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Management of Assortment Inventory Groups in Selected Foundry

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Abstract

As experience shows the practical, reliable assessment and optimisation of total costs of logistical processes implemented in supply chains of foundry plants is a quite complex and complicated process, because it requires to enclose all, without exception, performed actions, including them in various reference cross-sections, systematic activities and finally transforming them in a totally homogenous collection. Only solid analysis and assessment of assortment management in logistical supply systems in foundry plants of particular assortment groups allows to lower the supply costs significantly. In the article the analysis and assessment of the newest implemented optimising algorithms are presented in the process stock management of selected material groups used in a production process of a chosen foundry plant. A practical solution to solve a problem of rotary stock cost minimisation is given as well as of costs while creating a stock with the usage of economical volume and value of order.

Keywords: Computer support of casting production, Supply logistics in a foundry plant

1. Introduction

Everyday practise shows that having rational basis assessment and costs optimising of logistic processes connected with supply accomplishing, which stands for supply chains in foundry plants, is a process that is characterised by a rather large complexity. The proper solution to these problems requires considering all implemented in this field activities, proper placing in various reference cross-sections and different systematic and transforming activities in order to create totally homogonous collections. Only solid analysis and assessment of assortment management in logistical supply systems in foundry plants of particular assortment groups allow to lower the supply costs significantly [1, 2, 4]. Management methods of material stocks for production in enterprises are usually treated as separate for each ordered assortment alone. Based on practical experience it may be stated that in some peculiar cases much better solution, in case of stocks cost optimisation, will be the implementation of algorithms, which are connected with separate assortments groups. Among the most important factors of such approach based on assortment grouping and subjecting them to common procedure of creating the stock volume may be [1-6]:

- implementing of limits in supply process i.e. precisely defined number of deliveries in particular period, limited stock area or having limited capital;
- supplying at the same supplier or at the supplier close to each other of various assortment items.

2. Method of research

Used in own research, method of optimising the rotary stock cost amount minimises the average stock value and consequently the cost of its maintaining. As an advantage of this method it may be treated the possibility of its implementation in cases when the data connected with the amount of service costs of one order and

the ratio of periodical stock maintenance cost are unknown or they are under great uncertainty. The method requires the knowledge of summary number of deliveries in period under examination. The minimisation of assortment groups stock maintenance costs at first stage is based on the usage of the proportion rule of deliveries quantity of a defined assortment item to a square root of planned deliveries in a given period.

The method of costs minimisation and of assortment groups stock maintenance at the following stages can be proceeded with the usage of the cost minimisation through the orders grouping with the economical value of an order. The method based on costs minimisation may be used through the correction of economical order value and the number of deliveries for ordered items, per each delivery [1, 2].

3. The minimisation of stock cost

3.1. Usage of a coverage constant

The examined foundry plant produces the high quality malleable, ductile cast iron moulds and malleable weldable cast iron. These moulds are used in the energy industry (wheel covers, hangers, boats), automotive (mufflers, engine base, wing hubs), rail (bolts), mining (jaws, spreaders, sprinkles nozzles) or in building industry (joints, nuts, alloys). The foundry plant purchases the material necessary for a production process at three main suppliers: A, B i C. The planned amounts of annual demand on particular material PP_i (column D – Fig.1) was obtained by the usage of various forecast methods.

	A	B	C	D	E	F	G	H	I
1	Supplier	Material	i	PPi [Mg]	Price Ci [PLN]	Wi [PLN]	√Wi	Ldi	0,5Wi/Ldi [PLN]
2		Material A1	1	855	1400	1197000	1094,07	4	149625,0
3		Material A2	2	360	1400	504000	709,93	3	84000,0
4	**Supplier A**	Material A3	3	365	1800	657000	810,56	3	109500,0
5	14 deliveries	Material A4	4	100	=D2*E2	180000	424,26	2	45000,0
6		Material A5	5	100	1700	170000	412,31	2	42500,0
7		Material B1	6	1930	500	965000	982,34	4	120625,0
8	=SUMA(H2:H6)&" dostaw"	Material B2	7	1629	490	798	=ZAOKR(G2/$E$32;0)		59776,3
9		Material B3	8	493	510	251		2	62857,5
10		Material B4	9	1836	990	1817640	1348,20		=0,5*(F2/H2)
11		Material B5	10	132	980	129360	359,67	1	64680,0
12	**Supplier B**	Material B6	11	634	970	614980	784,21	3	102496,7
13	26 deliveries	Material B7	12	27	3150	85050	291,63	1	42525,0
14		Material B8	13	7	3050	21350	146,12	1	10675,0
15		Material B9	14	27	3100	83700	289,31	1	41850,0
16		Material B10	15	7	3110	21770	147,55	1	10885,0
17		Material B11	16	34	3030	103020	320,97	1	51510,0
18		Material B12	17	34	3100	105400	324,65	1	52700,0
19		Material B13	18	34	3120	106080	325,70	1	53040,0
20		Material C1	19	43	2150	92450	304,06	1	46225,0
21		Material C2	20	41	2200	90200	300,33	1	45100,0
22		Material C3	21	29	2100	60900	246,78	1	30450,0
23		Material C4	22	12	2100	25200	158,75	1	12600,0
24		Material C5	23	32	2900	92800	304,63	1	46400,0
25	**Supplier C**	Material C6	24	10	3000	30000	173,21	1	15000,0
26	12 deliveries	Material C7	25	27	3000	81000	284,60	1	40500,0
27		Material C8	26	7	3150	22050	148,49	1	11025,0
28		Material C9	27	34	3100	105400	324,65	1	52700,0
29		Material C10	28	10	3000	30000	173,21	1	15000,0
30		Material C11	29	=G32/52	3000	=SUMA(G2:G31)	13	1	22500,0
31		Material C12	30	10	3100	31000	176,07	1	15500,0
32				k=	249,5	Total	12973,24	52	1679009,4

Fig.1. Optimisation of rotary stock cost amount (own data)

Deliveries to the foundry plant are proceeded once a month, which gives $\sum Ld_i$=52 of delivery per year. After filling unit prices of all materials C_i (column E – Fig.1) the amounts of planned deliveries were calculated W_i by multiplying C_i with PP_i (column F – Fig.1).

At the following stage the summary value of square roots was indicated from the value of planned deliveries of examined assortment group $\sum\sqrt{Wi}$ (cell G32 – Fig.1), and dividing it by the total number of deliveries $\sum Ldi$ the value of so called coverage constant value k was calculated (cell E32 – Fig.1). By dividing the values of planned deliveries root $\sqrt{Wi}$ for each material item by the coverage constant value k the number of deliveries was calculated Ldi (column H – Fig.1).

At the final stage the summary average stock value was calculated SWZ (cell I32 – Fig. 1) according to the relation:

$$SWZ = \frac{1}{2}\sum_{i=1}^{n}\frac{W_i}{Ld_i} \tag{1}$$

To gain the lowest stock value SWZ equals 1679009,4 PLN Suppliers A, B and C should perform in examined periods following: 14, 26 and 12 deliveries while these 52 deliveries should be performed for every mould assortment items with the assigned structure.

3.2. Usage of economical order value

The method of cost minimising and assortment groups stock maintenance based on the order supply may be used when the amount of order costs are known as well as of accomplishing one delivery of each assortment, which means the costs connected with accomplishment of one delivery with acceptance to a warehouse Ku_i (column Q – Fig. 2) and the amount of ratio of stock maintenance cost in particular period $r\%$. (cell P35 – Fig.2). Next for each item cost of stock creating was assigned KTz_i (column S - fig. 2) dividing the product PP_i by Ku_i by EWZ_i.

	L	M	N	O	P	Q	R	S	T	U	V	W
1	Supplier	Material	i	PPi [Mg]	Price Ci [PLN]	Ku	EWZ	KTz	KTSz	KUz	KC	Ld
2		Material A1	1	855	1400	1840	112	14046	**14720**	14112	28158	8
3		Material A2	2	360	1400	1840	73	9074	**9200**	9198	18272	5
4	**Supplier A**	Material A3	3	365	1800	1840	64	10494	**11040**	10368	20862	6
5	25 deliveries	Material A4	4	100	1800	1840	34	5412	**5520**	5508	10920	3
6		Material A5	5	100	1700	1940	35	5257	**5520**	5355	10612	3
7								Total	44288	**46000**	44541	88824	25
8		Material B1	6	1930	500	1780	276	12447	**12460**	12420	24867	7
9		Material B2	7	1629	490	1780	266	11327	=W2*Q2	11290	22617	6
10		Mat	=ZAOKR(PIERWIASTEK((2*O2*Q2)/(P2*$O$35));0)						**7120**	6334		4
11		Material B4	9	1836	99	=ZAOKR((O2*Q2)/R2;0)			**17800**	17107	=S2+T2	10
12		Material B5	10	132	98				**5340**		=ZAOKR(O2/R2;0)	
13	**Supplier B**	Material B6	11	634	970	1780	114	9899	**10680**			
14	48 deliveries	Material B7	12	27	3150	1780		=ZAOKR($O$35*P2*0,5*R2;0)			883	2
15		Material B8	13	7	3050	1780	7				702	1
16		Material B9	14	27	3100	1780	13	3697	**3560**	3627	7324	2
17		Material B10	15	7	3110	1780	7	1780	**1780**	1959	3739	1
18		Material B11	16	34	3030	1780	15	4035	**3560**	4091	8126	2
19		Material B12	17	34	3100	1780	15	4035	**3560**	4185	8220	2
20		Material B13	18	34	3120	1780	15	4035	**3560**	4212	8247	2
21								Total	84630	**85440**	85371	170001	48
22		Material C1	19	43	2150	1520	18	3631	**3040**	3483	7114	2
23		Material C2	20	41	2200	1520	18	3462	**3040**	3564	7026	2
24		Material C3	21	29	2100	1520	15	2939	**3040**	2835	5774	2
25		Material C4	22	12	2100	1520	10	1824	**1520**	1890	3714	1
26		Material C5	23	32	2900	1520	14	3474	**3040**	3654	7128	2
27	**Supplier C**	Material C6	24	10	3000	1520	8	1900	**1520**	2160	4060	1
28	19 deliveries	Material C7	25	27	3000	1520	12	3420	**3040**	3240	6660	2
29		Material C8	26	7	3150	1520	6	1773	**1520**	1701	3474	1
30		Material C9	27	34	3100	1520	14	3691	**3040**	3906	7597	2
31		Material C10	28	10	3000	1520	8	1900	**1520**	2160	4060	1
32		Material C11	29	15	3000	1520	9	2533	**3040**	2430	4963	2
33		Material C12	30	10	3100	1520	7	2171	**1520**	1953	4124	1
34								Total	32718	**28880**	32976	65694	19
35	Ratio of annual cost of stock maintenance r%						**18%**					

Fig. 2. Assessing costs of stock maintaining and completing for individual assortment ordering (own data)

At first for each assortment the economical value of order was calculated (column R - fig. 2) according to the formula:

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

The cost of stock maintenance KUz_i (column U – Fig. 2) was calculated as a half of the product of stock maintenance ratio cost $r\%$, of unit price C_i and the economical order amount EWZ_i. The size of total costs KC_i for each item (column V – Fig. 2) were the sum of costs of creating KTz_i and maintaining stock. KUz_i. The corrected number of deliveries LD_i (column W – Fig. 2) were the quotient of the amount of planned demand PP_i and economical size of order EWZ_i. At the final stage the total number of deliveries was calculated as well as the summary costs of stock creating and maintaining separately for each of three suppliers.

Additionally for each assortment a corrected value of stock creating costs $KTSz_i$ (column T – Fig. 2) multiplying the corrected number of deliveries LD_i by KU_i.

The implemented at this stage method of stock cost minimising is based on orders grouping by using the order economical value $EWarZ$, which may be treated as a common relative value for all assortments. The order economical value $EWarZ_i$ for each assortment makes the product of order economical value EWZ_i and the price C_i. At first for each of the suppliers a single delivery and order cost was assigned - so called group cost of stock completing that consists of common order of all materials and individual costs of acceptance to the warehouse of each item KU_A, KU_B or KU_B (cells AC7, AC21 and AC34 – Fig. 3). Next, for each material the value of projected demand was assigned PWP_I (column AG – Fig. 3) and for each Supplier PWP_A, PWP_B, PWP_C (cells AG7, AG21 and AG34 – Fig. 3).

	AB	AC	AD	AE	AF	AG	AH	AI	AJ	AK	AL
1	Supplier	Material	i	PPi [Mg]	Price Ci [PLN]	PWPi	EWarZi	EWZi	KUzi	KTz	KC
2		Material A1	1	855	1400	197000	199500	143	18018		
3		Material A2	2	360	1400	504000	84000	60	7560		
4	**Supplier A**	Material A3	3	365	1800	657000	109500	61	9882		
5	6 deliveries	Material A4	4	100	1800	180000	30000	17	2754		
6	=700+5*(1840-700)	Material A5	5	100	1700	170000	28333	17	2601		
7	**KU_A =**	**6400**	**LD=**	**6**		**PWP_A =**	**2708000**	**$EWarZ_A$ =**	**438827**	40815	38400	**79215**
8		Material B1	6	1930	500	965000	160833	322	14490		
9		Material B2	7	493	1410	798210	133035	272	11905		
10		Material B3	8	493	510	251430	41905	85	3773		
11		Material B4	9	1836	900	1652400	302940	306	27265		
12		Material B5	10	132	900	118800	21780	22	1940		
13	**Supplier B**	Material B6	11	634	970	614980	102497	106	9454		
14	6 deliveries	Material B7	12	27	3150	85050	14175	5	1260		
15		Material B8	13	7	3050	21350	3558	1	275		
16		Material B9	14	27	3100	83700	13950	5	1395		
17		Material B10	15	7	3110	21770	3628	1	280		
18		Material B11	16	34	3030	103020	17170	6	1636		
19		Material B12	17	34	3100	105400	17567	6	1674		
20		Material B13	18	34	3120	106080	17680	6	1685		
21	**KU_B =**	**14740**	**LD=**	**6**		**PWP_B =**	**5102990**	**$EWarZ_B$ =**	**914197**	77070	88440	**165510**
22		Material C1	19	43	2150	92450	46225	22	4257		
23		Material C2	20	41	2200	90200	45100	21	4158		
24		Material C3	21	29	2100	60900	30450	15	2835		
25		Material C4	22	12	2100	25200	12600	6	1134		
26		Material C5	23	32	2900	92800	46400	16	4176		
27	**Supplier C**	Material C6	24	10	3000	30000	15000	5	1350		
28	2 deliveries	Material C7	25	27	3000	81000	40500	14	3780		
29		Material C8	26	7	3150	22050	11025	4	1134		
30		Material C9	27	34	3100	105400	52700	17	4743		
31		Material C10	28	10	3000	30000	15000	5	1350		
32		Material C11	29	15	3000	45000	22500	8	2160		
33		Material C12	30	10	3100	31000	15500	5	1395		
34	**KU_C =**	**10540**	**LD=**	**2**		**PWP_C =**	**706000**	**$EWarZ_C$ =**	**287542**	32472	21080	**53552**
35	Ratio of annual cost of stock maintenance r%:					**18%**						

=AE2*AF2 =AC7*AE7 =AJ7+AK7 =ZAOKR(AG7/AI7;0) =ZAOKR(AG2/$AE$7;0) =ZAOKR(AH2/AF2;0) =0,5*AF2*$AF$35*AI2 =SUMA(AG2:AG6) =ZAOKR(PIERWIASTEK((2*AG7*AC7)/$AF$35);0)

Fig. 3. Assessment of the maintenance and stock completing costs for group assortment orders (own data)

The group order economical value for Supplier A was assigned according to relation:

$$EWarZ_A = \sqrt{\frac{2 \cdot PWP_A \cdot KU_A}{r\%}} \tag{3}$$

In similar way order economical values were assigned for the rest of Suppliers (cells AI7, AI21 and AI34 – Fig. 3).

The values were used to indicate the optimal number of deliveries for particular Suppliers LD_A, LD_B and LD_C (cells AE7, AE21 and AE34 – Fig. 3). The order economical value for each material $EWarZ_i$ was achieved by dividing projected demand values PWP_i by the number of deliveries (column AH – Fig. 3). By dividing $EWarZ_i$ by C_i the order economical value for each material was achieved EWZ_i (column AI – Fig. 3). The size of stock maintenance costs for particular materials KUz_i (column AJ – Fig. 3) was calculated according to the relation:

$$KUz_i = \frac{1}{2} C_i \cdot EWZ_i \cdot r\% \tag{4}$$

The costs of stock creating for each Supplier KTz (cells AK7, AK21 and AK34 – Fig. 3) were calculated by multiplying quantity of deliveries LD (cells AE7, AE21 and AE34 – Fig. 3) performed by a particular supplier and the group cost of stock completing that consists of a common order for all items and individual costs of acceptance to the warehouse of each item KU (cells AC7, AC21 and AC34 – Fig. 3).

At the final stage the overall cost of stock creating and maintenance was calculated for the following suppliers KC_A, KC_B and KC_C (cells AL7, AL21 and AL34 – Fig. 3).

4. Summary and conclusions

The minimisation method of the rotary stock maintenance cost, with the assumption that the cost of rotary stock completing is constant and it results from determiners or outside limitations, allows the rational formation of assortment items group stocks.

Figure 4 presents the comparison of costs amounts of stock creating KT_Z, (Fig. 4), costs of stock maintenance KU_Z (Fig. 5) and summary costs KC stock creating and maintenance (Fig. 6) for individual and group orders including deliveries from a particular supplier.

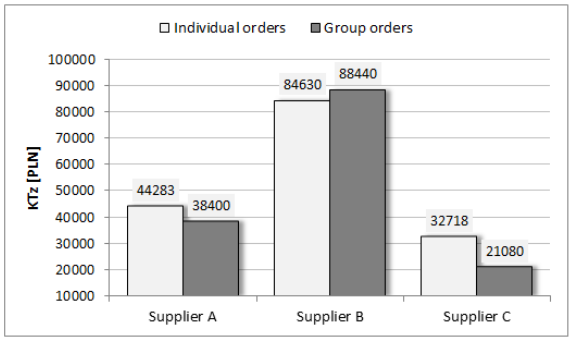

Fig. 4. Comparison of stock creating costs amounts KT_Z, for individual and group orders (own data)

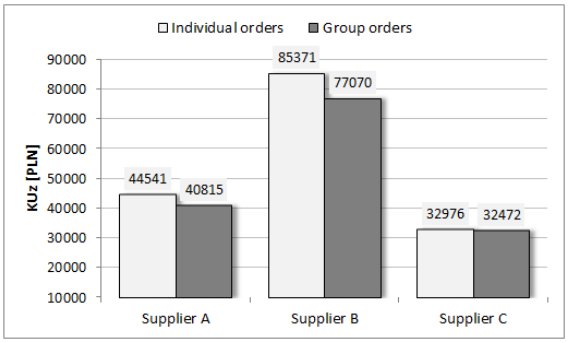

Fig. 5. Comparison of stock maintenance costs amounts KU_Z for individual and group orders (own data)

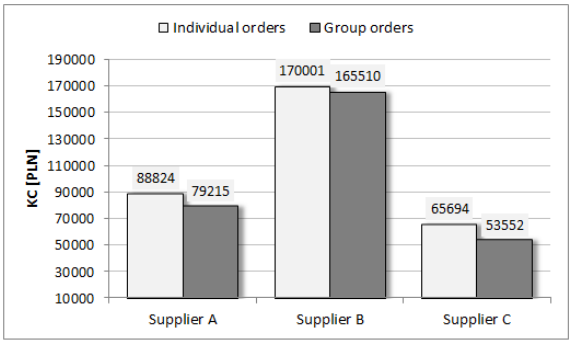

Fig. 6. Comparison of summary costs of stock creating and maintenance *KC* for individual and group orders (own data)

It may be concluded that in case of group orders the summary decrease in stock creating costs KT_Z equals about 13 700 PLN, however the decrease in stock maintenance costs KU_Z exceeds 12 500 PLN. The total cost *KC* of stock creating and maintenance of the examined assortment group is, in case of a group (assortment in division for a supplier) ordering, lower by over 26 000 PLN, in comparison to individual orders.

The minimising of stock creating and maintenance costs based on stock grouping with the usage of order economical value in comparison to the method based on individual assortment orders allows to achieve, during the production supply process of the examined foundry, the financial profits.

Taking into account the achieved results at the following stage it should be considered if all of the materials should be ordered at the same pace, it means that some of them do not have to be delivered in each of the deliveries.

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