A State of Art on Economic Production Quantity Models

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***Abstract.* - The classical economic production quantity model is a well known and commonly used inventory technique. No. of researcher work on the EPQ model and developed EPQ model by considering different parameter like shortage, backorder, setup cost, deterioration, constant or linear or power form of the demand , rework, scrap, inspection , machine breakdown , etc . The objective of this paper is to make review of some of that past work, so that upcoming researcher can have an idea about the topic. Literature review shows that as so many research have been done to developed the EPQ model, since there will be the scope for the upcoming researcher to work on the same.**

Keywords: - inventory, machine breakdown, deteriorating items, imperfect quality,

INTRODUCTION.

Most organizations in any sectors of the economy have some type of inventory system. Inventories are common to agriculture, manufacture, retail, etc. For many small business owners, inventory is one of the most visible and tangible aspects of doing business. Raw materials, subassemblies work in process, and finished goods all represent various forms of inventory. . Investment in inventories represents a considerable amount of money (1). Unless inventories are controlled, they are unreliable, inefficient and costly. Cash invested in inventories could be used for other purposes, like paying debts or making capital investments. Effective inventory management helps organizations to save money. Inventory management must determine how much and when to order/produce each item purchased/manufactured by the organization (2). The machine failure has the important role in the determination of the optimal inventory replenishment policy [3].During production it is always observed that the product quality is not always perfect and depends on the state of the production process [4]. The concept of inflation should be considered for long term investment and
forecasting[5]. In the manufacturing sector, when items are produced internally instead of being obtained from the outside, the EPQ model is often used to determine the optimal production lot size in order to minimize the total inventory and production cost[6]. A considerable amount of the research has been carried out to enhance the classical EOQ\EPQ model. The classical EPQ model has been used for a long time. The objective of this paper is to make literature review to find out the gap and future scope for the new researcher

Literature Review.

From the product life cycle, the demand rate remains stable only in the maturity stage of the product. But in Today's time based competition, the unit cost of the product decreases over its short product life cycle. In such situation the demand rate as well as unit purchase cost of the product cannot remains fixed or constant.

Teng el. at.(2005) developed EPQ model suitable for today's high tech product during any time horizon in its product life cycle. It is assumed that demand rate and production cost both are positive and fluctuating with time. The model is developed for the firm which adopt vender managed inventory. The total cost is a convex function of number of replenishment. The model shows the influence of demand and purchase cost over the length of the production run time and EPQ. The rate of production assumed as a constant for this model. But the model can be extended by assuming the time varying production rate , deterioration rate, shortages and quantity discount. During production machine can have random failures and due to this working stops. To avoid this there must be an appropriate preventive maintenance policy. In many manufacturing system , work in process inventory is one of the component of the inventory cost . Again during production defective items can get produced. And all these has an effect on the EPQ**.**

Alimohamadi el. at.(2011) developed EPQ model by considering preventive maintenance work in process inventory and shortage. It is considered that after machining, all products are inspected to determine the perfect and imperfect items. If imperfect items are present , then they are divided into rework able and non rework able items. Reworkable items are machined again to convert them into perfect one. The model has been developed to select the preventive maintenance policy. The model can be developed in future by considering other policies of the maintenance like, corrective maintenance, emergency maintenance etc. The random machine failure seems to be inevitable in most of the real manufacturing environment. So for most of the production planner it becomes a critical task , to effectively control the disruption caused by the random breakdown in

order to minimized the overall production cost. Hence the determination of the optimal replenishment policy for the production system subject to machine failure has received the attention from researchers.

Cheng el.at.(2010) investigate the effect of random machine failure on optimum run time and on the long run average cost. Imperfect quality EPQ model has been developed to obtain the optimal inventory replenishment policy by considering backorder, rework, and random machine failure. Uniformly distributed defective rate and Poisson distributed breakdown rate is assumed for the study. Due to randomness of defective, scrap, and breakdown rate , renewal reward theorem with variable cycle length and use of integration is used to deal with the random breakdown in stock pilling time. The model can be extended to investigate the effect of the random machine failure in backorder refilling time.

Widyadana el.at.(2009) developed EPQ model by considering machine breakdown and repair time.In the real environment of the production it is observed that the quality of the product usually depends on the state of the production process. Several authors develops various models to study the effect of imperfect process on the lot size. **Hou(2007)** developed EPQ model with imperfect process by considering the set up cost and process quality as s function of the capital expenditure. Generally set up cost is treated as a constant. But in practice the set up cost can be reduced through various ways. But here it is found that set cost reduction and quality improvement has a great effect on production system efficiency. It is assumed that the relationship between the set up cost reduction and capital investment can be described by the logarithmic investment function. It is proved that investment in set up reduction leads to a reduction in optimal production run length, whereas investment in process quality improvement leads to increase in optimal production run length.It is well known that the customer motivates by the stock level in a supermarket. Such situation is called as stock dependent demand. Again the resource of an enterprise is highly correlated to the return on the investment. It means inflation influence the inventory policy to any significant level.

Singh(2012) developed EPQ model by considering stock dependent demand under inflation. Power form stock dependent demand has been considered for EPQ model and it is assumed that the production rate is demand dependent. A genetic algorithm with varying population size is used to solve the model. It is found that this algorithm is efficient to solve the EPQ model. It is observed that profit increases with increases in demand parameters. **Jain el.at.(2007)** also developed the EPQ model by assuming that the constant fraction of the on hand inventory deteriorates and the demand rate depends upon the amount of the stock level. Newtons method is employed for cost optimization. It is concluded that with increase in production, maximum inventory level and total cost increases. Maximum inventory level and total average cost decreases with increase in deterioration rate. The EPQ model shows that the optimum lot size will generate minimum production cost. But it is possible if all produced items are of perfect quality and if there will be no shortage. But in actual production process problem like shortage and non conforming product are common. So this factors play important role at the time of calculating optimum production quantity. Imperfect quality items can be reworked with additional cost. Many researcher consider this factor for developing EPQ model

Shamsi el. at.(2009) integrate the production of imperfect quality items , rework , backlogging and inspection error into a single EPQ model. It is considered that the imperfect items can be sold as a single batch at a lower price through 100% inspection process. It is assumed that while screening products at a production process , imperfect quality items may be accepted and good items may be rejected. The finding of this study shows that the changes in net batch quantity needed to satisfy the demand and the total cost are very sensitive to error like perfect items incorrectly rejected. **Chen(2009)** includes the quality cost in the EPQ model. Taguchis symmetric quadratic quality loss function will be adopted for evaluating the product quality. It is considered that the Product quality is not always perfect and is the function of the production process. It is found out that the process standard deviation, the demand rate and quality loss coefficient have a major effect on the expected total cost per unit time. The model can be extended by considering others parameter like inspection error, manufacturing cost, and defective cost. As imperfect quality items are produced during production, the inspection of the lot becomes indispensable. Particularly when the products are of deteriorating in nature.

Jaggi & Mittal(2011) assumes inspection rate more than the demand. Developed model helps the retailer to determine his ordering policy. Initially at the start of the production demand and production rate are variable and after some time deterioration start and the demand and production rate becomes constant. In such situation increase in the demand can be possible by offering discount on the selling price and to reduce the loss due to deterioration. **Garg el. at.(2012)** developed the model which determines optimal discount to be given on unit selling price during deterioration to maximize the profit. It is assumed that the deterioration is non instantaneous and no repair or replacement of the deteriorating items. The developed model is suitable for new product like automobiles, mobile phones , fashionable goods, etc.In real production , the production system often gets disrupted due to uncertainty and unplanned events. This will directly affect the demand and the margin of the company. So by keeping this point in view

Khedlekar(2012) developed EPQ model to study the variation in demand with the disrupted production system. It is assumed that during production disruption , if shortage occur, then it ordered from the spot market once in the cycle. Exponential demand is considered for the study. It is found out that if the demand is increasing then the management need to order more from the spot market and if demand rate decreases then it need to stop the production before the planned time. **Mishra & Singh(2011)** attempt to developed the EOQ model with uniform replenishment rate , power form of demand and cubic deterioration . Developed an

algorithm to find the solution of the problem. The program in C^{++} has been written to compute the total optimal cost of the inventory model. It is observed that as the replenishment rate, set up cost per cycle, holding cost per cycle increases , the total optimal average cost of the inventory cycle increases. In many real life situation, some customer has to wait for backlogged items during shortage period. The longer the waiting time , smaller is the backlogging rate. In such situation taking backlogging rate into account is necessary. **So Bansal & Ahalawat(2012)** developed inventory model for decaying items by considering backlogging. The demand is considered exponential under inflation. Two warehouse inventory problem has been considered for the study. The developed model helps the decision maker to decide whether to rent the warehouse or not. Perfect or imperfect production system, perishable or nonperishable items are selected for the above developed model. Classical optimization technique or algebraic methods or differential calculus methods used to derive the model. Maple soft, Mathematica, Matlab, Skylab used to solve the model.

Cardenas-Barron(2001,2010) use the arithmetic geometric mean inequality and Cauchy Bunyakovsky Schwarz inequality to derive the optimal lot size and the optimal backorder level for EOQ and EPQ models with backorder. **Lan el at.(2007)** solve the economic production quantity model by using algebraic method. It is assumed that the lead time is stochastic and finite range. Shortage are allowed and backlogged. **Teng el at.(2005**) proposed an algorithm to determine the optimal replenishment cycle time and ordering authors could be found in the literature to develop EPQ model for the organization adopting VMI. It has been proves in many cases that VMI can bring significant cost saving to the participants. The new researcher has a scope work to focus on the VMI system. Again no. of combination of parameters can be possible to developed new EPQ model. It is found out that the techniques like Newton method , Taylors series approximation, dynamic programming, Renewal reward theorem has can be used for optimization quantity.EOQ model from the previous research is extended to allow for deteriorating item and non zero ending inventory. It is observed that increase in selling price results increase in optimal length of ordering cycle, optimal inventory level and maximum total profit per unit time. The optimal length of ordering cycle, optimal ordering quantity and maximum total profit per unit time decreases with increase in the deteriorating rate.

Chang(2004) calculate the optimal cycle time , optimal reorder time and minimum cost of the EOQ and EPQ without using classical optimization techniques. An algebraic approach suggested by previous researcher has been used to solve the EPQ model with shortage and variable lead time. **Widyadana & Wee(2012)** developed integrated EPQ model for deteriorating items with preventive maintenance ,random machine breakdown. It is assumed that the corrective and preventive maintenance times to be stochastic and unfilled demand as lost sale. Two models has been developed by considering corrective repair and maintenance times uniformly distributed for the first and exponentially distributed for the second. **Wee el.at(2013)** developed EPQ model for imperfect items with shortage and screening constraints. The renewal reward theorem is applied to calculate total expected profit per unit time.

Conclusion.

A literature review reveals that there are number of EPQ models developed by various researchers. Not many

and differential calculus method can be used to developed the model. Without differential calculus also it is possible to developed the model.

Further research can be carried out by considering machine breakdown in production period, during backorder refilling time with linear or power form of demand, demand as a function of selling price, demand with respect to stock.

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