OPTIMIZATION OF MOVING STOCK VOLUME IN RELATION TO PRICE DISCOUNT

KUCZYŃSKA - CHALADA Marzena, GRABOWSKA Sandra, PAWLAK Szymon, SZYMSZAL Jan

Silesian University of Technology, Faculty of Materials Engineering and Metallurgy, Katowice, Poland, EU

Abstract

Stocks are the most important elements of the logistic process at each stage of the manufacturing company's operation, e.g. supply, manufacturing and distribution. They allow efficient flow of materials and may also play an important role in the case of risk and uncertainty.

The aim of article is to presents modified method based on the Economic Optimal Quantity (EOQ) to optimize moving stock volume in the manufacturing company. The article also considers the necessity of incremental order to make use of a price discount for specific raw materials/components. The results of the research are presented on the basis of data from a company from the metallurgical sector.

Keywords: Optimization, moving stock, price discount, Economic Optimal Quantity

1. SUPPLIES MANAGEMENT

Inventories are a very important part of the business and they are "material goods stored in larger quantities than they would be from current needs" to be used appropriately when needed. According to Stanislaw Krawczyk [1, 2], the concept of stock is closely related to storage, since stocks are stored goods. Storage is a stored quantity of something whose size is greater than the demand at a given moment. H. K. Compton and D. Jessop formally invent stocks [3, 4]. According to them, it is "a set of all the materials, as well as the goods and services that are used in the company whether purchased, delivered or created on the spot."

Inventory management consists of the following processes: planning, organization, and execution and control of stages whose flow rate is zero. These processes depend on the rules adopted in the flow of information and goods between entities that take part in flows or the separation of their flows into dependent and independent demand. Entities operate irrespective of each other (independently), and information is exchanged by nearby links, leading to the fact that the demand data goes to everyone, for example in the form of an order [5-9].

Inventories are also tangible and in-house assets are used for their own needs, converted into finished goods or purchased for further resale. Turnover assets are raw materials, semi-finished products, finished products and goods [3].

Inventories are expressed in units of natural, valuable and time units. In places where a great variety of materials exist, wages are expressed in unit of time. This is to ensure continuity and a better assessment of the degree of uniformity of production [8, 9].

Inventories in economic terms are influenced by decision variables such as volume of supplies in terms of quantity and temporal delivery cycle. The delivery cycle is the delivery time that is necessary to set the time limit for placing an order [5, 7].

One of the basic stock management objectives is strive to cover independent demand properly through optimization of the level of created rotating stock. The element of great importance is the methodological approach towards risk limitation [1]. Each of gathered stock, material or commodity may take part in two different situations, such as: it takes part in disposals and incomes or it does not show any rotation. Rotating stock is commonly used both in production and sales and it should ensure proper functioning of an enterprise. It has to be highlighted that the rotating stock is mainly connected with consumption (demand), which has regular character, as well as with deliveries, which are to cover current and planned (forecasted) demand on

particular assortment. Practical experience indicates that its renewal uses informative level and interim review. [2,3].

2. OPTIMIZATION OF THE ROTATION STOCK - CASE STUDY

The purpose of the research was to modify the method based on the Economic Optimal Quantity (EOQ) to optimize moving stock volume in the manufacturing company. In research also considers the necessity of incremental order to make use of a discount price for specific raw materials / components. This study uses the data (**Table 1**) from an enterprise focused on production and sales of metallurgical goods. Due to limited possibility of data publishing details allowing to identify the enterprise have been omitted.

Table 1 The factsheet of data connected with supply of a chosen metallurgical enterprise

No.	Raw material's	Name	Unit	Weekly demand	Unit price [euro]	Value [euro]
1.	S1	high strenght low alloy steel	Sheet	40	155.50	6220.00
2.	S2	steel for laser cut	Sheet	85	76.00	6460.00
3.	S3	steel for pressure vessel and boilers	Sheet	25	208.50	5212.50
4.	S4	steel for gas containers	Sheet	33	145.95	4816.35
5.	S5	high carbon steel	Sheet	50	100.25	5012.50
6.	S6	weldable steel, fine-grained, normalized	Sheet	35	162.84	5699.40
7.	S7	steel for enamelling	Sheet	73	55.64	4061.72
8.	S8	steel for pipe production	Sheet	38	115.39	4384.82
9.	S9	steel for cold processing and deep rolling	Sheet	53	85.30	4520.90
10.	S10	construction steel	Sheet	103	53.45	5505.35

Meanwhile information was received that the sost related to one delivery (order) equals 350 euro, and rate of annual unit cost of stock maintenance equals r% = 26% of purchase price.

In the literature quite a lot of methods may be found due to which the volume of demand can be defined, taking into consideration various and proper factors for certain cases [10,11]. In this optimization of rotating stock a classic method of order amount optimization was used, which is based on minimization of overall cost of the rotating stock complement and maintenance, and the formula looks as follows [12]:

$$KZC = SKUzZR + ZKUzZR + SKUtZR + ZKUtZR \quad (1)$$

where:

SKUzZR - fixed costs connected with rotating stock complement,
ZKUzZr - variable costs connected with rotating stock complement,
SKUtZR - fixed costs connected with rotating stock maintenance,
ZKUtZR - variable costs connected with rotating stock maintenance.

In chosen methods of rotating stock optimization with appliance of Economic Volume of order in accordance with suggestions of the literature on subject [11] a few initial assumptions were made such as:

- Level of order's volume, which does not influence significantly on fixed elements of stock costs function of the rotating stock not influencing the result of optimization,
- The independent variable is the volume of order,
- The function of the rotating stock cost KZR may be presented by this dependence:

$$KZR = SKUzZR + \frac{PP_o}{WZ} ku \quad + SKUtZR + r\% \cdot C \cdot 0,5 \cdot WZ \tag{2}$$

where:
WZ - order's volume,
PP_o - volume of demand in considered period of time,
k_u - cost of order and one delivery that results from it,
C - unit price of particular assortment,
r% - rate of stock maintenance cost.
is minimal because the first derivative to volume of order equals zero (appearance of extremum as necessary condition). It has to be highlighted that the level of delivery volume is the same as the level of order.

In the following stage of own studies optimization of the rotating stock cost was performer in situation when demand is unequally spread in chosen periods of evaluation. In this case the chosen periods will be quarter, which is three months, as it was stated that planned demand in these periods spreads quite unequally during the year:

- volume of demand in I quarter: 15% of annual demand;
- volume of demand in II quarter: 20% of annual demand;
- volume of demand in III quarter: 30% of annual demand
- volume of demand in II quarter: 35% of annual demand.

In the first instance the amount of planned demand was calculated *PP* for particular year (**Figure 1** - column D) multiplying demand by number of weeks in year, which is 52. Next the volume of planned demand was estimated in each quarter PP_I, PP_{II}, PP_{III} *i* PP_{IV} (**Figure 1** - columns from G to J).

	A	B	C	D	E	F	G	H	I	J
1	Material	Unit	Weekly demand	Price [euro]	Value [euro]	PP Demand planned for a year [unit]	PP_I demand in I quarter [unit]	PP_{II} demand in II quarter [unit]	PP_{III} demand in III quarter [unit]	PP_{IV} demand in IV quarter [unit]
2	S1	arkusz	40	155,50	6220	2080	312	416	624	728
3	S2	arkusz	85	76,00	6460	4420	663	884	1326	1547
4	S3	arkusz	25	208,50	5212,5	1300	195	260	390	455
5	S4	arkusz	33	145,95	4816,35	1716	257	343	515	601
6	S5	arkusz	50	100,25	5012,5	2600	390	520	780	910
7	S6	arkusz	35	162,84	5699,4	1820	273	364	546	637
8	S7	arkusz	73	55,64	4061,72	3796	569	759	1139	1329
9	S8	arkusz	38	115,39	4384,82	1976	296	395	593	692
10	S9	arkusz	53	85,30	4520,9	2756	413	551	827	965
11	S10	arkusz	103	53,45	5505,35	5356	803	1071	1607	1875
12				=C2*D2		=C11*52	=$F2*D$19			
13						=$F2*D$18		=$F2*D$20	=$F2*D$21	
14	Rate of annual unit cost of stock maintenance r%:					0,26	26% of purchase price			
15	Rate of quarter unit cost of stock maintenance $r\%_k$:					0,065	(6,5% of purchase price)			
16	Cost connected with one order service k_{ui}:					350	euro	=F14/4		
17	volume of demand in I quarter			0,15	15%					
18	volume of demand in II quarter			0,20	20%					
19	volume of demand in III quarter			0,30	30%					
20	volume of demand in IV quarter			0,35	35%					

Figure 1 Estimation of demand volume in the following quarters

Applying slightly modified Wilson's formula:

$$EWZ_k = \sqrt{\frac{2 \cdot PP_k \cdot ku_i}{C_i \cdot r\%_k}} \quad (3)$$

Where:
PP_k - volume of planned demand in each quarter (k = *I, II, II* or *IV*);
ku_i - cost connected with order, i.e. one delivery of one assortment
C_i - unit price of particular assortment,

Economical volume of order has been defined EWZ_k for four quarters (k = *I, II, II* or *IV*). The gathered results were presented on **Figure 2** - in columns *K*, *L*, *M* and *N*.

The volume of quarter unit cost of stock maintenance rate $r\%_k$ with the assumption that between four quarters there are no significant differences in conditions and at the same time in stock maintenance cost - annual unit cost of stock maintenance rate value was divided $r\%$ equals 26% (0.26) of purchase price by four, i.e. $r\%_k$ = 6.5% (0.065) (cell F15 - **Figure 1**).

Cost connected with one delivery service (order) ku_i equals 350 euro. Volume of overall rotsting stock costs for each of four quarters KZR_k (k = *I, II, II* or *IV*) was calculated according to the relation:

$$KZR_k = \frac{PP_k}{EWZ_k} ku_i + r\%_k \cdot C_i \cdot 0{,}5 \cdot EWZ_k \quad (4)$$

The obtained results KRZ_k are presented on **Figure 2** - in columns *O*, *P*, *Q* i *R*.

	K	L	M	N	O	P	Q	R
1	EWZ_I Economical order volume in I quarter [unit]	EWZ_{II} Economical order volume in II quarter [unit]	EWZ_{III} Economical order volume in III quarter [unit]	EWZ_{IV} Economical order volume in IV quarter [unit]	KZR_I Rotating stock cost in I quarter [euro]	KZR_{II} Rotating stock cost in II quarter [euro]	KZR_{III} Rotating stock cost in III quarter [euro]	KZR_{IV} Rotating stock cost in IV quarter [euro]
2	147	170	208	225	1485,76	1715,61	2101,18	2269,53
3	307	354	433	468	1514,15	1748,39	2141,33	2312,90
4	100	116	142	153	1360,12	1570,53	1923,49	2077,61
5	138	159	195	211	1307,41	1509,67	1848,96	1997,10
6	205	236	289	313	1333,77	1540,10	1886,23	2037,36
7	134	155	190	205	1422,22	1642,24	2011,33	2172,48
8	332	383	469	507	1200,63	1386,36	1697,94	1833,99
9	166	192	235	254	1247,47	1440,45	1764,18	1905,54
10	228	264	323	349	1266,68	1462,63	1791,35	1934,88
11	402	465	569	615	1397,80	1614,04	1976,79	2135,18
12				Total	13536,00	15630,02	19142,79	20676,58
13				Overal coast [euro]	68985,39			
14								
15								
16								
17								
18								

=SQRT((2*G2*F16)/($D2*$F$15))
=SUM(O2:O11)
=SUM(O12:R12)
=((G2/K2)*F16)+(F15*$D2*0,5*K2)

Figure 2 Optimization of volume of rotating stock costs based on EWZ calculated in particular quarters

The volume of overall costs of rotating stock for each of four quarters ΣKZR_k estimated in cells *O*12, *P*12, *Q*12 i *R*12 (**Figure 2**) were the basis for calculating the overall rotating stock cost in particular year KZR_C:

$$KZR_C = \Sigma KZR_{CI} + \Sigma KZR_{CII} + \Sigma KZR_{CIII} + \Sigma KZR_{CIV} \quad (5)$$

On the basis of obtained results of calculations it was stated that the volumes of overall rotating stock cost in particular year KZR_C taking account of diversity of demand equals 68985.39 euro (cell O13 - **Figure 2**).

To compare a following situation should be considered in which for each of raw material (from S1 ... S10) same value was estimated EWZ_i (formula 1).

That is why to calculate EWZ_i the following relation was used:

$$EWZ_i = \sqrt{\frac{2 \cdot PP_i \cdot ku_i}{C_i \cdot r\%}} \tag{6}$$

where:
PP_i - volume of demand on particular assortment in evaluated year,
ku_i - cost connected with order, i.e. one delivery of one assortment,
C_i - unit cost of particular assortment,
$r\%$ - rate of stock maintenance cost.

The results of assessment of economical order volume for every assortment (*S*1.. *S*10) were presented in column K (**Figure 3**). Volume of overall rotating stock costs for every of each quarter KZR_k^* (k = *I, II, II* or *IV*) was calculated according to the relation:

$$KZR_k^* = \frac{PP_k}{EWZ_i}\, ku_i + r\%_k \cdot C_i \cdot 0{,}5 \cdot EWZ_i \tag{7}$$

Obtained results KRZ_k^* were presented on **Figure 3** in columns *L*, *M*, *N* i *O*. Volume of overall rotating stock costs for every of each quarter ΣKZR_k^* estimated in cells *L*33, *M33*, *N33* i *O*33 (**Figure 3**) were the basis for calculating the volume of overall rotating stock cost in particular year KZR_C^*:

$$KZR_C^* = \Sigma KZR_{CI}^* + \Sigma KZR_{CII}^* + \Sigma KZR_{CIII}^* + \Sigma KZR_{CIV}^* \tag{8}$$

It was stated that the volume of overall rotating stock cost in particular year KZR_C^* not including diversity of demand in evaluated quarters equals 69899.59 euro (cell L34 - **Figure 3**), and it is by 914.20 euro higher that including diversity of demand.

	A	B	C	D	E	F	G	H	I	J
14	Rate of annual unit cost of stock maintenance r%:					0,26	26% of purchase price			
15	Rate of quarter unit cost of stock maintenance r%$_k$:					0,065	(6,5% of purchase price)			
16	Cost connected with one order service k$_{ui}$:					350	euro	=F14/4		
17	volume of demand in I quarter			0,15	15%					
18	volume of demand in II quarter			0,20	20%					
19	volume of demand in III quarter			0,30	30%					
20	volume of demand in IV quarter			0,35	35%					
21										
22	Raw material's	Unit	Weekly demand	Unite price [euro]	Value [euro]	PP Demand planned for a year [unit]	PP$_I$ demand in I quarter [unit]	PP$_{II}$ demand in II quarter [unit]	PP$_{III}$ demand in III quarter [unit]	PP$_{IV}$ demand in IV quarter [unit]
23	S1	sheet	40	155,50	6220,00	2080	312	416	624	728
24	S2	sheet	85	76,00	6460,00	4420	663	884	1326	1547
25	S3	sheet	25	208,50	5212,50	1300	195	260	390	455
26	S4	sheet	33	145,95	4816,35	1716	257	343	515	601
27	S5	sheet	50	100,25	5012,50	2600	390	520	780	910
28	S6	sheet	35	162,84	5699,40	1820	273	364	546	637
29	S7	sheet	73	55,64	4061,72	3796	569	759	1139	1329
30	S8	sheet	38	115,39	4384,82	1976	296	395	593	692
31	S9	sheet	53	85,30	4520,90	2756	413	551	827	965
32	S10	sheet	103	53,45	5505,35	5356	803	1071	1607	1875

Figure 3 Optimization of volume of rotating stock costs based on EWZ calculated within whole year

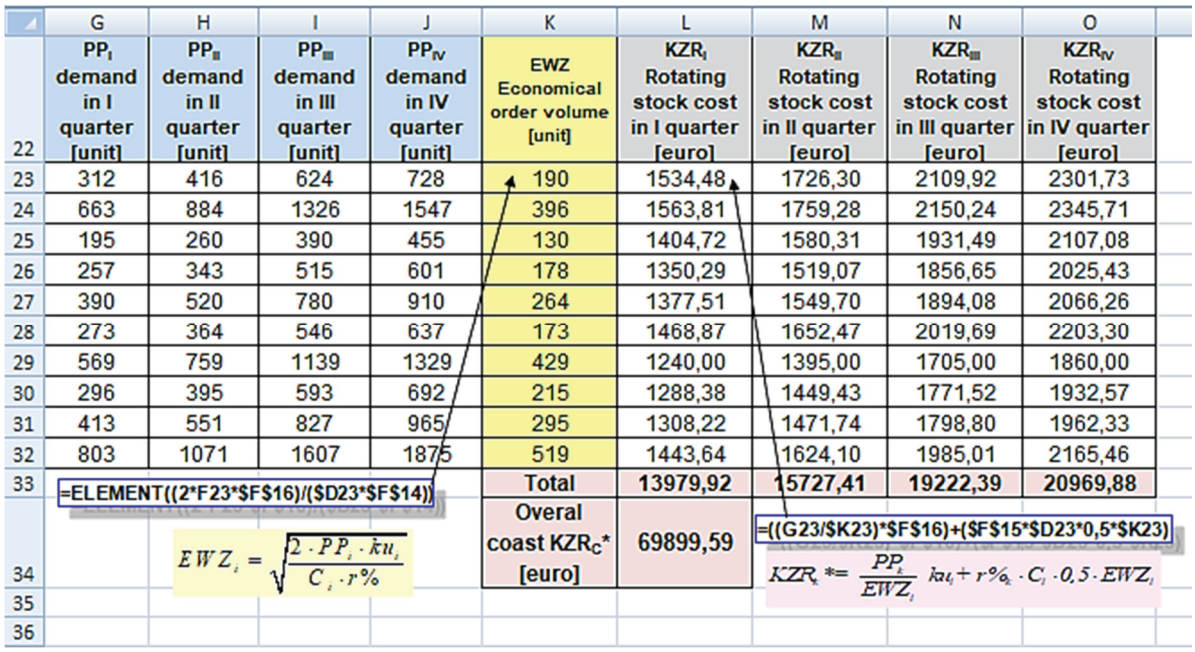

Figure 3 (Continued) Optimization of volume of rotating stock costs based on EWZ calculated within whole year

3. CONCLUSION

In the turbulently changing environment enterprises are forced to search for the most effective methods of process optimization [13]. Stock management is the basic role of an enterprise. Proper steering of storage flow and management constitutes the foundation of effective management e.g. of production plant in a way that allows to gain previously set goal, which may include minimization of costs. As the research results showed the optimization of rotating stock volume in unequally spread demand may be done on the basis of evaluation of order's economical volume. The example presented in the article may act as a tool to optimize stocks in conditions of unequal demand.

REFERENCES

[1] KRZYŻANIAK S., *Podstawy zarządzania zapasami w przykładach*. Poznań, Wyd. Instytutu Logistyki i Magazynowania, 2002, pp. 23-34.

[2] KUCZYŃSKA-CHAŁADA M., *The analysis of qualification processes of metallurgy sector suppliers*. Solid State Phenomena, Vol. 246, 2016, pp. 263-266.

[3] ŚLIWCZYŃSKI B., *Controling operacyjny łańcucha dostaw w zarządzaniu wartością produktu*. Poznań, Wydawnictwo Uniwersytetu Ekonomicznego w Poznaniu, 2011, pp. 45-56.

[4] MARTIN CH., Logistics & supply chain management. UK, PEARSON, 2016, pp.23-56.

[5] JACOBS F.R., CHASE R. B., *Operations and supply chain management*. Mcgraw - Hill/Irwin, United Kingdom, 2013, pp. 120-130.

[6] JOHNSON P.F., FLYNN A., *Purchasing and supply management.* Mcgraw - Hill/Irwin, United Kingdom, 2014, pp. 34-45.

[7] MONCZKA R.M., HANDFIELD R.B., *Purchaising and supply chain management.* Hardcover, Boston, 2015, pp.45-67.

[8] SINGH S.P., PANDA G.C., A*n inventory model for generalized weibull deteriorating items with price dependent demand and permissible delay in payments under inflation.* LodForum Scientific Journal of Logistics, Zeszyt 6, Poznań 2010.

[9] SZOZDA N., JAKUBIAK M., *Analysis of the inventory level in the production cell.* LodForum Scientific Journal of Logistics, Zeszyt 3, Poznań 2015.

[10] KRZYŻANIAK S., NIEMCZYK A., MAJEWSKI J., *Organizacja i monitorowanie procesów magazynowych*. Poznań, Biblioteka Logistyka, 2014, pp. 78.

[11] MYERSON P., *Lean supply chain and logistics management (mechanical engineering)*. NY, McGraw-Hill companies, 2016, pp.140-145.

[12] JACOBS R.A., *Basics of logistics in the New Era: Everything You need to know about logistics*. Kindle book, 2016.

[13] GRABOWSKA, S., Business model metallurgical company built on the competitive advantage. In *METAL 2016: 25th International Conference on Metallurgy and Materials*. Ostrava: TANGER, 2016, pp.1800-1807.