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RESEARCH OF THE VARIATION OF FIRMNESS OF POINTED DRILLS BY METHOD OF SIMULATION MODELING OF PROCESS OF WEAR

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ABSTRACT---*The analytical analysis of flat drills stability variation at opening processing in structural steels is considered. The technique and software for research, of tools stability variation by method of simulation modeling is developed. It is shown that at given modes of processing, average value of stability decreases with ascending of bars hardness variation level. the received expression allows to determine quantity of openings* Z_x *drilling by one tool before its blunting at a variation of hardness of material of raw material by the set distribution law and at the set modes of cutting of* V_1 *and* S_1

Keywords---*processing of metals cutting, an axial tool, empirical models, a numerical experiment, a hardness variation, wear resistance.*

I. INTRODUCTION

Nowadays there is a significant progress in the theory and practice in the field of technologist and machining of details by creation of new tool materials. Improvement of geometry of the tool and construction of machines is one of the important issues is the workability of cutting depending on a great number of factors as dispersion of firmness approximately for 50% is explained by a variation of dimensional parameters of tools even at their compliance to

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requirements of GOST standards. As practice shows, a half of the cases of instability of cutting tools' quality occurs owing to a variation of the sizes, and other half - owing to metallurgical errors [5, 6, 11].

Usually the operability of the drilling tool under standard conditions of processing is estimated experimentally on number of the processed openings before final fracture of the cutting edges. It is rather expensive and can lead to the wrong outputs.

An essential lack of these methods of a research is also that one combination of experimental values of cutting speed and giving cannot give information on how the firmness of a drill at minor change of these parameters will change. Thus, construction of a drill, a grade of material of the cutting part or a type of heat treatment that under some experimental conditions provide the maximum working capacity under other experimental conditions can correspond to the minimum working capacity. Similar provisions arise when the classical equation of Taylor is reliable, but exponents of this equation differ and respectively the simple tolerance equation is inapplicable for drilling process evaluation. Therefore, results of short-term tolerance tests with marginal conditions of cutting cannot be applicable for assessment of operability of drills under production conditions [1, 3, 6, 10]. In reference books and standards for the modes of cutting considerable is saved up and generalized in the form of empirical degree dependences experimental material on processing of different materials drills of different construction. Therefore, development of a technique of using this information is great practical interest to assessment of dispersion of toolfirmness under different conditions of its operation [3-6]. The analysis of the known tolerance dependences shows that it is directly impossible to evaluate parameters of dispersion of firmness of the tool from empirical process models of drilling as this dependence does not reflect internal communications between factors, and considers only average result of joint impact of separate factors on firmness of the tool. Additional information on the nature of process of wear of the tool when processing big an array of openings can be obtained, but to techniques of simulation modeling of implementation of wear in the course of machining [2-3, 5-6].

II. METHODOLOGY

Drilling process by one tool is possible until the value of the saved-up wear did not reach critical value, i.e.

$$\sum_{i=1}^{z_x} \overline{h_{HBi}} \leq h_{kp} \qquad (1)$$

Wherez_x - quantity of the openings processed by one drill until achievement of wear of h_k; h_{HBi} - the value of average wear of a drill when processing an opening in preparation with HB hardness.

The quantity of openings of z_x drilled by one tool before its flooding at a variation of hardness of material of preparations on the set distribution law and at the set modes of cutting of V_k and S_k can be defined from expression:

$$\sum_{i=1}^{z_x} (HB)^{n/m} \leq C \cdot (V_k^{m-1} \cdot S_k^{m-y})^{1/m} \qquad (2)$$

The HB_i (2) parameter represents a random element from the sequence of the numbers imitating the distribution law of firmness of preparation in kit of parts. At the same time selection of an element is carried out without repetitions (the selected element is removed from the sequence of numbers). The value of firmness is defined by expression:

$$T_i = Z_x \cdot t_{osn} \qquad (3)$$

Where t_{osn}, - the main time of processing of an opening.

The program for personal computer that is carrying out process of simulation of tests of drills when processing preparations from steel 45 at change of firmness of preparations on the set law is developed for implementation of a numerical experiment [3, 4, 12, 13, 15].

For carrying out a simulation experiment, it is necessary to prepare the basic data including:

- Parameters of an empirical process model of drilling;
- The recommended range of giving (45 tools with BK8 hard alloy became S_{min}, S_{max}) for processing.

Conditions restriction for productivity of operations of drilling, according to process requirements for definition by the program of range of cutting speeds (V_{min} ,V_{max}), lie in limits:

$$t_{osn} \leq 1{,}2 \min T_{iSRmin} \geq t_{ost} \qquad (4)$$

Where T_{iSRmin} - the minimum firmness of the tool in a point (V_i, S_i) spaces of the modes of cutting.

Sampling tests of drills for each batch of preparations (9 drills are tested) when drilling preparations with three different hardness of HB_{min}, HB_0, HB_{max} for definition of type of dependence of wear from time were carried out.

According to the developed technique, 20 series of experiments with testing in each series of the first batch of tools in number of 25 pieces for the purpose of impact on assessment of random waves of hardness of material of preparation are conducted to kits of parts. However, to the normal law on a variation of firmness of the tool and to change of power parameters of process of cutting of P_0, M_{kp}, and N_{eff}.

Experiments were made for operating conditions of pointed drills with plates from BK8 when processing deaf openings with a diameter of 25 mm of steel 45 on depth of 75 mm. The variation of firmness of preparations in lot of products made Var HB=0%; 5%; 10%; 15%; 20% at the same average of values of hardness of HB0 = 2235 MPas, corresponding for steel 45 in accordance with GOST 22761-77 and to value σ_B =610 MPa.

In figure 1, the diagrams of change of a variation of firmness of pointed drills depending on change of the modes of cutting constructed by results of simulation modeling of implementation of wear in processing of openings are submitted.

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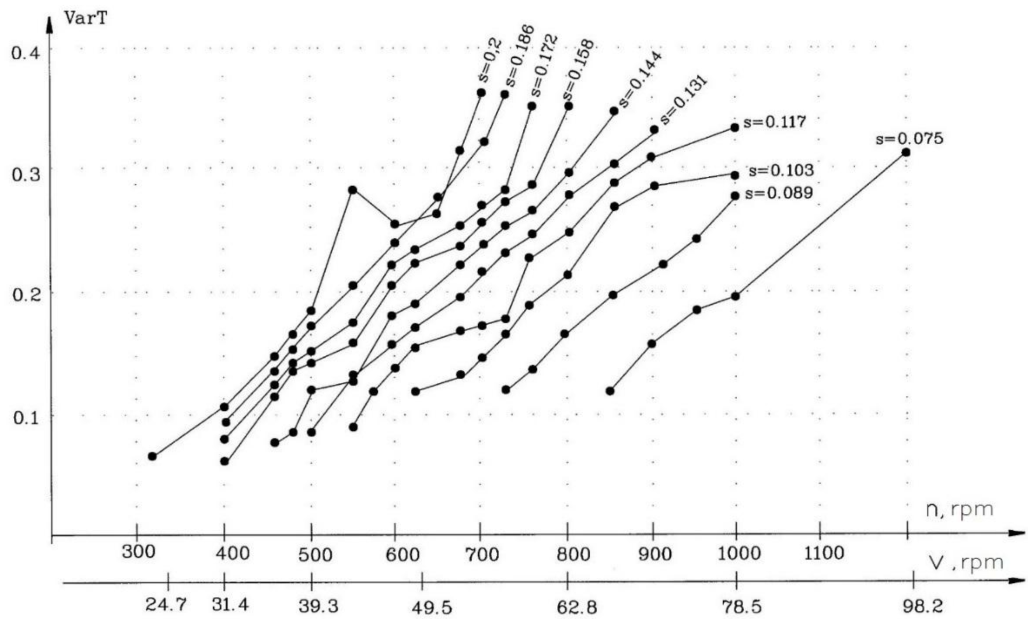

Figure 1. Dependence of a variation of firmness of drills on the cutting modes. Results of simulation modeling of processing of structural steel($\sigma_{в}$=610 MPa; HBo=2235 MPa; VarHB=20%) pointed drills with plates from BK8

III. RESULTS AND DISCUSSIONS

The analysis of the obtained design data allows noting that at the set VarHB level the variation of firmness of drills increases with increase in the modes of cutting. At the set cutting modes V and S mean value of firmness decrease with increase of level of a variation of firmness of preparations (VarHB). However, relative change of a variation of firmness of tools is small in comparison with similar relative change of a variation of firmness of preparations [19, 20].

The value of average firmness falls along with increase in a variation of firmness, at practical operation of the tool under production conditions it leads to the fact that the unreasonable intensification of the modes of cutting leads to rapprochement of the lower and upper borders of an interval of admissible change of firmness.

In figure 1 the flowchart of a technique of calculations of the modes of cutting when drilling openings is submitted. Seven stages of a new technique follow from this flowchart [4, 16, 17, 18].

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Start

Input (reading) of basic data

- processed material
  D, L, ofe, HBo, VarHB, K_r , A_1 A_2, n, zN%
- Parameters of an empirical process model of drilling
  C_v, q, *y,* m, Cp, CM, KMP, ym, yp, XM, Xp.
- Data on the used tool *
  TipKonIns$, Mins$, hкр, Fед.и, Tpiece, TIpModIn%, V_T, Nin, Nser
- Data on the used equipment
  Machine model, [POmax], [Mkmax], [Nmax], FeD.st, C1st.min
  s=<sl, s2, s3, ... , sl>, 1=1, ns
  n=<nl, n2, n3, ... , nj>, J=l, nv
- The recommended range of the modes of cutting for practical use under the set conditions
  (sRmin, sRmax) и (VRmin, VRmax)
- Technical requirements and restrictions to technological process and drilling operation
  TipPRS – type of production,
  nSM - number of shifts a day
  T1SM – duration of the 1st shift in minutes
  PRDG - Necessary program of release of details <piece>, T
  PRDG - time, released on execution of program details (day),
- Restrictions for the range of change of replaceable productivity of operation of drilling (Hsmv_min, Hsmv_max)
- Restrictions for the range of change of the working tool batch resources (Rins_min, Rins_max)

Restrictions for the range of cost change of processing of an opening for drilling operations!
  (C1opn_min, C1opn_max)

Stage 1. Definition of the allowed borders of change of the main technological time

(PROG, TPROG, nSM) — (t_{piece}_min , t_{piece}_max) – (-tosn_min, -tosn_max)

$$tosn\_min = \frac{T1SM\ TPRDG\ nSM}{PRDG\ (1+EPSsmax)} \qquad tosn\_max = \frac{T1SM\ TPRDG\ nSM}{PRDG\ (1+EPSsmin)}$$

2

1

Stage 2. The choice of level of reliability at operation of drills

Level of reliability of p (probability of trouble-free operation) of operation of the tool is selected:

p=0.95	-	on automatic transfer lines at almost deserted technology,
p= 0.92	-	on CNC machines, the processing centers,
p= 0.9	-	at multimachine service,
p= 0.8	-	in line mass production on a general purpose equipment,
p= 0.5	-	in single production on a general purpose equipment.

Stage 3. Definition of a set admissible giving {$s_{доп}$}

1) $s_{1д}$	-	the maximum allowed feed motion from a drill durability condition,
2) $s_{2д}$	-	the maximum allowed feed motion from a condition of durability of the feed motion's mechanism of the machine,
3) $s_{3д}$	-	the maximum allowed feed motion from a condition of durability of the mechanism of the main movement of the machine,
4)		$s_{max\_д} = min\{s_{1д}, s_{2д}, s_{3д}, \dots, s_{kд}\}$
5)		Definition set of admissible giving as products of sets of giving (s^R_{min}, s^R_{max}), $s_{max\_д}$ and $\{s_1, s_2, s_3, \dots, s_i\}$ $\{s_{доп}\}=\{s_1, s_2, s_3, \dots, s_r\}$

Stage 4. Definition of a set of admissible cutting speeds

Set of admissible cutting speeds $\{V_{доп}\}$ find taking into account the recommended range of speeds(V^R_{min}, V^R_{max}), a number sequence of the turns of a spindle provided with kinematics of the machine and a set of admissible feed motion $\{s_{доп}\}$, satisfying to the set restrictions for process productivity. At the same time include only those cutting speeds which provides in a set $\{V_{доп}\}$

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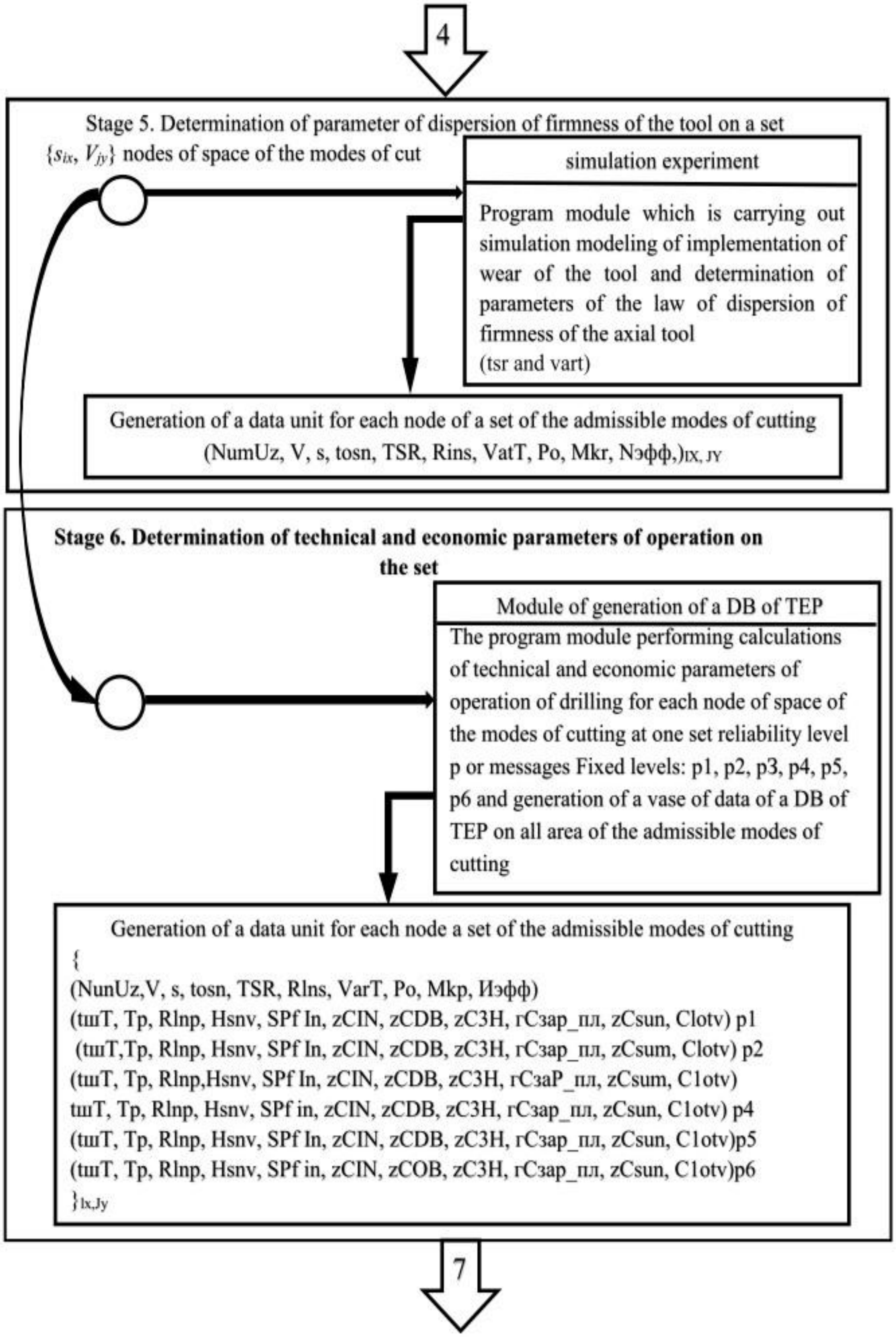

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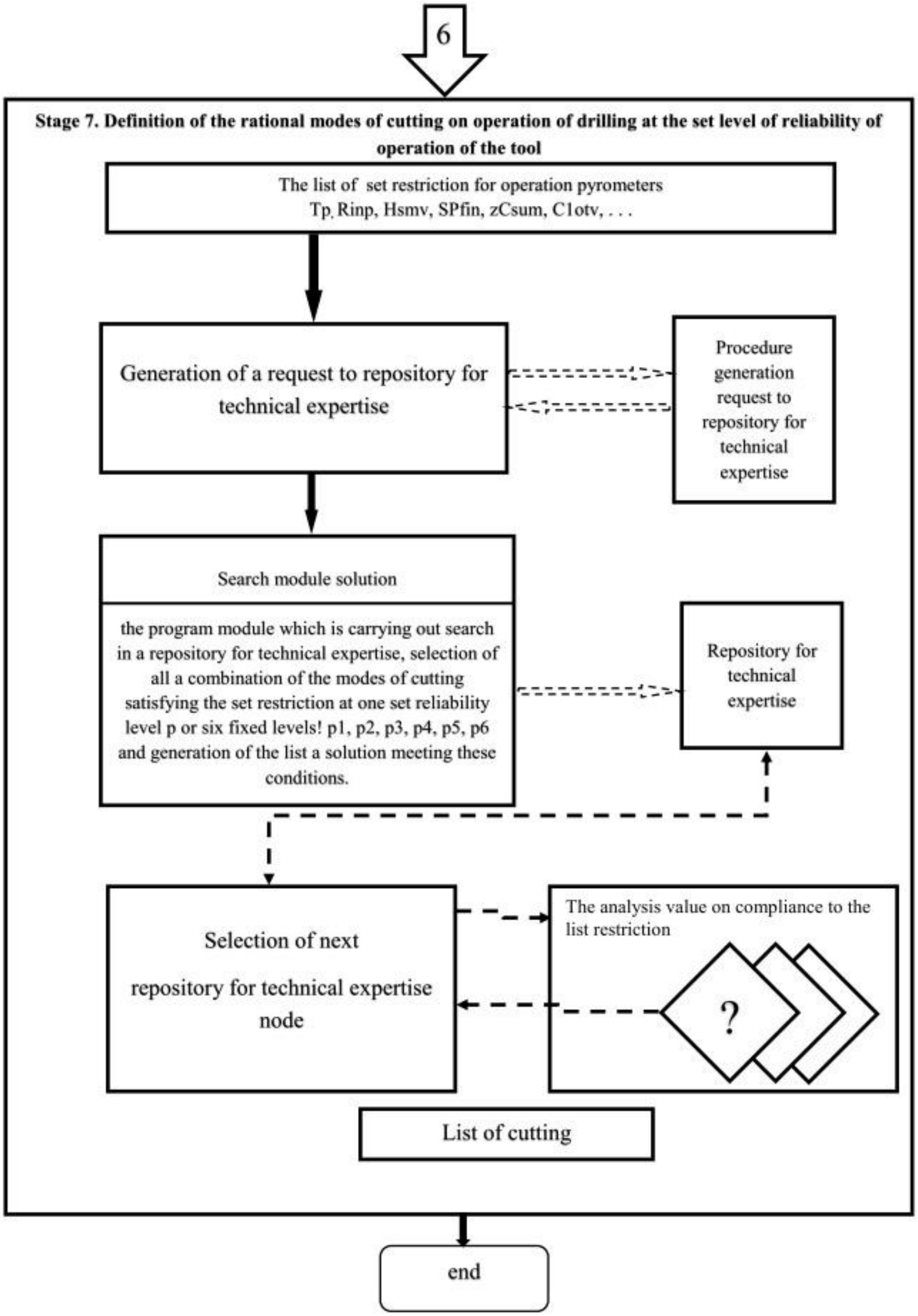

Figure 2. Sequence of Definition of the Modes of Cutting providing the set probability p trouble-free operation of the axial tool in the presence of the limiting factors.

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Stage 1. Definition of the allowed borders of change of the main technological time

Proceeding from the PROG program of release of details, the set time of T_{PROG} of execution of a task and amount of shifts of n_{SM} in day, borders of change of the main time are determined by the scheme

$$(PROG,\ T_{PROG},\ n_{SM}) \rightarrow (t_{piece\_min},\ t_{piece\_max}) \rightarrow (t_{osn\_min},\ t_{osn\_max}) \qquad (5)$$

Necessary average replaceable productivity (median number of the details processed for one shift) providing release of the PROG program of details for preset time of T_{PROG} can be determined as

$$\overline{H_{smv}} = \frac{PROG}{T_{PROG} \cdot n_{SM}} \qquad (6)$$

According to dependences $T_{piece} = t_{osn} \cdot (1 + eps + \frac{t_{sin}}{T})$ and $H_{SMV} = \frac{492}{T_{piece}}$ it is possible to write

$$\overline{H_{smv}} = \frac{T_{ISM}}{T_{piece}} = \frac{T_{ISM}}{t_{osn} \cdot (1 + eps + t_{sin}/T)} \qquad (7)$$

From the Eq.(6) and Eq.(7), accepting T_{1SM} = 492 min and neglecting the value t_{sin}/T in expression Eq.(7) as very small in comparison with eps we will receive

$$t_{osn} \approx \frac{492 \cdot T_{PROG} \cdot n_{SM}}{PROG \cdot (1+eps)} \qquad (8)$$

Setting borders of change of eps: eps_{min} and eps_{max} taking into account specific conditions of production, we will receive expressions for assessment of borders of change of the main technological time for operations of drilling taking into account ensuring the set productivity

$$t_{osn\_min} = \frac{492 \cdot T_{PROG} \cdot n_{SM}}{PROG \cdot (1+eps_{max})};\ t_{osn\_max} = \frac{492 \cdot T_{PROG} \cdot n_{SM}}{PROG \cdot (1+eps_{min})} \qquad (9)$$

Stage 2. The choice of level of reliability at operation of drills

Level of reliability of p(probability of trouble-free operation) of operation of the tool can be selected on the basis of design data for economic reasons, or be set proceeding from requirements to operation:

p= 0.95 - on automatic transfer lines at almost deserted technology,

p= 0.92 - on CNC machines, the processing centers,

p= 0.9 - at multi machine service,

p= 0.8 - in line mass production on a general purpose equipment,

p= 0.5 - in single production on a general-purpose equipment.

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Stage 3. Definition of a set admissible giving {s_{adm}}

Based on data on the tool, the equipment, normative data and data of reference books we determine the maximum allowed giving for processing of openings in this material by the instrument of the set construction and a standard size. The maximum allowed giving needs to be selected similarly, as well as in a traditional way proceeding from restrictions for giving:

$s_{1\partial}$ – the maximum allowed giving from a drill durability condition,

$s_{2\partial}$– the maximum allowed giving from a condition of durability of the mechanism of giving of the machine,

$s_{3\partial}$ – the maximum allowed giving from a condition of durability of the mechanism of the main movement of the machine,

The maximum allowed giving is defined as

$$s_{max\_\partial} = min\{s1\partial, s2\partial, s3\partial, \dots , sk\partial\} \qquad (10)$$

Considering s^R_{min}, s^R_{max}, s_{max}_d and { s_1, s_2, s_3..., s_i } - a number sequence of the feed motion provided with machine kinematics set a set of admissible feed motion

$$\{s_{adm}\}=\{s_1, s_2, s_3, \dots , s_r\} \qquad (11)$$

where s_r - the greatest feed motion from a number of feed motion provided with kinematics of the machine and meeting a condition of $s_r \leq s_{max\_\partial}$, and each element of a number of feed motions to conditions: $s^R_{min} \leq s_i \leq s^R_{max}$

Stage 4. Definition of a set of admissible cutting speeds

Set of admissible cutting speeds {V_{adm}} find in the following sequence:

- considering the range of the recommended speeds of V^R_{min}, V^R_{max} and a number sequence of the turns of a spindle of the machine provided with kinematics of the machine determine a number of cutting speeds: {V_j} = {$\pi \cdot D \cdot n_j$ /1000 }, where j=1, n_j - meeting conditions: $V^R_{min} \leq V_j \leq V^R_{max}$;

- using dependence $t_{osn} = \pi \cdot D_{om} \cdot \frac{L_{opn} + L_b}{s} \cdot n$ by method of consecutive search of feed motion from a row {s_{adm}} and cutting speeds from {V_j} discard all those cutting speeds from a row {V_j} which do not provide execution of conditions:

$$t_{\text{osn\_min}} \leq t_{osn} \leq t_{\text{osn\_max}} \qquad (12)$$

As a result of execution of the first four stages we receive ordered sets of admissible feed motion {s_{adm}}= {s_1, s_2, s_3, ... , s_k} and admissible cutting speeds {V_{adm}}= {V_1, V_2, V_3, ... , V_{sv}}. $k \cdot sv$ of pair combinations defines a set of nodes of space of the modes of cutting {s_{ix}, V_{jy}}, $ix=1,k$ and $jy=1,sv$ satisfying to a ratio Eq.(12).

Stage 5. Determination of parameter of dispersion of firmness of the tool on a set {s_{ix},V_{jy}} nodes of space of the modes of cutting

By means of the program's module which is carrying out simulation modeling of implementations of wear of the tool determine parameters of the law of dispersion of firmness. And this law for the axial tool (T_{SR} and VarT) for each node of

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space of the modes of cutting $\{s_{ix},V_{jy}\}$ at dispersion of hardness of material of preparations by the normal distribution law with parameters $(HB_o,VarHB)$. As a result for each node, Uz(ix, jy)= $\{s_{ix},V_{jy}\}$ spaces of the modes of cutting the module generates a data unit:

$$(NumUz,V, s, t_{osn}, T_{SR}, R_{ins}, VarT, P_o, M_{кр}, N_{эфф})_{ix, jy} \qquad (13)$$

The representing set of input data for the module calculating technical and economic parameters of operation of drilling. Data sets in the form of the sequence of records save in work files of data.

Stage 6. Determination of technical and economic parameters of operation on the set $\{s_{ix},V_{jy}\}$ nodes of space of the modes of cutting

Determine parameters of operation of drilling for each node of space of the modes of cutting by the module of the program performing calculations of technical and economic parameters $\{s_{ix}, V_{jy}\}$ at the set level p of reliability of operation of the tool, or (if this level is not determined yet) at reliability levels: $p_1=0.95$; $p_2=0.90$; $p_3=0.8$; $p_4=0.7$; $p_5=0.6$ and $p_6=0.5$.

The module creates for each node of a grid $\{S_{ix},V_{jy}\}$ a complex of data $K_{Dix, jy}$ including the following data elements:

$$\begin{aligned}
\{ \quad &(NumUz,V, s, t_{osn}, T_{SR}, R_{ins}, VarT, P_o, M_{кр}, N_{эфф})\\
&(t_{piece},T_p,R_{inp},H_{smv},SP_{fin},zC_{IN},zC_{OB},zC_{ЭН},zC_{зар_пл},zC_{sum},C1_{opn})_{p1}\\
&(t_{piece},T_p,R_{inp},H_{smv},SP_{fin},zC_{IN},zC_{OB},zC_{ЭН},zC_{зар_пл},zC_{sum},C1_{opn})_{p2}\\
&(t_{piece},T_p,R_{inp},H_{smv},SP_{fin},zC_{IN},zC_{OB},zC_{ЭН},zC_{зар_пл},zC_{sum},C1_{opn})_{p3}\\
&(t_{piece},T_p,R_{inp},H_{smv},SP_{fin},zC_{IN},zC_{OB},zC_{ЭН},zC_{зар_пл},zC_{sum},C1_{opn})_{p4}\\
&(t_{piece},T_p,R_{inp},H_{smv},SP_{fin},zC_{IN},zC_{OB},zC_{ЭН},zC_{зар_пл},zC_{sum},C1_{opn})_{p5}\\
&(t_{piece},T_p,R_{inp},H_{smv},SP_{fin},zC_{IN},zC_{OB},zC_{ЭН},zC_{зар_пл},zC_{sum},C1_{opn})_{p6} \quad \}_{ix, jy} \qquad (13)
\end{aligned}$$

Where k=1 - 6 - the index corresponding to BD_{pk} data unit in Eq.(13) concluded in parentheses and containing the list of the data calculated by the module at value of probability of trouble-free operation of the $p=p_k$ tool.

ix, jy - the indexes corresponding to a complex of data $KD_{ix, jy}$ in Eq.(13) concluded in curly brackets and containing the list of data units BD_{pk} at change of k from 1 to 6.

The set of complexes of data of $KD_{ix, jy}$ for each node of a grid $\{S_{ix},V_{jy}\}$ saves the module in the form of the sequence of entries in the work file with the set name, representing the repository for technical expertise dynamic database with records of variable structure (the number of the considered levels of reliability can change).

The received DB then is used for definition of the rational modes of cutting depending on the set optimality criterion and the set system of technical and economic restrictions.

Stage 7. Definition of the rational modes of cutting on operation of drilling at the set level of reliability of operation of the tool

By means of the module of the program which is carrying out the choice of the modes of cutting carry out search of combinations of the modes (s_{ix} and V_{jy}), answering to the set of conditions (restrictions) at the set level p of reliability of

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operation of the tool, or (if this level is not determined) at 6 fixed reliability levels: $p_1=0.95$; $p_2=0.90$; $p_3=0.8$; $p_4=0.7$; $p_5=0.6$ and $p_6=0.5$.

The module carries out search and the module carries out data sampling from repository for technical expertise by method of full search of all nodes of space of the admissible modes of cutting Uz(*ix*, *jy*) the set conditions (restrictions) written in the database and checks of each node on compliance of set. In figure 2 the enlarged flowchart of the module of the program which is carrying out search and data sampling from a DB(database) is submitted.

In the course of search of a solution, the module creates the list of nodes of the set restrictions satisfying sets. At the same time, there can be three cases:

a) The list of nodes (number of solutions) consists of one element. In this case the set of restrictions satisfies only one combination (*s, V*), being the only solution.

b) The quantity of nodes in the list exceeds unit. In this case the set of restrictions satisfies a set of combinations (s_i, V_j), each of which can be accepted as a solution.

c) The list of nodes (number of solutions) does not contain any element, i.e. Nil is. In this case the set of restrictions does not satisfy any node of space of the admissible modes of cutting U_z (*ix*, *jy*), i.e. the objective has no solution at the set of restrictions.

Examples of calculations of the modes of cutting by a new technique

By the developed technique databases for definition of the modes of cutting on operation of drilling of a deaf opening of ∅25 mm and L=75 mm in depth in steel 12X18H10T. Instruments of three different constructions generated them: spiral drills from P6M5, pointed drills with plates from BK8 and drills with MNS structure equipped with trihedral throwaway plates from T15K6.

Basic data, results of simulation modeling of wear of drills and the generated repository for technical expertise for each construction of the tool are presented in table 1 application.

In table 4 the sequence of forming of a repository for technical expertise according to the technique described above is shown, examples of definition of the rational modes of cutting corresponding to different sets of technical and economic restrictions to drilling operation are presented in tables 1 - 2 As an example 8 different systems of technical and economic restrictions for definition of the modes of cutting for levels of reliability of operation 0.95 are considered; 0.90 and 0.80 for each type of the considered tool:

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Initial set of the modes of cutting

definition of a set of the modes of cutting of an(V_i, S_i) satisfying to the set operation productivity diapason

1

ii	n	V	S
1	60	4.81	0.150
2	60	4.81	0.200
3	60	4.81	0.250
4	60	4.81	0.300
5	60	4.81	0.350
6	80	6.41	0.150
7	80	6.41	0.200
8	80	6.41	0.250
9	80	6.41	0.300
10	80	6.41	0.350
11	100	8.01	0.
12	100	8.01	0.200
13	100	8.01	0.250
14	100	8.01	0.300
15	100	8.01	0.350
16	160	12.82	0.150
17	160	12.82	0.200
18	160	12.82	0.250
19	160	12.82	0.300
20	160	12.82	0.350
21	200	16.02	0.150
22	200	16.02	0.200
23	200	16.02	0.250
24	200	16.02	0.300
25	200	16.02	0.350
26	250	20.03	0.150
27	250	20.03	0.200
28	250	20.03	0.250
29	250	20.03	0.300
30	250	20.03	0.350
31	300	24.03	0.150
32	300	24.03	0.200
33	300	24.03	0.250
34	300	24.03	0.300
35	300	24.03	0.350
36	350	28.04	0.150
37	350	28.04	0.200
38	350	28.04	0.250
39	350	28.04	0.300
40	350	28.04	0.350
41	400	31.41	0.150
42	400	31.41	0.200
43	400	31.41	0.250
44	400	31.41	0.300
45	400	31.41	0.350
46	450	35.34	0.150
47	450	35.34	0.200
48	450	35.34	0.250
49	450	35.34	0.300
50	450	35.34	0.350

2

tosn
~~0.16~~
~~6.12~~
~~4.90~~
~~4.08~~
~~3.50~~
~~6.12~~
~~4.59~~
~~3.68~~
~~3.05~~
~~2.62~~
~~4.90~~
~~3.60~~
~~2.94~~
~~2.45~~
2.10
3.06
2.30
1.84
1.53
1.31
2.45
1.84
1.53
1.31
2.45
1.84
1.47
1.23
1.05
1.96
1.47
1.18
0.98
0.82
~~0.70~~
~~1.40~~
~~1.05~~
~~0.84~~
~~0.70~~
~~0.60~~
~~1.25~~
~~0.94~~
~~0.75~~
~~0.63~~
~~0.54~~
~~1.11~~
~~0.83~~
~~0.66~~
~~0.56~~
~~0.48~~

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Figure 3.

Table 1. Result of work of programming module of the parameter of dispersion of firmness of the axial tool implementing a simulation experiment by definition

i	i		V	S n	tos in	F sr	T k	o	F eff	N	vThb
5	1 00		8.01 350	0. 100	2. 46	4 8.4	93 3	193	6 .87	0	0.126
6	1 60	2	12.8 150	0. 060	3. 58	1 6.5	48 1	725	3 .69	0	0.136
7	1 60	2	12.8 200	0. 300	2. 18	1 3.6	27 2	427	4 .87	0	0.143
8	1 60	2	12.8 250	0. .840	1 5	9 5.1	17 3	061	5 .05	1	0.151
9	1 60	2	12.8 300	0. .530	1 9	7 1.6	12 3	646	5 .22	1	0.167
0	2 60	2	12.8 350	0. .310	1 8	6 .4	89 3	193	6 .39	1	0.78
1	2 00	2	16.0 150	0. 450	2. 5	6 9.7	15 1	725	3 .86	0	0.180
2	2 00	2	16.0 200	0. 840	1. 8	4 .8	89 2	427	4 .09	1	0.185
3	2 00	2	16.0 250	0. 470	1. 9	3 .5	57 3	061	5 .31	1	0.192
4	2 00	2	16.0 300	0. 230	1. 2	3 .9	39 3	646	5 .53	1	0.199
5	2 00	2	16.0 350	0. 050	1. 7	2 .3	29 3	193	6 .73	1	0.204
6	2 50	3	20.0 150	0. 960	1. 6	2 .3	52 1	725	3 .07	1	0.211
7	2 50	3	20.0 200	0. 470	1. 9	1 .4	29 2	427	4 .36	1	0.216
8	2 50	3	20.0 250	0. 180	1. 5	1 ,8	18 3	061	5 .64	1	0.221
9	2 50	3	20.0 300	0. 980	0. 3	1 . 1	13 3	646	5 .91	1	0.227
0	3 50	3	20.0 350	0. 840	0. 1	1 6	9. 3	193	6 .17	2	0.232
1	3 00	3	24.0 150	0. .630	1 2	1 .0	21 1	725	3 .29	1	0.212
2	3 00	3	24.0 200	0. 230	1.	9 .8	11 2	427	4 .63	1	0.217
3	3 00	3	24.0 250	0. 980	0.	7 6	7. 3	061	5 .97	1	0.226
4	3 00	3	24.0 300	0. 820	0.	6 3	5. 3	646	5 .29	2	0.232
6	3 50	4	28.0 150	0. 400	1.	6 7	9. 1	725	3 .50	1	0.215

Table 2. Repository for technical expertise– result of operation of the module of determination of technical and economic parameters of operation of drilling

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i		ı	V	S	tosn	in	sr	k		Po f	Nef T	Var
5	00	:	8.01 0	0.35	2. 100	46		938.4 3	93	61 7	0.8 .304	0
6	60	:	12,82 0	0.15	3.060	58		486.5 1	25	37 9	0.6 9	0.30
7	60	:	12.82 0	0.20	2.300	18		273.6 2	27	44 7	0.8 .312	0
8	60	:	12.82 0	0.25	1.840	5		175. 1 3	61	50 5	1.0 .316	0
9	60	:	12.82 0	0.30	1.530	9		121.6 3	46	56 2	1.2 .325	0
0	60	:	12.82 0	0.35	1 .310	8		89. 4 3	93	61 9	1.3 .331	0
1	00	:	16.02 0	0.15	2.450	5		159.7 1	25	37 6	0.8 .332	0
2	00	:	16.02 0	0.20	1.840	8		89.8 2	27	44 9	1.0 .335	0
3	00	:	16.02 0	0.25	1 .470	9		57.5 3	61	50 1	1.3 .340	0
4	00	:	16.02 0	0.30	1.230	2		39.9 3	46	56 3	1.5 .344	0
5	00	:	16.02 0	0.35	1.050	7		29.3 3	93	61 3	1.7 .347	0
6	50	: .03	20 0	0.15	1.960	6		52.3 1	25	37 7	1.0 .351	0
7	50	: ,03	20 0	0.20	1.470	9		29.4 2	27	44 6	1.3 .355	0
8	50	: .03	20 0	0,25	1. 180	5		18.8 3	61	50 4	1.6 .358	0
9	50	: .03	20 0	0.30	0.980	3		13.1 3	46	56 1	1.9 .362	0
0	50	:	20.03 0	0.35	0.840	1		9.6 3	93	61 7	2.1 .365	0
1	00	:	24.03 0	0.15	1.630	2		21.0 1	25	37 9	1.2 .352	0
2	00	:	24.03 0	0.20	1.230			11.8 2	27	44 3	1.6 .355	0
3	0 0	:	24.03 0	0.25	0.980			7.6 3	61	50 7	1.9 .361	0
4	00	:	24.03 0	0.30	0 .820			5.3 3	46	56 9	2.2 .365	0
6	50	:	28.04 0	0.15	1.400			9.7 1	25	37 0	1.5 .354	0

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Table 3

Tp	Dp	Rinp T	TSH	HP_{snv}	SPfin	S	zCIN	Eoper	Clotv
468.4	3583	223	3.046	161	1	9	1162	27084	168
938.4	7179	446	3.045	161	1	9	1162	27082	168
239.2	1830	78	4.439	110	1	9	1162	26958	245
486.5	3722	158	4.438	110	1	9	1162	26954	245
133.0	1017	57	3.338	147	1	9	1162	27092	184
273.6	2093	118	3.336	147	1	9	1162	27086	184
83.9	642	45	2.671	184	1	9	1162	27181	148
175.1	1340	95	2.670	184	1	9	1162	27171	148
56.6	433	36	2.223	221	1	9	1162	27228	123
121.6	930	79	2.220	221	1	9	1162	27213	123
40.7	311	31	1.904	258		7	2325	38918	151
89.4	684	68	1.902	258	1	9	1162	27268	106
72.4	554	29	3,558	138	1	9	1162	27099	196
159.7	1222	65	3.555	138	1	9	1162	27087	196
40.3	30 8	21	2.675	183		7	2325	38759	212
89.8	687	48	2.671	184	1	9	1162	27193	148
25.4	194	17	2.140	229		7	2325	38851	170
57.5	440	39	2.135	230	1	9	1162	27256	119
17.3	133	14	1.794	274	3	6	3488	50601	185
39.9	305	32	1.788	275	2	7	2325	38978	142
12.6	96	И	1.535	320	4	5	4651	62283	195
29.3	224	27	1.528	322	2	7	2325	39053	121
22.1	169	11	2.855	172	2	7	2325	38802	226
52.3	400	26	2.848	172	1	9	1162	27133	158
12.3	94	8	2.150	228	4	5	4651	62123	272
29.4	225	19	2.139	230	2	7	2325	38928	169
7.7	59	6	1.734	283	7	1	8140	97120	343
18.8	144	15	1.720	285	3	6	3488	50597	178
5.3	41	5	1.449	339	9	4658	10	120477	355
13.1	100	13	1.432	343	4	5	4651	62345	182
3.8	29	4	1.251	393	13	73	1511	167089	425
9.6	73	11	1.231	399	5	3	5814	74058	186
8.8	68	5	2.391	205	6	2	6977	85359	416
21 ,0	161	12	2.375	207	3	6	3488	50522	244
4.9	38	3	1.821	270	12	44	1395	155288	575
11.8	90	9	1.799	273	4	5	4651	62248	228
3.1	24	3	1.469	334	15	30	1744	190242	570

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7.6	**58**	**7**	**1.440**	**341**	**7**	**1**	**8140**	**97245**	**285**
2.1	**16**	**2**	**1.247**	**394**	**26**	**46**	**3023**	**318279**	**808**
5.3	**41**	**6**	**1.212**	**405**	**9**	**58**	**1046**	**120598**	**298**
4.1	**31**	**2**	**2.082**	**236**	**16**	**59**	**1860**	**201745**	**855**
9.7	**74**	**6**	**2.052**	**239**	**6**	**2**	**6977**	**85435**	**357**

Table 4. An example of definition of the modes of cutting (steel 12X18H10T processing by a spiral drill from P6M5)

№	List of restrictions	The list of nodes of a set of the modes of cutting answering to the set conditions
1	$1,30 \leq t_{osn} \leq 1.75$	19 20 23 27 31 36
2	$220 \leq H_{smv} \leq 235$	19 23 27
3	$\begin{cases} 1.30 \leq t_{osn} \leq 1.35 \\ R_{0.95} \geq 15 \end{cases}$	19 23 27
4	$\begin{cases} 220 \leq H_{smv} \leq 235 \\ 15 \leq R_{0.95} \leq 35 \end{cases}$	23
5	$\begin{cases} 1,45 \leq t_{osn} \leq 1.55 \\ R_{0.95} \geq 40 \end{cases}$	Nil
6	$\begin{cases} 220 \leq H_{smv} \leq 235 \\ C1otv \rightarrow min \end{cases}$	19

IV. Conclusion

The carried-out analytical calculations showed that:

- At low values of the modes of cutting (V_i and S_i) and respectively minor changes of coefficient of a variation of firmness of VarT of change of the value SP_{fin}, CL_{opn} practically does not occur at change of a variation of firmness of preparations from 0 to 20% at all considered levels of reliability p_i;
- At mean values of the modes of cutting (V_i and S_i) and changes of coefficient of a variation of firmness of VarT from 0.125 to 0.237 observe a tendency to increase of the values SP_{fin_Pi}, CL_{opn_Pi} at increase of a variation of firmness of preparations from 0 to 20%.
- At great values of the modes of cutting (V_i and S_i) and changes of coefficient of a variation of firmness of VarT from 0.125 to 0.293 observe a tendency to sharp increase of the values SP_{fin_Pi}, CL_{opn_Pi} at increase of a variation of firmness of preparations from 0 to 20%.

The developed technique allowed to generate the database for definition of the modes of cutting on operation of drilling of a deaf opening Ø25 of mm of L=75 mm in depth. On this operation, steel 12X18H10T instruments of three different

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constructions (spiral drills from P6M5, pointed drills with plates from BK8 and drills with MNS structure equipped with trihedral throw-away plates of T15K6) are used.

The developed technique allows considering in the course of definition of the modes of cutting the wide accumulated experience on operation of tools in the most different conditions presented in standards for the modes of cutting and reference books, providing thereby objectivity of the calculated cutting modes to real conditions of processing.

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