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THE PROPOSAL OF IMPROVEMENT INVENTORY MANAGEMENT SYSTEM USING ECONOMIC ORDER QUANTITY MODEL

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Abstract: *The aim of the article is to analyze supply logistic in company that deals with the sale of metallurgical materials. The optimization was performed on randomly selected items using EOQ model. This methodology is very suitable because it helps to improve the inventory management system in Slovak company.*

Keywords: Supply, management systems, economic order quantity model, EOQ.

1 INTRODUCTION

One of the tools of stocks maintenance and utilization in which we achieve the minimum cost associated with the procurement and maintenance of inventory is to determine the optimal size of order. Just EOQ model is one of the method associated with calculating optimal inventory ordering quantity in company logistics. It is one of the oldest classical production scheduling models. In 1913, Ford W. Harris developed this formula whereas R. H. Wilson is given credit for the application and in-depth analysis on this model .Using this model, companies can minimize the costs associated with ordering and inventory holding.

2 CHARACTERISTIC OF EOQ MODEL

The Economic Order Quantity (EOQ) is the number of units that a company should add to inventory with each order to minimize the total costs of inventory - such as holding costs, order costs, and shortage costs. The EOQ is used as part of a continuous review inventory system in which the level of inventory is monitored at all times and a fixed quantity is ordered each time the inventory level reaches a specific reorder point [2].
Assumptions of the EOQ model [6, 7]:

- Demand is known and constant.
- Lead time is known and constant.
- Receipt of inventory is instantaneous.
- Quality discounts are not available.
- Variable costs are limited to: ordering costs and carrying costs.
- If orders are placed at the right time, stockouts can be avoided.

The following figure shows the graphic description of inventory situation. Each inventory cycle begins with the receipt of an order of Q units. i.e Q units are ordered and stocked in the system. Demand is occurring at the rate of D units per time unit during cycle time T. At the reorder point R, when the on-hand inventory is barely sufficient to satisfy demand during the lead time, LT, an order of Q units is placed. Since the demand rate and the lead time are constant, the order of Q units is received exactly when the inventory level reaches zero. This means that there are no shortages [4, 5].

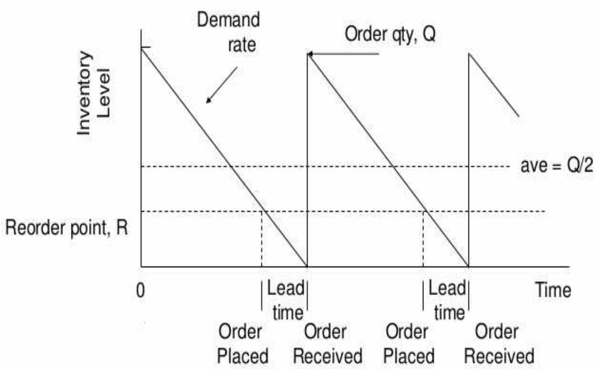

Fig. 1 The Inventory order cycle

The inventory level varies from Q to zero, so the average inventory level during the inventory cycle is Q/2. So, the inventory holding cost is obtained by multiplying this quantity with the cost of holding one unit per time unit. Hence, IHC = (Q/2) C_h . This cost is a linear function of Q. The number of orders placed during the planning horizon would be D/Q and hence the inventory ordering cost OC will be a function of the number of orders placed and the ordering cost per order. Thus, OC = (D/Q) C_o. Because the number of orders made in the planning horizon, D/Q, decreases as the order size, Q, increases, OC is inversely proportional to Q [5].

The cost of the individual item is assumed to be constant, regardless of the size of order. So the purchase cost of the item is a horizontal line as shown in the following figure. It only increases the total inventory cost by the constant amount, DC, during the entire quantity range. It does not affect the optimal order quantity, Q*. Therefore, it is not really a relevant cost for the economic order quantity decision and we can eliminate it from further consideration in the model. Hence, Total Inventory Cost TC = Ordering cost + holding cost [3, 5].

$TC = (D/Q)\,C_o + (Q/2)\,C_h$ (1)

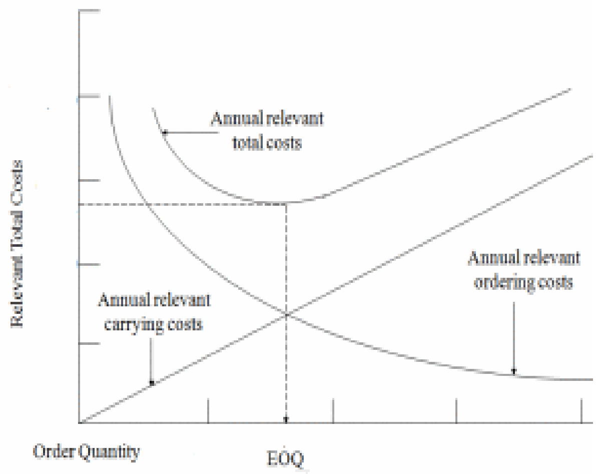

Fig. 1 Basic EOQ model

Alternatively, we can use calculus to obtain the expression for Q*, setting the first derivative of TC to zero and solving for Q [5]. Thus:

$$TC = \left(\frac{D}{Q}\right)C_o + \left(\frac{Q}{2}\right)C_h \tag{2}$$

$$\frac{dTC}{dQ} = \left(\frac{-D}{Q^2}\right)C_o + \frac{C_h}{2} = 0 \tag{3}$$

$$Q^* = \sqrt{\frac{2 * D * C_0}{C_h}} \tag{4}$$

Parameters [7]:

Q*= Optimal order quantity (the EOQ)
D = Annual demand
C_o= Ordering cost per order
C_h= Carrying (or holding) cost per unit per year
P= Purchase cost per unit

3 THE PROPOSAL OF IMPROVEMENT INVENTORY MANAGEMENT SYSTEM USING EOQ MODEL

Whereas that the conditions related to the ordering of material items can change during the year, it is necessary to find an optimal solution that will prevent the formation of large quantities of supplies [3]. The analysis is carried out for the order of 4 types of material items in Slovak metallurgical company. The aim is to identify and graphically represent the size of orders in achieving the minimum cost associated with the stockholding [3].

Round bar formed by heat Φ65 S355J2:

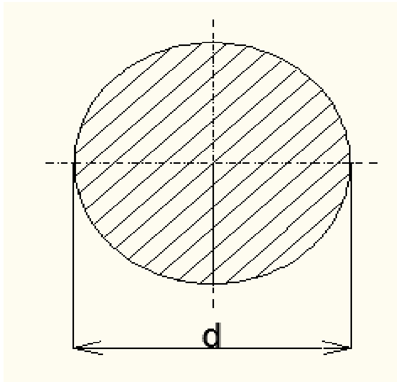

Fig. 1 Round bar formed by heat *Φ65 S355J2*

D = Annual demand = 170 t

P = Purchase cost per unit= 560 €/t

C_o = Ordering cost per order = 327 €

C_h = Carrying (or holding) cost per unit per yr

$$c_h = \frac{560 \cdot 0{,}037}{170}$$

$$c_h = 0{,}1219\ €$$

The optimal number of orders Q_{opt}:

$$Q_{opt} = \sqrt{\frac{2 \cdot D \cdot c_o}{c_h \cdot T}} \tag{5}$$

$$Q_{opt} = \sqrt{\frac{2 \cdot 170 \cdot 327}{0{,}1219 \cdot 365}}$$

$$Q_{opt} = 49{,}9879t$$

The length of delivery cycle:

$$T_{opt} = 365 \,/\, \frac{D}{Q_{opt}} \tag{6}$$

$$T_{opt} = 365 \,/\, \frac{170}{49{,}9879}$$

$$T_{opt} = 107{,}327$$

Average supply cost:

$$c_{opt} = \sqrt{2 \cdot D \cdot c_o \cdot c_h} \tag{7}$$

$$c_{opt} = \sqrt{2 \cdot 170 \cdot 327 \cdot 0{,}1219}$$

$$c_{opt} = 116{,}4167\ €$$

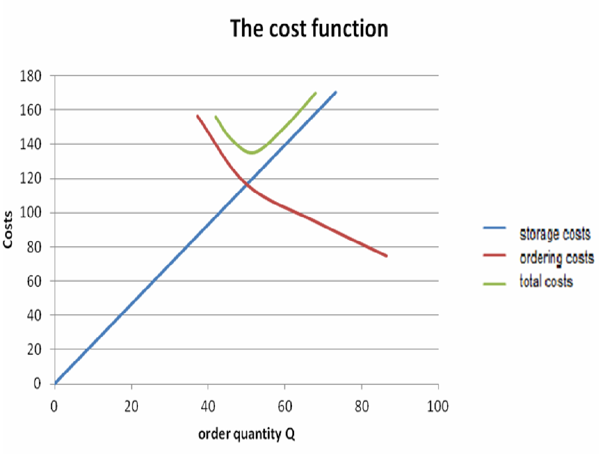

Fig. 2 Inventory analysis

Reinforcing steel Φ12mm BSt500S

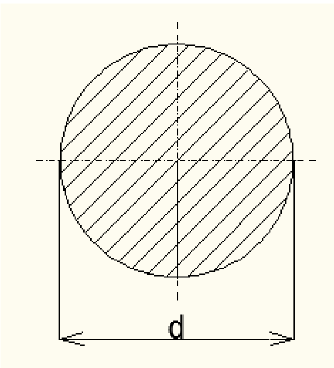

Fig. 3 Reinforcing steel Φ12mm BSt500S

D = Annual demand = 8250 t

P = Purchase cost per unit= 460 €/t

C_o = Ordering cost per order = 327 €

C_h = Carrying (or holding) cost per unit per yr

$$c_h = \frac{460 \cdot 0{,}037}{8250}$$

$$c_h = 0{,}002\ €$$

The optimal number of orders Q_{opt}:

$$Q_{opt} = \sqrt{\frac{2 \cdot 8250 \cdot 327}{0{,}002 \cdot 365}}$$

$$Q_{opt} = 2718{,}657\ t$$

The length of delivery cycle:

$$T_{opt} = 365 / \frac{8250}{2718{,}657}$$

$$T_{opt} = 120{,}2799$$

Average supply cost:

$$c_{opt} = \sqrt{2 \cdot 8250 \cdot 327 \cdot 0{,}002}$$

$$c_{opt} = 103{,}8797\ €$$

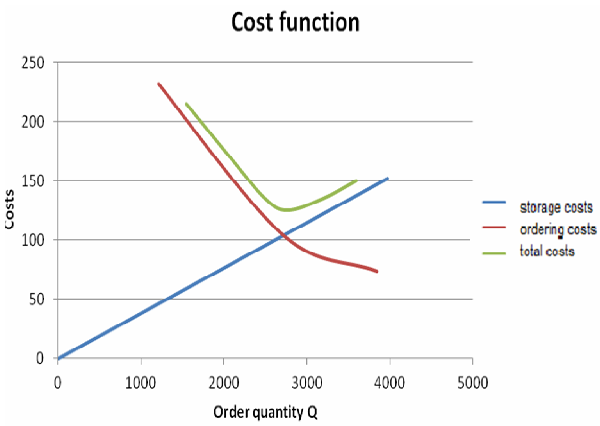

Fig. 4 Cost function of reinforcing steel

Galvanized sheet 1,5x1500x3000 DX51D+Z200:

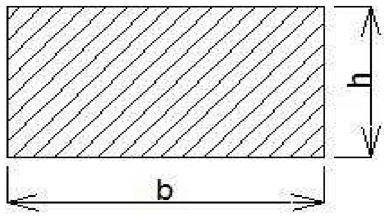

Fig. 5 galvanized sheet

D = Annual demand = 133 t

P = Purchase cost per unit= 687 €/t

C_o = Ordering cost per order = 15 €

C_h = Carrying (or holding) cost per unit per yr

$$c_h = \frac{687 \cdot 0{,}037}{133}$$

$$c_h = 0{,}191\ €$$

The optimal number of orders Q_{opt}:

$$Q_{opt} = \sqrt{\frac{2 \cdot 133 \cdot 15}{0{,}191 \cdot 365}}$$

$$Q_{opt} = 7{,}5652\ t$$

The length of delivery cycle:

$$T_{opt} = 365 / \frac{133}{7{,}5652}$$

$$T_{opt} = 20{,}7616$$

Average supply cost:

$$c_{opt} = \sqrt{2 \cdot 133 \cdot 15 \cdot 0{,}191}$$

$$c_{opt} = 27{,}6059 \text{ €}$$

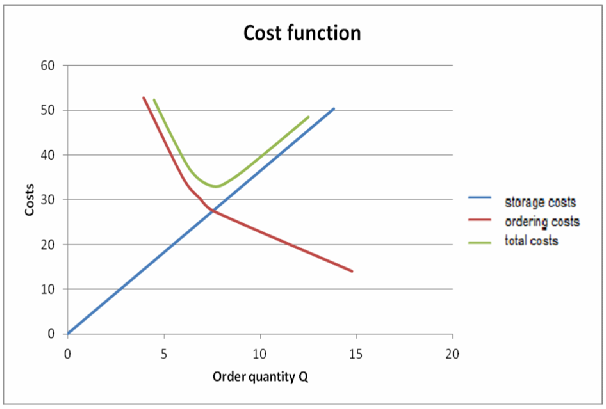

Fig. 5 Cost function of galvanized sheet

<u>Thin rolled sheet 4,0x1500x3000 S235JR</u>

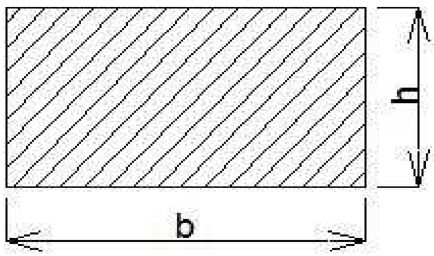

Fig. 6 Thin rolled sheet 4,0x1500x3000S235JR

D = Annual demand = 1291 t

P = Purchase cost per unit= 550 €/t

C_o = Ordering cost per order = 15 €

C_h = Carrying (or holding) cost per unit per yr

$$c_h = \frac{550 \cdot 0{,}037}{1291}$$

$$c_h = 0{,}0158 \text{ €}$$

The optimal number of orders Q_{opt}:

$$Q_{opt} = \sqrt{\frac{2 \cdot 1291 \cdot 15}{0{,}0158 \cdot 365}}$$

$$Q_{opt} = 81{,}9499 \ t$$

The length of delivery cycle:

$$T_{opt} = 365 / \frac{1291}{81{,}9499}$$

$$T_{opt} = 23{,}1694$$

Average supply cost:

$$c_{opt} = \sqrt{2 \cdot 1291 \cdot 15 \cdot 0{,}0158}$$

$$c_{opt} = 24{,}7273 \text{ €}$$

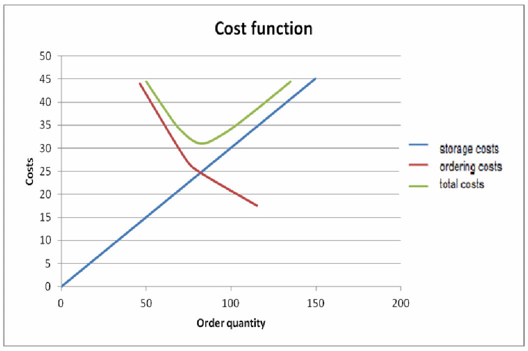

Fig. 7 Cost function of thin rolled sheet

The proposal of improvement inventory management system

In the current state of supply the average number of orders is in the following ranges [3]:
<u>round bar formed by heat Φ65 S355J2:</u>
average order: 100 – 150 t
number of orders: 3
<u>reinforcing steel Φ12mm BSt500S:</u>
average order: 1500–2000 t
number of orders: 6
<u>galvanized sheet 1,5x1500x3000 DX51D+Z200:</u>
average order: 18 – 20 t
number of orders: 5
<u>thin rolled sheet 4,0x1500x3000 S235JR:</u>
average order: 90 – 110 t
number of orders: 16

The situation after the implementation of EOQ model:
<u>round bar formed by heat Φ65 S355J2:</u>
Q_{opt}: 49,98t
number of orders: 4
<u>reinforcing steel Φ12mm BSt500S:</u>
Q_{opt}: 2718,657t
number of orders: 4
<u>galvanized sheet 1,5x1500x3000 DX51D+Z200:</u>
Q_{opt}: 7,5652t
number of orders: 18
<u>thin rolled sheet 4,0x1500x3000 S235JR:</u>
Q_{opt}: 81,9499t
number of orders: 16

4 SUMMARY AND CONCLUSION

The aim of this article was to optimize the supply logistics in company. Testing revealed that number of orders in the case of first pair items is well-selected. Conversely, the second pair of tested items needs more effected way of delivery.

The analysis of the current situation shows that optimal amount and number of deliveries is well established in the case of *round bar formed by heat.* The new situation is proposed in the case of *reinforcing steel*. It is better to order in longer intervals with larger quantities. In case of *thin rolled sheet* the number of orders is optimal and also an order size is set correctly. For the galvanized sheet the optimal order quantity and number of orders were not established. On the base of the results we suggest new order quantity: 7,56t and number of orders will be 18 per year.

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