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Determination of the Best Size of Fabrication Lot in Machine Building

"In keeping with the size of the fabrication lot, all parameters of the circulation of the objects of work are established: the length of the fabrication cycle, the period of the repetition of lots and the unfinished production stocks and these, in their turn, condition the size of the production lot. The lot influences the degree of utilization of the means of production and of man power. Consequently, "the lot" may be considered as a basis of operative scheduling of production in the machine building industry."

The organization of fabrication in lots is, in mass production, an objective necessity determined by the observance of the principles of parallelism, rhythmicity and continuity. The size of the fabrication lot is the main parameter of the unfolding of the production process in time and space. The essential criterion of determining the optimum fabrication lot is the minimization of determining the optimum fabrication lot is the minimization of production expenses per unit of product. The increase in the size of the fabrication lot is leading to a reduction of the cost price through a better use of production capacities and the decrease of unit expenditure for the preparation of fabrication. On the other hand, however, the increase in the lot of products is leading to the growth of the length of the production cycle, which contributes to increasing the various categories of stocks and to raising the level of immobilization of the circulating means.

In keeping with the dependence among various expenditures made in the fabrication of a product and the number of products in the lot, we distinguish the following kinds of expenditure:

1. Expenditure irrespective of the size of the fabrication lot; it is calculated with the aid of the relation:

$$Y_1 = c_m + c_s, \text{ lei/piece} \qquad (1)$$

where

c_m represents the cost of the objects of work, until the lot entering the respective processing stage, in lei/piece;

c_s represents the processing expenditure, in lei/piece and is given by the relation:

$$C_s = \left(1 + \frac{R_f}{100}\right) \sum_{i=1}^{k} \frac{t_{ui}}{60} \cdot S_{mi}$$

where

t_{ui} represents the unit time for each operation (i), in min./piece

s_{mi} — the tariff salary of workers according to the category of work for each operation (i), lei/piece;

R_f — the fabrication administration, of the section, in %;

k — the number of operations according to the technological process.

2. Expenditure depending on the size of the fabrication lot is made up of:

a) Expenditure made with the preparation — completion of fabrication and the administrative preparation of circulation of the lot; it is calculated in lei/lot according to the relation

$$A = \left(1 + \frac{\gamma}{100}\right) \sum_{i=1}^{k} \frac{t_{pc_i}}{60} \cdot m_i S_{ri} \tag{2}$$

where

t_{pc_i} represents the necessary time for the preparation — completion of work for each operation (i), in min/lot;

m_i — the number of machine-tools participating in the processing of the pieces in the lot;

s_r — the workers' salary according to the category of the work for the preparation-completion of fabrication, in lei/h;

γ — percentage representing expenditure with the administrative preparation of lot launching.

b) Expenditure for the upkeep of the equipment; it is calculated in lei/lot, with the aid of the formula:

$$B = \sum_{i=1}^{k} \frac{t_{pc_i}}{60} m_i a_i \tag{3}$$

where

a_i represents the hour quota of this expenditure.

Noting $C = A + B$, the quota of expenditure of the categories a) and b) per unit of product is:

$$Y_2 = \frac{C}{n} \tag{4}$$

where

n represents the size of the fabrication lot, in pieces;

C — expenditure linked with the immobilization of circulating means.

In keeping with the form of organization in time and space of the production process (successive, parallel or mixed), the average number of lots τ to be found simultaneously in fabrication (belonging to the same indi-

cator) and the annual losses (D) are calculated. They are determined with the aid of the relation (in lei/year):

$$D = (Y_1 \cdot n + C) \cdot \varphi \cdot \tau \cdot \varepsilon \tag{5}$$

where

φ represents the coefficient taking into consideration the variation of expenditure made in the production unfinished during the fabrication cycle.

The paper considers a uniform variation of fabrication expenditure during the fabrication cycle.

ε — the coefficient with the aid of which the loss in lei per one leu/year immobilized circulating means is determined.

The calculation relation of the average number of lots to be found simultaneously in fabrication (τ), for each form of organization (successive, parallel or mixed) is given in the calculation algorithm.

The afferent quota per unit of product of the expenditure related to the immobilization of the circulating means in lei/piece is obtained by referring the annual losses (D) to the annual volume of products (N)

$$Y_3 = \frac{D}{N} \tag{6}$$

The analytic expression of the production expenses (Y), in lei/piece in keeping with the dimension of the fabrication lot is

$$Y = Y_1 + Y_2 + Y_3 \tag{7}$$

The best size of the fabrication lot is its value (n) for which the fabrication expenses (Y) per unit of product are minimum. From the study of the derivates I and II of the function $Y = f(n)$ it results that the best sought size of the fabrication lot is:

$$n = \sqrt{\frac{2N_\lambda \cdot C}{(c_m + Y_1) \cdot \varepsilon \cdot \tau}} \tag{8}$$

The annual volume of pieces (N) of the indicator (λ) is given by the relation:

$$N_\lambda = \left(1 + \frac{\beta}{100}\right) \sum_{j=1}^{k} (q_j N_j + N_{s\lambda_j} + P_{s_j}) \tag{9}$$

where

N_j represents the volume of products in pieces/year;

$N_{s\lambda_j}$ — the volume of spare parts of the given indicator, in pieces/year;

$P_{s\lambda_j}$ — safety production, in pieces/year;

q_j — the number of parts of the same product;

β — the average percentage of technological reject;

p — the number of assortments in the plan.

Thus, the determination of the best lots on indicators requires the carrying out of complex calculations implying a considerable volume of work. Operatively, the calculation of the fabrication lots can be made with the aid of an electronic computer for all indicators $\lambda = 1, \ldots, u$ and all products. Therefore, we shall present in continuation the algorithm of determination of the best size of the fabrication lots in several steps.

1. The annual volume of parts (N_λ) is calculated for each indicator according to relation (9).

2. Independent expenditure (Y_1) is calculated according to relation (1).

3. Dependent expenditure (C) is calculated with relations (2), (3) and (4).

4. The annual nominal time fund, in d/year, is calculated with the relation:

$$F_n = Z_1 \cdot S_1 \cdot h \tag{10}$$

where

Z_1 represents working days per year;
S_1 — working shifts per day;
h — working hours per shift.

5. The average annual rate of fabrication in hours/pieces is calculated according to the relation:

$$r_m = \frac{F_n}{N_\lambda} \cdot \tag{11}$$

6. If the successive form of organization is requested, we pass on to step 7, if not, we pass on to step 8.

7. We calculate

$$\tau_s = \frac{1}{r_m} \sum_{i=1}^{k} \frac{t_{u_i}}{m_i k_i} \tag{12}$$

where: k_i represents the average coefficient for fulfilling the time norm of operation (i) and (n) is determined in the relation (8).

8. If the parallel form of organization is requested, we pass on to step 9, if not, we pass on to step 10.

9. We calculate

$$\tau_p = \frac{1}{r_m} \left[\max_{1 \leqslant i \leqslant k} \left(\frac{t_{u_i}}{m_i \cdot k_i} \right) \right] \tag{13}$$

and (n) is determined according to relation (8).

10. If the mixed form of organization is requested, we pass on to step 11, if not, we pass on to step 12.

11. We calculate

$$\tau_m = \frac{1}{r_m} \left[\sum_{i=1}^{k} \left(\frac{t_{u_i}}{m_i k_i} - \frac{t_{u_{i+1}}}{m_{i+1} \cdot k_{i+1}} \right) + \frac{t_{u_k}}{m_k k_k} \right] \tag{14}$$

on condition that the difference between the durations of the consecutive operations i and $i + 1$ should be positive, that is

$$\frac{t_{u_i}}{m_i \cdot k_i} + \frac{t_{u_{i+1}}}{m_{i+1} \cdot k_{i+1}} > 0$$

(n) is determined according to relation (8).

12. If this indicator is not the last one, we pass on to step 1 for the following indicator, if not, STOP.

The logical scheme of calculation of the best lot according to this algorithm is given in the figure.

Thus, the determination of the optimum lots on indicators requires complex calculations; taking into account the big number of indicators in

machine building, the solution to the problem is conditioned by the utilization of an electronic computer.

Based on the described algorithm and on the logical scheme, the respective programme was worked out in the FORTRAN IV language. The programme was tested on some indicators which are being mechanically processed at the "Autobuzul" and "Semănătoarea" plants. For example, for the indicator "STEERING SWIVEL BUS T.V.", the following data were given:

DATA CONCERNING PRODUCTION

These data are used for calculating the annual volume of products N, using relation (9). For the considered indicator we have: $p = 1$, $q_1 = 1$, $N_1 = 28{,}000$, $N_{s1} = 2000$, $P_{s_1} = 0$.

DATA CONCERNING THE TECHNOLOGICAL PROCESS

For the respective indicator, we have: $k = 15$ (the number of technological operations), $R_f = 166\,200$ %, $c_m = 64.00$, $\gamma = 14.3\%$, $\beta = 0.0\%$, the number of shifts per day 2.

After the automized effectuation of the calculations, the following values have resulted for the best lot:

a) successive organization — $n_s = 195$ pieces
b) parallel organization — $n_p = 510$ pieces
c) mixed organization — $n_m = 315$ pieces

K	t_{u_i}	s_{m_i}	t_{pc_i}	m_i	s_{r_i}	a_i	k_i
1	5,75	6,0	20,0	1	8,0	2,0	1,150
2	4,40	6,0	30,0	1	8,0	2,0	1,100
3	18,00	6,0	20,0	3	8,0	2,0	1,200
4	22,00	6,0	30,0	2	8,0	2,0	1,100
5	2,30	6,0	120,0	1	8,0	2,0	1,150
6	17,60	6,0	40,0	2	8,0	2,0	1,100
7	3,36	6,0	20,0	1	8,0	2,0	1,120
8	4,80	6,0	40,0	1	8,0	2,0	1,200
9	2,60	6,0	30,0	1	8,0	2,0	1,300
10	12,60	6,0	30,0	2	8,0	2,0	1,050
11	3,20	6,0	50,0	1	8,0	2,0	1,100
12	11,50	6,0	20,0	2	8,0	2,0	1,150
13	7,00	6,0	0,0	1	8,0	2,0	1,000
14	2,44	6,0	120,0	1	8,0	2,0	1,220
15	2,45	6,0	30,0	1	8,0	2,0	1,225

In contradistinction to the classical formula [1], [2], [4], [6] frequently met in the literature of speciality and largely used in the practice of the machine building works, the relation (8), inferred from the study, allows the differentiation of the optimum lot in keeping with the peculiarities of the technological process and of its form of organization; at the same time, it ensures a correct valuation of the average volume of circulating means and of the money losses caused by their immobilization.

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DETERMINATION DE LA GRANDEUR OPTIME DU LOT DE FABRICATION DANS LA CONSTRUCTION DES MACHINES

Dans l'article on présente certains problèmes de la détermination du lot optime de fabrication par la minimisation des dépenses pour la production par unité d'objet du travail. On établit les formules pour le calcul des dépenses, indépendant et dépendant de la grandeur du lot de fabrication.

Les formules pour le calcul de la grandeur optime du lot de fabrication permettent de differencier le lot optime par rapport aux particularités du processus technologique et de sa forme d'organisation (successive, possible, mixte). On expose aussi, l'algorithme du calcul du lot optime, programmé pour un ordinateur électronique, le schéma logique et un exemple pratique.

ОПРЕДЕЛЕНИЕ ОПТИМАЛЬНОЙ ВЕЛИЧИНЫ ПАРТИИ ПРОДУКЦИИ В МАШИНОСТРОЕНИИ

В настоящей статье рассматриваются вопросы определения оптимальной партии продукции путем минимизации производственных расходов на единицу предмета труда. Устанавливаются формулы для расчета расходов, не зависящих и зависящих от величины партии продукции.

Формулы для расчета оптимальной величины партии продукции повзоляют дифференцировать оптимальную партию в зависимости от особенностей технологического процесса и формы его организации (последовательной, возможной, смешанной). Приводятся также запрограммированный на электронном калькуляторе алгоритм расчета оптимальной партии, логическая схема и практический пример.