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## IMPROVING THE EFFICIENCY OF MAINTENANCE AND REPAIR ON ENTERPRISES OFFICIAL DEALERS USING THE AUTOMATED SYSTEM INVENTORY MANAGEMENT

### POPRAWA WYDAJNOŚCI EKSPLOATACJI I NAPRAWY W PRZEDSIĘBIORSTWACH STOSUJĄCYCH ZAUTOMATYZOWANY SYSTEM ZARZĄDZANIA MAGAZYNAMI

#### Abstract

The paper suggests the decision-making technique to control processes of spare parts supplies and turnovers. The basis of the technique is the imitating simulation determination of warehouse parameters values which allow to optimize the given system operation. The obtained data allow the expert in planning stocks to make an optimal decision out of a variety of offered alternatives to attain the formulated aim according to the company's policies and financial possibilities.

*Keywords: planning of spare parts supplies, stocks control, multiproduct analysis, imitating simulation of systems*

#### Streszczenie

W artykule zaproponowano metodę podejmowania decyzji w zakresie procesów kontroli dostawy i obrotu częściami zamiennymi. Podstawą tej metody jest naśladowanie symulacyjnego określania wartości parametrów magazynowania, co pozwala na optymalizację działania danego systemu. Uzyskane dane pozwalają projektantowi systemu składowania na podjęcie optymalnej decyzji przy wyborze wśród oferowanych możliwości tak, aby osiągnąć zamierzony cel zgodnie z polityką danego przedsiębiorstwa i jego finansowymi możliwościami.

*Słowa kluczowe: planowanie zaopatrzenia w części zamienne, kontrola magazynów, analiza wielotowarowa, imitacyjna symulacja systemów*

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The quality of control of a warehouse of spare parts and materials substantially influences the performance of transport infrastructure enterprises such as official automobile dealers, transportation companies, and automobile spare parts shops in particular. The main purpose of control is to provide the warehouse with a complete set of necessary assortment in sufficient quantities and minimum costs connected with its storage. The problem of stocks control of automobile spare parts and materials in the warehouse is multicriterion. Criteria of estimating the warehouse performance can be stocks turnover  $Y$ , grade of service  $U$ , the warehouse average stock  $\bar{N}$ , and some others. Auto parts have multivariate properties and consequently have their own features of realization which are not characteristic, for example, of food provisions.

The core of the offered technique of the automatic control system is the imitating simulation process. The set of initial data for simulation contains turnover statistics of each item of stocks in the warehouse, their purchase cost, sale price, storage expenses, etc. Output data are quantitative estimations of efficiency parameters of the warehouse control. The purpose of the problem is to obtain optimal values of the parameters of the control system of stocks for a specific auto transportation enterprise (a concrete set of initial data).

The initial data for demand forecasting has been the information obtained as a result of full-scale observation of spare parts turnover at the warehouse. If there was an opportunity to properly select theoretical distribution for the collected statistical data of spare parts sales, then we used it, if not, then we specified empirical distribution function. To forecast spare parts demand, a sample of the obtained distributions had been made.

Having analyzed the work of “For Auto” company of the city of Krasnoyarsk which sells spare parts of the KamAZ brand in nomenclature volume of five thousand items, we developed two imitating simulations of stocks control: with the fixed volume of the order and the “maximum-minimum” model. In the former the warehouse stock is replenished each time by the known fixed amount  $Q = \text{const}$  (the volume of the order) as soon as it reaches the specified minimum admissible level  $N_{\min}$ . The latter strategy of control is in that the order for supplies is also realized at the moment when the stock reaches level  $N_{\min}$ , while providing its increase up to the specified maximum admissible level  $N_{\max}$ , i.e.  $Q = N_{\max} - N_{\min}$ .

The values of all the listed parameters of the stocks control system are applied in the problem to each position of the total many thousand nomenclature. Therefore the unit of measure had been accepted as a universal amount equal to average quantity of parts supplied from the warehouse for one day. Thus, the expression  $N_{\min} = 15$  means that for each item of stocks the minimum admissible level in the warehouse is equal to its average quantity sold for 15 days. Further in the text the units of measure have been omitted for convenience of formatting.

An optimizing experiment has been made on the models. In the former model we changed values of two input parameters of the control system—the volume of the order in a range from  $Q = 10$  to  $Q = 30$  and the minimum admissible volume of stock  $N_{\min}$  in a range from 10 to 30 with interval 5. And in the latter—the values of the minimum admissible volume of stock  $N_{\min}$  in a range from 10 to 30 and the maximum admissible volume of stock  $N_{\max}$  in a range from  $N_{\min} + 10$  to  $N_{\min} + 30$  with interval 5. Average warehouse stock  $\bar{N}$ , deficit level of spare parts  $D$  (%), and grade of service of clients  $U$  (%) had been chosen as the output parameters. The obtained results are presented in the table and figure. The grade of service is understood as probability of availability of a demanded part in the warehouse. The deficit level is equal to the ratio of a backlog demand to the satisfied one.

**Dependences of indices of the warehouse control efficiency on the parameters of the stocks control system**

Model with the fixed volume of the order							The “maximum-minimum” model						
1. Average warehouse stock													
		Minimum warehouse stock							Minimum warehouse stock				
		10	15	20	25	30			10	15	20	25	30
Volume of the order	10	7.3	10.4	13.7	17.3	20.6	Maximum warehouse stock	$N_{\min}+10$	8.6	12.0	15.5	19.1	22.6
	15	10.0	13.4	16.8	20.4	24.0		$N_{\min}+15$	11.0	14.5	18.1	21.7	25.3
	20	12.7	16.1	19.7	23.3	27.0		$N_{\min}+20$	13.5	17.0	20.6	24.3	27.9
	25	15.4	18.9	22.5	26.1	29.7		$N_{\min}+25$	16.1	19.6	23.2	26.8	30.5
	30	17.9	21.5	25.2	28.8	32.5		$N_{\min}+30$	18.5	22.2	25.7	29.5	33.1
2. Deficit													
		Minimum warehouse stock							Minimum warehouse stock				
		10	15	20	25	30			10	15	20	25	30
Volume of the order	10	32.29	20.03	12.01	8.33	5.28	Maximum warehouse stock	$N_{\min}+10$	18.0	9.93	6.06	3.46	2.04
	15	18.71	10.62	6.75	3.99	2.61		$N_{\min}+15$	12.5	7.02	3.99	2.26	1.50
	20	11.55	7.22	3.96	2.48	1.48		$N_{\min}+20$	9.08	5.57	3.11	1.82	1.05
	25	7.80	4.74	2.68	1.88	0.99		$N_{\min}+25$	6.80	3.88	2.26	1.33	0.83
	30	5.97	3.41	2.06	1.24	0.86		$N_{\min}+30$	5.29	3.08	1.86	1.04	0.58
3. Grade of service													
		Minimum warehouse stock							Minimum warehouse stock				
		10	15	20	25	30			10	15	20	25	30
Volume of the order	10	78.41	85.97	91.26	94.03	95.98	Maximum warehouse stock	$N_{\min}+10$	86.66	92.55	95.45	97.40	98.42
	15	86.51	92.04	94.82	96.84	97.90		$N_{\min}+15$	90.53	94.68	96.88	98.25	98.86
	20	91.12	94.55	96.82	98.02	98.76		$N_{\min}+20$	92.95	95.79	97.61	98.60	99.17
	25	93.84	96.28	97.76	98.52	99.15		$N_{\min}+25$	94.53	96.89	98.20	98.92	99.35
	30	95.08	97.22	98.33	98.95	99.32		$N_{\min}+30$	95.64	97.51	98.49	99.17	99.49

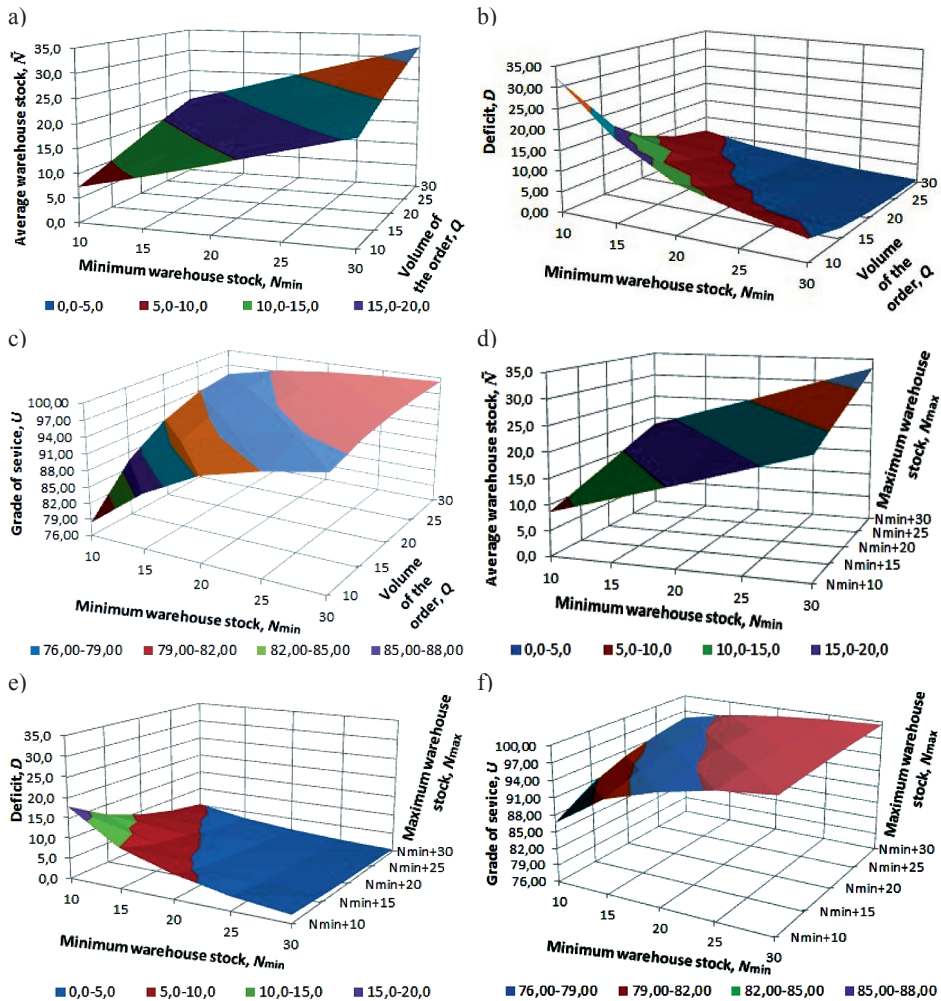


Fig. 1. Dependences of indices of the warehouse control efficiency on the parameters of the stocks control system: a, b, c – model with the fixed volume of the order; d, e, f – the “maximum-minimum” model

Rys. 1. Zależności wskaźników skuteczności kontroli magazynowej od parametrów systemu kontroli składowania

Having compared the data of the stocks control strategy, it is possible to draw a conclusion that for the enterprise under consideration, the strategy with the fixed volume of the order is appreciably inferior since the deficit level is much higher and the grade of service is respectively lower with the same volumes of the average stock in the warehouse.

The obtained regularities allow to set admissible limits of deficit and grade of service. Thus, the values of parameters  $N_{max}$  and  $N_{min}$  can be set so that the average warehouse stock would be minimum. If the enterprise is not stringent in circulating assets, then to determine the optimum values of parameters of the warehouse control  $N_{max}$  and  $N_{min}$ , it is possible to

employ the formula offered in what follows. Reasoning from the fact that increasing an average warehouse stock  $\bar{N}$  is expedient until expenses for storage of an additional batch of spare parts  $\Delta N$  and thanks to it do not exceed profit from decreasing of deficit  $\Delta D$ . Expenses for storage of spare parts are made up of losses from freezing the money, expenses for the warehouse keeping and the personnel wages. Generally, annual expenses on storage of part  $C$  can be presented as a share of its purchase cost  $S$  for the company. By denominating the ratio of profit from the part realization to its purchase cost as  $P$ , one can prove that increasing an average warehouse stock  $\bar{N}$  is expedient till the inequation is satisfied:

$$S \cdot C \cdot (\bar{N}_2 - \bar{N}_1) \leq S \cdot P \cdot (D_1 - D_2) \quad (1)$$

or

$$\frac{\Delta \bar{N}}{\Delta D} \leq \frac{P}{C} \quad (2)$$

where:

$\Delta D = D_1 - D_2$  – deficit decreasing, %;

$\Delta N = N_2 - N_1$  – increasing the average warehouse stock.

For the enterprise under consideration  $P = 30\%$  and  $C = 20\%$ , in view of  $\Delta D$  being reduced in percentage of an annual sales volume, and  $\Delta N$  is in days, we obtain:

$$\frac{\Delta \bar{N}}{\Delta D} \leq \frac{30}{100} \cdot \frac{360}{20} = 5.4 \quad (3)$$

Thus, proceeding from the table and formula (3), we obtain optimum parameters for the control system of spare parts supplies, namely  $N_{\min} = 25$ ,  $N_{\max} = 50$ , with the average warehouse stock  $\bar{N} = 26.8$ , deficiency  $D = 1.33\%$ , and grade of service  $U = 98.9\%$ .

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