has recommended along with techniques to help them reduce their product stock outs. This topic is in the form of a literature review on models of spare parts management. This topic has presented first methods of identification and classification of parts, the approaches of estimation and identification of spare parts needs, spare parts management, and to develop a mathematical model of an efficient inventory strategies for a distribution company such that using this system they optimise the inventory and minimize the inventory cost.

Keywords:-Inventory Models, Spare parts Management, Mathematical Model , Inventory optimisaion.

INTRODUCTION:

The Economic Order Quantity (EOQ) model is perhaps the best known and most fundamental inventory decision model. The model hallmarks management science methods geared towards improving the timing of inventory delivery and streamlining overall production or service delivery process. The use of basic EOQ enables a store manager to better understand the challenges maintenance, Repair and Operations (MRO) Spare Parts present some unique problems when attempting to automate their stocking operations. The spare parts inventory is a necessity to ensure the continuity of services. Analytical models begin to look to the random nature of inventory problems. Despite the existence of a wide variety of inventory management models, inventory management of spare parts is a major challenge for organizations. Some authors have integrated the principle of risk of shortage in their different models based on probabilistic and graphical models.

The term 'inventory' can be defined as, "The term inventory includes materials like – raw, in process, finished packaging, spares and others; stocked in order to meet an unexpected demand or distribution in the future."

Various aspects are very important in warehouse management system, such as inventory management, warehouse maintenance, overhead management, pricing systems, etc. However, determining optimal ordering quantity is one of the main aspects in inventory management that can facilitate the inventory management to run with optimal cost.

Spare Parts Management purpose is to provide "the right parts, in the right quantity, to the right place, at the right time, with the right level of quality, and at the least total cost to the organization". Effective management of maintenance spare parts is a critical contributor to equipment operating performance and to the cost of the maintenance investment.

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The scope of Spare Parts Management therefore includes all functions from the supplier through to the point of use. Identification and coding, criticality classification, procurement, quality inspection, stocking policies, links to work planning (kitting, staging), supplier management and internal performance.

Asset maintenance results inevitably in Spare parts consumption. The unavailability of the right parts may have a serious, negative impact on equipment availability, due to increased downtime, and on resource efficiency, due to schedule interruptions. Also, it can increase the risk of reducing the quality of goods produced, cause environmentally hazardous emissions and create a hazard to staff.

This easily leads to the accumulation of an excessive amount of spare parts, which often leads to large amounts of capital expenditure.

To avoid this reality, it is important to have a good spare parts inventory system in place. Positive impacts on business performance due to effective Spare Parts Management include:

- Reduced downtime
- Reduced inventory costs
- Increased availability of working capital
- Improved safety

Spare parts management It is a form of Risk Control; its purpose is to control the risk to business operations caused by equipment downtime by ensuring the availability of spares at optimum cost.

"Optimizing Economic Order Quantity"

In the article, Optimizing Economic Order Quantity" published by Dave Piasecki in 2001, focused on the economic order quantity. Piasecki mentions that in today's leading technology, many companies are not taking advantage of the fundamental inventory models. There are various software packages in aiding companies with inventory control, but if the data inputted are inaccurate, it may lead to poor results. (Piasecki 2001) In order to have suitable results for any inventory model, accurate product costs, activity costs, forecasts, history, and lead times need to be in place. (Piasecki 2001) As a result of bad data, companies have had bad experience with some inventory models, and that is one of the reasons they do not take advantage of the EOQ model.

Piasecki also explains that another reason why a company does not take advantage of the EOQ model is because management does not know how it works. (Piasecki 2001) Even if a company has implemented a leading software package to help them, if they do not know how the system works it could cost more harm than good. Many times the users do not understand how the data is calculated and how the system is set up. They simply rely on the system built-in default software calculations, which in most cases, the system is "out of whack". (Piasecki 2001) In order to prevent the system from going "out of whack," management as well as the user, need to obtain proper knowledge of the EOQ concepts and how they are derived. The software is only design to aid and not replace the traditional way of running a business.

LITERATURE REVIEW:

C. Hax, A. C., and D. Candea, D. (1984) observed that the model aims at determining the optimal number of units to order so that management can minimize the total cost associated with the purchase, delivery and storage of a product. In other words, the classic EOQ is the amount of inventory to be ordered per time for purposes of minimizing annual inventory cost. In broad terms, the optimal order quantity at a given time must be determined by balancing two factors: (i) the cost of possessing or carrying the product and (ii) the cost of acquiring or ordering materials. Purchasing larger quantities may reduce the unit cost of acquisition, but the saving may not offset the cost of carrying the product in inventory for a longer period of time. The more specific variables required for the solution are (i) the total demand for the year, (ii) the purchase cost for each item, (iii) the fixed cost to place the order (not the cost of the goods) and (iv) the storage or carrying cost (warehouse space, refrigeration, insurance, security, etc.) for each item per year.

Keth et al. (1994) in their text also stated that the major objective of inventory management and control is to inform managers how much of a good to re-order, when to re-order the good, how frequently orders should be placed and what the appropriate safety stock is, for minimizing stockouts. Thus, the overall goal of inventory is to have what is needed, and to minimize the number of times one is out of stock.

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In this article, "Stack Them High, Let 'em Fly" by **Anantaram Balakrishnan, Michael S Pangburn, and Euthemia Stavrulaki,** introduced a revised EOQ model to help increase profit in retail. It mentions how some retails stock large quantities of inventory to drive sales and stimulate demand. By having high inventory level of a certain product, the company could create side stacks or distribute the products in different locations within the store in hence promotes impulse buying. As a result to stimulating demand, the standard economic order quantity model had to be modified in order to incorporate the demand parameter from prior cycles. They show how their new method could increase profit even though it may not be the optimal result.

Bill Roach(2005) explains how the origin of the Economic Order Quantity began in his article, "Origin of the Economic Order Quantity formula; transcription or transformation?" published in 2005. Roach explains that the Economic Order Quantity (EOQ) has been a well-known formula that calculates the optimal economic order quantity. He also mentions how Ford W. Harris contribution to the EOQ formula was significant. Harris was always a self taught individual that only received formal schooling that extended throughout high school. He managed to write and publish the economic order quantity formula in 1915 as an undergraduate student.

According to **Parasuraman, N. R. (2014)** the basic EOQ model computation is based on constant system of ordering and holding costs, constant system of demand quantity, and instantaneous replenishment. In this regard, it should be recalled that the EOQ is a measure used to find the optimal quantity that needs to be ordered at a given point in time, given the cost of placing the order and the storage cost, as well as the amount required .

Shah et al (2014) tried to address EOQ model's assumptionof immediate payment for inventories by proposing an integrated inventory policy for vendor-buyer in situations when demand is stock-dependent and trade credit is associated with order quantity. Through mathematical models, differential calculus, along with numerical examples and sensitivity analysis, these studies were able to demonstrate that joint total profit could be maximized through the modified EOQ approach

Umamaheswai et al (2014) examined the use of EOQ model for crafting economic purchasing strategy. The author tried to justify optimal ordering policy by maximizing the difference between the classical EOQ cost and discounted price quantity during the same sample period. This means that the CEOQ is versatile enough to permit some appreciable level of operational flexibility or disaggregation to meet business realities.

Togwe, T.; Eveleigh, T.J.; Tanju, B.(2019) found that Both consumable and repairable spare parts are normally procured from external suppliers or manufactured by OEM's. However, it is possible that repairable spare parts are supplied from repair shops by fixed faulty ones. The identification of supply source is important because different supply modes represent various emergency levels of orders. For example, when the inventory is depleted and orders cannot be backlogged, ordering new spare parts from external suppliers is more preferable if the lead time is short because waiting to repair a faulty part possibly costs more (e.g., penalties on long customer waiting time beyond the agreed level in the service contracts).

Gupta, Agrawal and Vihayvargy (2020), they stated that inventory management is an important aspect of any business, and that it is difficult for them to determine the appropriate quantity level required to avoid shortages and waste. They developed a multi-criteria decision-making approach to formulate the inventory management problem without shortages, with the goal of concurrently optimising profit and holding costs. Both ordering and storage costs have been evaluated as a non-linear function of the rapid stock level. They also used linear goal programming to determine the minimum optimal amount level to keep in stock in order to avoid out-of-stock situations. Finally a numerical depiction of an FMCG company was created to demonstrate how the proposed work may be applied.

SIGNIFICANCE OF THE STUDY:

Economic Order Quantity (EOQ) is a measure for optimizing the inventory ordering and cost. Simply put, it answer the questions of how much to order and when to do it.

- Reduced wastage and no over-ordering - locking capital in inventory is avoided and also reordering levels and times are optimized with demand
- Provides specificity - the EOQ number is specific to a particular business and not an industry standard. It enables the business owner to optimize for their individual and specific needs, not just to an industry standard
- Useful when producing multiple products - it is difficult to keep tabs on inventory with multiple products. EOQ solves order problems in such cases.

OBJECTIVE OF THE STUDY:

The review is underlying assumptions of the basic EOQ model for the improved understanding of modern inventory managers.

- To describe the model's vital variables and formula in its foundational, classic format.
- To introduce the spreadsheet applications of the basic EOQ model.
- To identify some emerging aspects of the classic EOQ model where some modifications may be needed in the context of the developing economies.

METHODOLOGY:

For the study, Secondary data has been analyzed and used to know the methodology adopted in the field of retail. Secondary data comprehensive review of existing literature, i.e., Journals, Books, Magazines, Internet, and Newspapers was undertaken to know the New Research Methodology adopted in the field of spare parts Management.

"**THE EOQ INVENTORY FORMULA"**

The retail sectors in the manufacturing company do not know or do not understand what EOQ stands for and how it is used? In this paper, "The EOQ Inventory Formula," written by James A. Cargal clearly explains the fundamental theory of the Economic Order Quantity.Cargal published this paper from Troy State University Montgomery. This paper is straight forward and easy to understand.The formula is describing below:

$$Q = \sqrt{\frac{2 * D * S}{H * C}}$$

Where, Q= the EOQ order quantity.

This is the variable of optimize. All the other variables are fixed quantities.

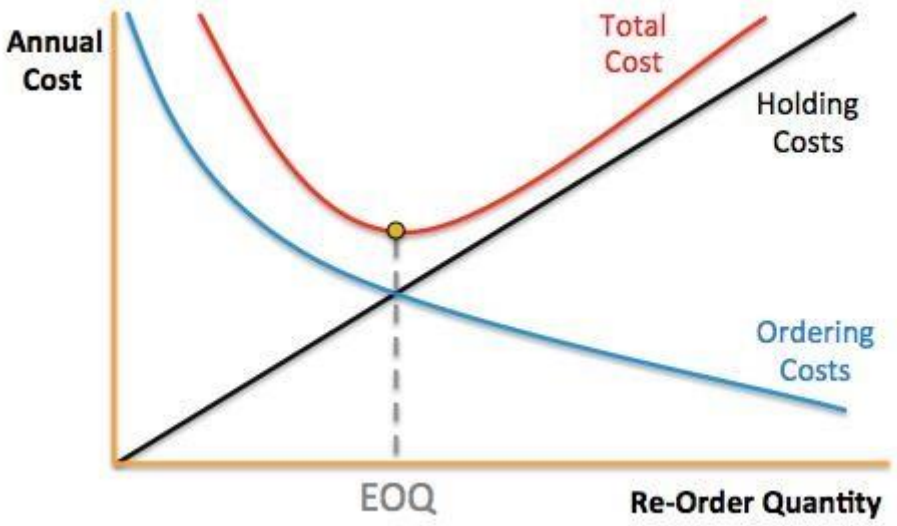
D is the annual demand of product in quantity per unit time. This can also be known as a rate.

S is the product order cost. This is the flat fee charged for making any order and is independent of Q.

C is the unit cost.

H is the holding cost per unit as a fraction of product cost.

Figure 1: EOQ model Graph



CARRYING COST:

The carrying costs, also known as holding costs and inventory carrying costs, are the costs a business pays for holding inventory in stock. A business can incur a variety of carrying costs, including taxes, insurance, employee costs, depreciation, the cost of keeping items in storage, the cost of replacing perishable items, and opportunity costs. Even the cost of capital that helps to generate income for the business is a carrying cost.

PROBLEM:

Annual consumption=12000units,

Cost of ordering =15per order,

Cost of material=1.25 per unit

Carrying cost=20percentage of average inventory

Find the calculation of EOQ?

Table-1

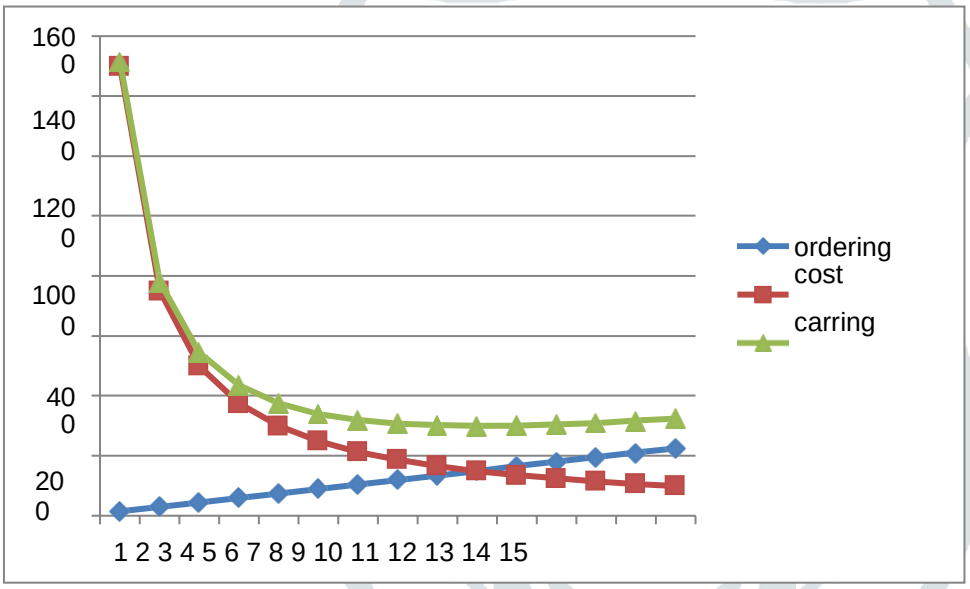
Analysis of EOQ

No of order per year	Unit per order	Value per order	Ordering cost	Carrying cost	Total cost
1	12000	15000	15	1500	1515
2	6000	7500	30	750	780
3	4000	5000	45	500	545
4	3000	3750	60	375	435
5	2400	3000	75	300	375
6	2000	2500	90	250	340
7	1714	2142	105	214	319
8	1500	1875	120	188	308
9	1333	1667	135	167	302
10	1200	1500	150	150	300
11	1090	1364	165	136	301
12	1000	1250	180	125	305
13	923	1154	195	115	310
14	857	1071	210	107	317
15	800	1000	225	100	325

The carrying cost and ordering cost both are equal then find the EOQ level. In this table if the ordering level is 1200 units 10 times per year .The carrying cost and ordering cost both are same i.e 150 . The result of total cost is 300 which is minimum and find the EOQ level.

$$EOQ=\sqrt{\frac{2*12000*15}{1.25*20\%}}=1200\text{unit}$$

Fig-2



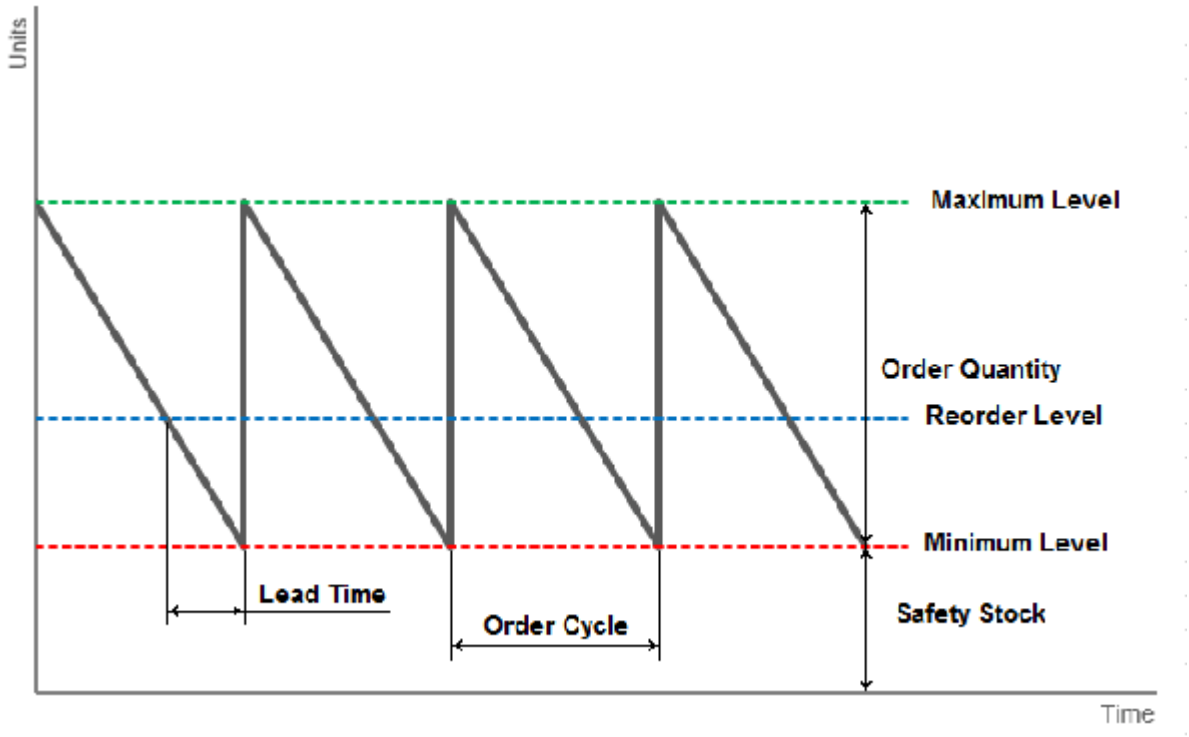
"A TECHNIQUE FOR APPLYING EOQ MODELS TO RETAIL CYCLE STOCK INVENTORIES"

The focus of this paper has to applied the EOQ model to small business in order to calculate the order quantity in the amount for each vendor. William Bassin illustrated how the EOQ model minimized the total cost of ordering and carrying stock in small businesses.

- Yield cost savings by reducing inventory investments
- Not requiring measurements of or assumptions about ordering and carrying costs
- Keying the technique to the current mode of doing business.

REORDER POINT AND SAFETY STOCK:

Another important technique used along with the Economic Order Quantity is the Reorder Point (ROP) and Safety Stock. According to Fangruo Chen, the ROP quantity reflects the level of inventory that triggers the placement of an order for additional units. Where as, the quantity associated with safety stock protects the company from stock outs or backorders. Safety stock is also known as a "buffer".



In Figure 2, the graph illustrates how the reorder point is connected with the lead time and the order quantity as a function of time. In determining the reorder point the following three factors need to be at hand:

- **Demand** - Quantity of inventory used or sold each day
- **Lead Time** - Time (in days) it takes for an order to arrive when an order is placed
- **Safety Stock** - The quantity of inventory kept on hand incase there is a unpredictable event like delays in lead time or unexpected demand.

If the demand is constant and the lead time is known, then the reorder point is written as the following:

- **Reorder Point**= Daily usage*Lead time (in days) (EQ:2) When a safety stock is maintained, then the reorder point is written as the following:
- **Reorder Point**= [Daily usage*Lead time (in days)] +safety stock.

CONCLUSION:

"Inventory" to many small business owners is one of the more visible and tangible aspects of doing business. Raw materials, goods in process and finished goods all represent various forms of inventory. Each type represents money tied up until the inventory leaves the company as purchased products. Likewise, merchandise stocks in a retail store contribute to profits only when their sale puts money.

EOQ is the quantity to order, so that ordering cost + carrying cost finds its minimum. (A common formula tries to find when these are equal.) Inventory models for calculation of EOQ .Table no-1 show that the annual consumption is 12000 unit, cost of ordering 15 per order, cost of material 1.25 per unit and carrying cost 20 % of average inventory . The quantity per unit order is 1200 for 10 times per year .So find out the total cost, the total cost is ordering cost(150)+carrying cost (150)=300.So the ordering cost is equal with the carrying cost, the total cost is minimum as compare to other cost of quantity in this point of view the EOQ is 300 of total cost.

The study suggests to rectify certain defects in the company inventory policy and if these suggestion are1 implemented, the company's inventory management by using of EOQ model. Economic order quantity model is using to maintain an optimal level of materials in store.

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