ON ONE METHOD FOR CONSTRUCTING AN ALGORITHM THAT MODELS A CERTAIN PRODUCTION PROCESS

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Fig. 1

Figure 1: Fig. 1

Abstract

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ON ONE METHOD FOR CONSTRUCTING AN ALGORITHM THAT MODELS A CERTAIN PRODUCTION PROCESS

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The analysis of individual mass-service systems is the subject of articles by N. P. Buslenko ([1]), G. P. Klimov and G. A. Aliev ([2,3]). In these works algorithms are constructed that well reflect the specific features of concrete production processes.

In the present note another method is proposed for formalizing production processes, one which, in our view, is more universal.

The operation of a mechanized section (Fig. 1) is modeled by simultaneously scanning all units at certain sufficiently small intervals of time Δt. This facilitates the formalization of the process, since its unfolding in time when modeled on an electronic computer corresponds to the real functioning of the system.

Fig. 1

Along conveyor I, parts of one type are transported successively to bins j ($j = 1, \dots, n$). The parts that have entered bin j may be processed by any of the m identical machines i, j ($i = 1, \dots, m$), each of which simultaneously processes q parts, after which they enter bins $n + j$ ($j = 1, \dots, n$). As conveyor II moves at certain intervals of time, parts from bins $n + j$ may simultaneously enter it and be delivered to bin $2n + 1$.

Each machine and conveyor may fail. The time of trouble-free operation of a machine or conveyor, as well as the time required for their repair, are random variables distributed according to prescribed laws.

Below is given the logical scheme of an algorithm modeling the operation of the described section. In addition to generally accepted notation (see ([4])), the following designations are used: t_I^r, t_{II}^r are the times at which conveyor stoppages end; M is the random time of trouble-free operation of a machine or of conveyor motion; N_j is the number of parts in bin j at the given moment t; N_j^0 is the capacity of bin j; $t^r_{i,j}$ is the time at which machine

i, j for processing the next batch; $\pi_{i,j} = 1$, a sign that machine i, j at time $t^r_{i,j}$ finishes processing the batch; u^k is the k-th group of s digits of logical scale I; v^l is the l-th digit of logical scale II.

$$\underset{58}{\downarrow} \ H_0 P_1(t^r_I < t) \ \underset{6}{\uparrow} \ P_2(M_I = 0) \ \underset{4}{\uparrow} \ A_3(t^r_I, M_I) \ \underset{5}{\uparrow} ; \ \underset{2}{\downarrow} \ A_3(M_I) \ \underset{3}{\downarrow} \ [u^k \to u^{k+1}(k \geq 1),$$

$$0 \to u^1]_5 \ \underset{1}{\downarrow} \ \{1 \to j\}_6 \ \underset{34}{\downarrow} \ 3_7(j) P_8(u^k_{j=i}) \ \underset{15}{\uparrow} \ P_9(N_j < N_j^0) \ \underset{12}{\uparrow} \ A_{10}(N_j)[0 \to u^k_j]_{11} \ \underset{15}{\uparrow} ;$$

$$\underset{9}{\downarrow} \ P_{12}(j < n) \ \underset{14}{\uparrow} \ [j+1 \to u^k]_{13} \ \underset{15}{\uparrow} ; \ \underset{12}{\downarrow} \ A_{14} \ \underset{8,11,13}{\downarrow} \ \{1 \to i\}_{15} \ \underset{22}{\downarrow} \ P_{16}(t^r_{i,j} = t) \ \underset{21}{\uparrow}$$

$$P_{17}(\pi_{i,j} = 1) \ \underset{21}{\uparrow} \ P_{18}(N_{n+j} \leq N^0_{n+j} - q + 1) \ \underset{20}{\uparrow} \ A_{19}(N_{n+j}) \ \underset{21}{\uparrow} ; \ \underset{18}{\downarrow} \ A_{20}(t^r_{i,j}) \ \underset{16,17,19}{\downarrow}$$

$$F_{21}(i) P_{22}(i = m+1) \ \underset{16}{\uparrow} \ O_{23}(i) P_{24}(N_j \geq q) \ \underset{32}{\uparrow} \underset{29}{\downarrow} \ P_{25}(\min t^r_{i,j} \leq t) \ \underset{32}{\uparrow} \ A_{26}(i_0)$$

$$P_{27}(M_{i_0,j} = 0) \ \underset{30}{\uparrow} \ A_{28}(t^r_{i_0,j}, M_{i_0,j})[0 \to \pi_{i_0,j}]_{29} \ \underset{25}{\uparrow} ; \ \underset{27}{\downarrow} \ A_{30}(t^r_{i_0,j}, M_{i_0,j}, N_j)[1 \to$$

$$\to \pi_{i_0,j}]_{31} \ \underset{24,25}{\downarrow} \ 3_{32}(j) F_{33}(j) P_{34}(j = n+1) \ \underset{7}{\uparrow} \ O_{35}(j) P_{36}(v^l_{2n+1} = 0) \ \underset{53}{\uparrow} \ P_{37}(t^r_{II} < t) \ \underset{56}{\uparrow}$$

$$P_{38}(M_{II} = 0) \ \underset{40}{\uparrow} \ A_{39}(t^r_{II}, M_{II}) \ \underset{41}{\uparrow} ; \ \underset{38}{\downarrow} \ A_{40}(M_{II}) \ \underset{39}{\downarrow} \ [v^l \to v^{l+1}(l \geq 1), \ 0 \to v^1]_{41}$$

$$A_{42}(\tau) P_{43}(\tau = v) \ \underset{52}{\uparrow} \ [0 \to \tau]_{44} \{1 \to j\}_{45} \ \underset{50}{\downarrow} \ P_{46}(N_{n+j} \geq 1) \ \underset{49}{\uparrow} \ A_{47}(N_{n+j})[1 \to v^{l\,n+j}]_{48}$$

$$\underset{46}{\downarrow} \ F_{49}(j) P_{50}(j = n+1) \ \underset{46}{\uparrow} \ O_{51}(j) \ \underset{43}{\downarrow} \ P_{52}(v^l_{2n+1} = 1) \ \underset{56}{\uparrow} \underset{36}{\downarrow} \ P_{53}(N_{2n+1} < N^0_{2n+1}) \ \underset{56}{\uparrow}$$

$$A_{54}(N_{2n+1})[0 \to v^l_{2n+1}]_{55} \ \underset{37,52,53}{\downarrow} \ H_{56} A_{57}(t) P_{58}(t \geq T_0) \ \underset{0}{\uparrow} \ \text{Я}_{59}.$$

We now turn to the description of the logical scheme of the algorithm given above. By operator H_0, parts numbered from 1 to n are fed onto conveyor I at random times t. Operator P_1 checks the serviceability of conveyor I in the time interval $[t - \Delta t, t)$. If the conveyor is serviceable, the possibility of its failure at the given moment t is analyzed (operator P_2). If a breakdown of conveyor I has occurred, then operator A_3 determines the random time t^r_I at which it will be ready, and a new value M_I is generated for the time of trouble-free operation of conveyor I until the next breakdown. If at time t conveyor I is serviceable, then operator A_4 decreases the value M_I by Δt and transfers control to operator 5. The operation of the conveyor is imitated by means of logical scale I, each s ($2^s > n$) digits of which correspond to definite positions on the conveyor, and its motion (operator 5) is effected by shifting this scale. Each group of s digits may contain the number of the bin into which the given part is to be loaded. Operator 3_7 enters, in the standard cells, information on bins j, $n + j$ and machines i, j ($i = 1, \dots, m$). If a part is on conveyor I opposite bin j (this position corresponds to the k_j-th group of digits of logical scale I), then, if there is room in it (operator P_9), the part is loaded into the bin (operators A_{10} and 11). If bin j is full, then the part is assigned for loading into bin $j+1$ (operator 13). Operator A_{14} determines losses whose cause is the absence of a free place in bin n when a part approaches it. If, at the moment t under consideration, machine i, j finishes processing parts (P_{16} and P_{17}), then the possibility of loading them into bin $n+j$ is checked (operator P_{18}); this loading is carried out by operator A_{19}. If in bin $n+j$ there is no room for q parts, then machine i, j is forced to stand idle, and operator A_{20} increases the value of $t^r_{i,j}$ by Δt. If there are q parts in bin j (operator P_{24}) and at least one free machine i, j $(i = 1, \ldots, m)$ (operator P_{25}),

the number i_0, j of the machine with the minimum readiness time (A_{26}) is determined. Operator P_{27} checks whether a breakdown of machine i_0, j occurs at time t, and, in the event of a breakdown, the random time $t^r_{i_0,j}$ at which the repair ends is determined, as well as the random time $M_{i_0,j}$ of trouble-free operation of the machine until the next breakdown (A_{28}). If no breakdown occurs at time t, then operator A_{30} loads the machine: the time $t^r_{i_0,j}$ at which machine i_0, j is freed from processing parts is determined, the quantity $M_{i_0,j}$ is decreased by the processing time of the batch, and the current capacity of hopper N_j is decreased by q. Operator 3_{32} performs a return from the standard cells of the information entered earlier by operator 3_7.

The presence of parts in front of hopper $2n+1$ indicates that at the moment $t - \Delta t$ this part had not been loaded into the hopper and that in the interval $[t - \Delta t, t)$ conveyor II was idle. In this case operator P_{36} transfers control to operator P_{53}. Simultaneously with the motion of conveyor II (operator 41), the time τ is counted off (operator A_{42}), and every v seconds (operator P_{43}) parts from all hoppers $n+i$ $(i = 1, \ldots, n)$ are fed onto conveyor II (operators $P_{46}, A_{47}, 48$). If a part has approached hopper $2n+1$ (operator P_{52}), then, if there is free space in it (P_{53}), the part is transferred from conveyor II (operator 55) into the hopper (operator A_{54}). Further, hopper $2n+1$ may be unloaded (operator H_{56}), and a new value of t is generated (operator A_{57}).

Satisfaction of the inequality $t \geq T_0$ is the sign that the work has ended.

The algorithm considered, which simulates the operation of a mechanized section (Fig. 1), makes it possible to carry out a broad analysis of the given technological process and to solve the following problems:

1. To evaluate the structure of the system under study and choose the optimal composition of the equipment.

2. To determine the optimal operating modes of the equipment on the basis of an analysis of the system' s productivity, the product-quality indicator, the reliability of the equipment, and other characteristics.

3. For given values of the system parameters, to calculate its production capabilities taking random factors into account.

4. To evaluate the influence of deviations of the system parameters on its functioning.

Solving the indicated problems on an electronic computer by the Monte Carlo method will make it possible to determine the technical-economic level of the section under study according to the main criterion: the cost of the technological operation.

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3. G. P. Klimov, ibid., p. 935.

4. A. A. Lyapunov, *Problems of Cybernetics*, no. 1, 1958, p. 46.

Note: Figure translations are in progress. See original paper for figures.