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Construction and technology similarity

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Analysis and modelling

ABSTRACT

Purpose: The main aim of study is to present the theory of construction similarity and technology. The theory of similarity is based on the theory of physical similarity. Model in the theory of similarity of construction and technology is construction and technology standard.
Design/methodology/approach: The essence of this theory is to choose such constructional features of the new designed construction to obtain the identical states: physical, stereo mechanical or simple like in the standard construction However, in creating new technologies to obtain the same technological conditions: cutting power, cutting forces and cutting performance as standard technology.
Findings: Elaborated methodology aim to identify similarities in the way of semi-automated construction and technology. Features are determined for the items stored in the form of series of construction and technology types.
Research limitations/implications: Analysed methods develop algorithmisation of engineers and technologists environment and support integration with the process of preparation the production.
Practical implications: Described methods were being developed on practical examples of creating the series of types of hydraulic cylinders used in mining.
Originality/value: Method of the constructional similarity, technological similarity presented in the paper are basis of selection of design features in the process of series of types and module systems of constructions and technology creating. All of these methods support intensive development of the types of technical features and affect on their competitive on the ready market.
Keywords: Technological design; Series of types; Module system; Theory of similarity

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1. Introduction

The basis of creating ordered family of construction with use of construction similarity is a standard construction (equation 1) with set of standard needs (equation 2).

$$ks_0\{ y_{ol}^{e_j};(l=1,lv_j)(j=1,jz)\} \quad (1)$$

$$\overline{X}_0\{ x_{0a};(a=1,az)\} \quad (2)$$

On a base of standard construction and needs the families similar in geometrical form (equation 3) are being created in order of matrix of needs with maintained identical relations of conjugations and relations of transformations (equation 4). Values of dimensions are matched to normal numbers [2, 3, 4, 5].

$$ks_i\{y_{il}^{e_j};(l=1,\ldots,lv_j)(j=1,\ldots,jz)\}\in RK_n \quad (3)$$

$$\overline{X}_i^u\{x_{ia}^u;(i=1,\ldots,iz)(a=1,\ldots,az)\} \quad (4)$$

The model selection variable value dimensions, can be written in the form:

If $\overline{X}_0\{x_{0a};(a=1,az)\}\to ks_0^{te_j}\{y_{0l}^{e_j};(l=1,lv_j)(j=1,jz)\}$,

that $\overline{X}_i\,\{x^u_{ia};(a=1,az)(i=1,iz)\}$
$\rightarrow ks^{te_j}_i\,\{y^{e_j}_{il};(l=1,lv_j)(j=1,jz)\}$

Standard construction is a construction verificated by practical and experimental methods and used once in a process of production. Product complied with this conjugation fills all set of criterions in the best possible way [2, 3, 6]. Standard construction for the sake of precision of computations of dimensions values should be represented by a centre of set of created family of constructions. Construction can be adopted as the standard construction, when the corresponding product best met the criteria for experimental verification.

In view the precision of value calculations $y^{e_j}_{il}$, it is advisable to accept the construction model of middle range ordered vector needs (i_z / 2), Figure 1.

2. Construction similarity

Analysed method uses numbers of similarity:

- similarity of parameter $\varphi^u_{ia}=\frac{x^u_{ia}}{x_{0a}}$,
- similarity of dimension $\varphi^{e_j}_{il}=\frac{y^{e_j}_{il}}{y^{e_j}_{0l}}$.

There is a strict relation between digitization of characteristic features which generates sequence of parameters $\vec{X}^u_a\left(x^u_{1a},\ldots,x^u_{ia},\ldots,x^u_{iza}\right)$ and digitization of variable dimension which generates sequence of dimension $\vec{Y}^{e_j}_l\left(y^{e_j}_{1l},\ldots,y^{e_j}_{il},\ldots,y^{e_j}_{izl}\right)$ [10, 11, 12, 14, 15].

The similarity of two geometric constructions $\langle ks_0, ks_i\rangle$, can be

- complete, when

$$\bigwedge_{l=1,lv_j}\varphi^{e_j}_{il}=\varphi^{e_j}_{l}=const, \tag{5}$$

- no complete, when

$$\bigvee_{l_1,l_2=1,lv_j}\varphi^{e_j}_{il_1}\neq\varphi^{e_j}_{il_2}. \tag{6}$$

The families of structured constructions should be directed to the full geometric constructions similarity.

Theory of constructional similarity rules the selection of design features maintaining relations and transformations in the new construction from standard construction. Moreover the set of variationality of constructions should be optimal.

Relations may be represented by set of mathematical functions which describe physical phenomenons, stereomechanical states (critical stress) and simple states (geometrical relations between dimensions of conjugate elements).

Fulfilment of theory of constructional similarity within stereomechanical states is called Cauchy problem [1, 9]. In mechanical engineering Cauchy problem rules maintenance of the level of effort of material, strain and safety number in every new construction.

The process of classification of similarity depending on the type of element shown Figure 2.

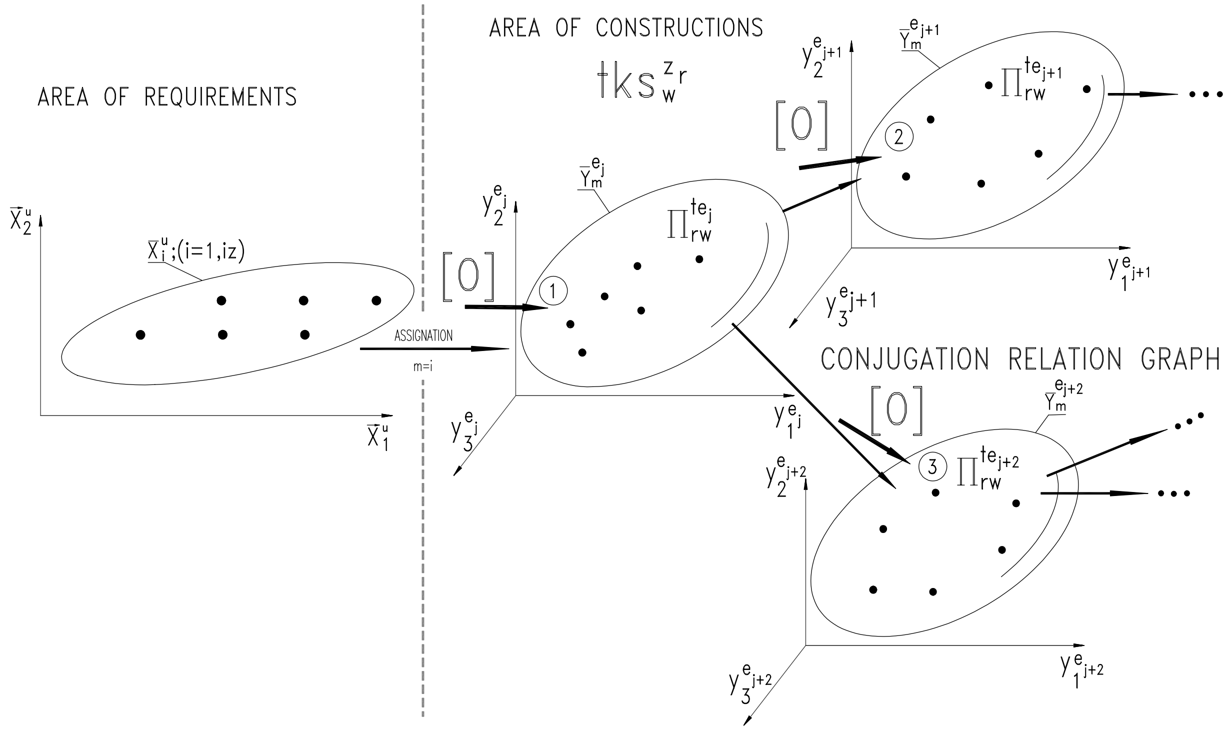

Fig. 1. A model of the selection quantitative construction features on the based construction similarity

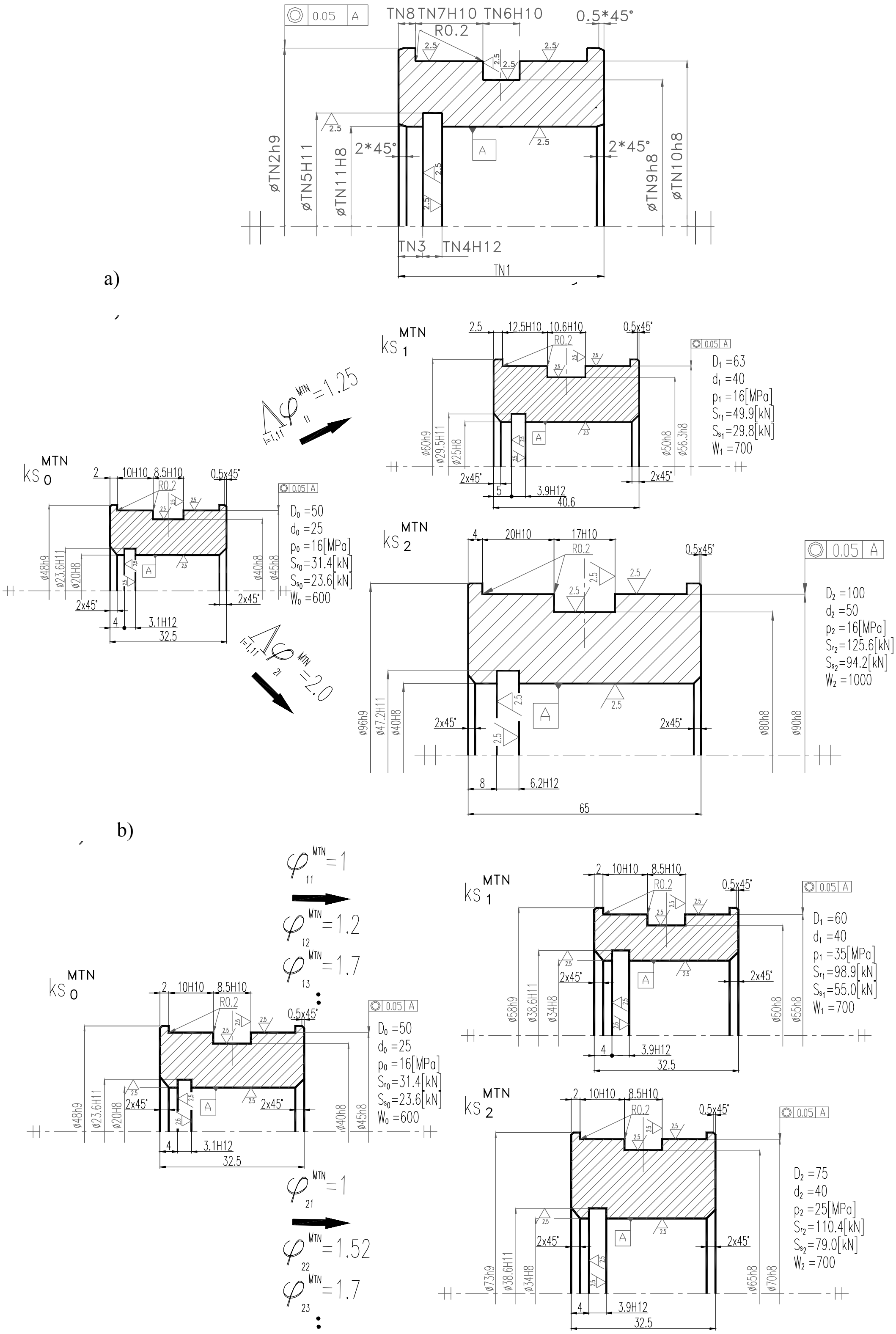

Fig. 2. Construction form Π^{MTN} of complete and no complete similarity

2.1. Condition of constructional similarity

Relationships linkage and transformation should be the same as in standard construction. Relationships are represented by mathematical functions, whose general model shown in Figure 3. Figure 3 shows a block write scheme, where each isomorphic relationship is assigned a set of mathematical functions, describing:

- physical states [1, 2],
- stereomechanical states (stress criterial),
- other states of simple (eg. the conditions for the coupling between the dimensions of interacting elements, the geometric relationship between the dimensions of the elements).

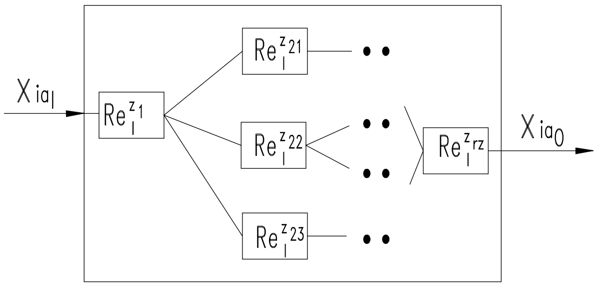

Fig. 3. Mathematical description of a future state technical object

In theory, of construction similarity to the aims of such a selection of construction elements to maintaining geometric similarity, to obtain identical conditions: physical, stereomechanical and simple, in the newly created structures such as the construction standard under the terms of construction similarities. Geometric similarity is satisfied primarily because of the possibility of using similar technology of production, thereby reducing manufacturing costs. If the family construction to verify the states stereomechanical it aims to maintain the newly created structures, respectively, as the design standard, identical or similar:

- strength of the material,
- deformation,
- security numbers.

Standard construction responsible overall mathematical function:

$$C_0 f_{0A} = C_1 f_{0B} + C_2 f_{0C} + C_3 f_{0D}, \tag{7}$$

where:

$$\bigwedge_{I=A,B,C,D} f_{0I} \to f(y_{0l}^{e_j}, x_{0a}); j \in 1, jz; l \in 1, lv_j; a \in 1, az$$

C_0, C_1, C_2, C_3 – constant values of function.

The general form of a mathematical function corresponding to the created construction (for Π=const),

$$C_0 f_{iA} = C_1 f_{iB} + C_2 f_{iC} + C_3 f_{iD}, \tag{8}$$

where:

$$\bigwedge_{I=A,B,C,D} f_{iI} \to f(y_{il}^{e_j}, x_{ia}); j \in 1, jz; l \in 1, lv_j; a \in 1, az.$$

on the basis of similarity measures:

$$\varphi_{iA} = \frac{|f_{iA}|}{|f_{0A}|},\ \varphi_{iB} = \frac{|f_{iB}|}{|f_{0B}|},$$
$$\varphi_{iC} = \frac{|f_{iC}|}{|f_{0C}|},\ \varphi_{iD} = \frac{|f_{iD}|}{|f_{0D}|}, \tag{9}$$

where:

$|f_{0I}|, |f_{iI}|$ - function value

These mathematical functions (7) and (8) with dependencies (9) create a system of equations:

$$C_0 f_{0A} = C_1 f_{0B} + C_2 f_{0C} + C_3 f_{0D},$$
$$\varphi_{iA} C_0 f_{0A} = \varphi_{iB} C_1 f_{0B} + \varphi_{iC} C_1 f_{0C} + \varphi_{iD} C_1 f_{0D} \tag{10}$$

Since both mathematical functions in the system of equations describing the same states and the isomorphic relations, Π = const, so the fulfilment of these equations is possible if:

$$\varphi_{iA} = \varphi_{iB} = \varphi_{iC} = \varphi_{iD}. \tag{11}$$

On the basis of the relationships (9), it is possible to study the conditions of similarity of family construction, enabling the fulfillment of conditions and the geometric similarity in the whole family construction created.

The aim is to obtain the relationship between the parameters and the values of dimensions, under the conditions of construction similarity.

$$\varphi_l = f(\varphi_a) \tag{12}$$

Assuming that form design is identical (Π = const), while the known dimensions of standard value,

$$ks_0\{y_{ol}^{e_j}; (l = 1, lv_j)(j = 1, jz)\}$$

and the standard parameters,

$$\overline{X}_0\{x_{0a}; (a = 1, az)\}.$$

3. Technological similarity

Technological similarity is applied in the process of defining technological features to generate the parameters of processing.

Those parameters concern the processes of machining: turning, hole making, milling. For series of types of technology for one selected technology the parameters of process are calculated. They are being calculated by: algorithms, analytical programmes, norms. The parameters defined as standard parameters (technological features) are selected on the basis of constructional features [7, 8, 10, 11, 13].

The theory of technological similarity is applied for elements characterized by constant constructional form and variational values of dimensions, Fig 4. Technological working plan is created by advanced graphic programs according to traditional methods with use program and relation parametrization.

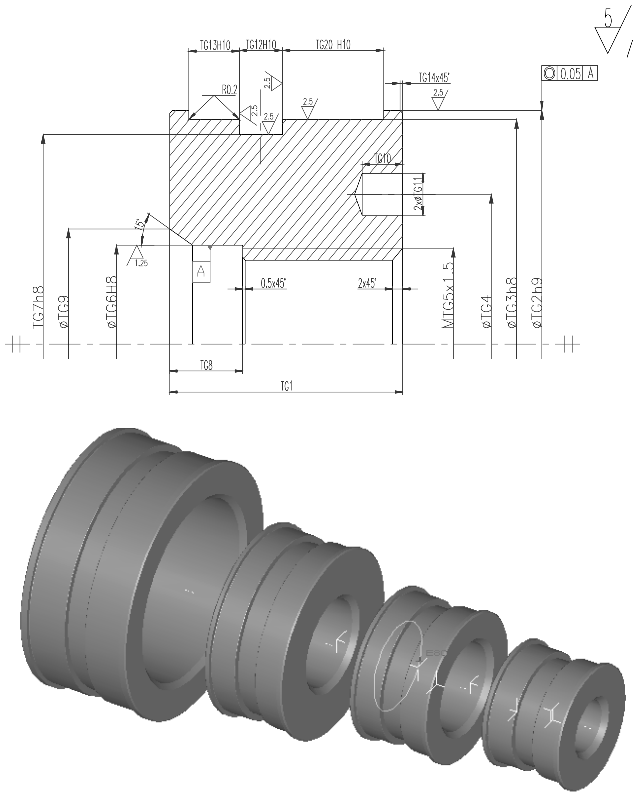

Fig. 4. Constructional form of element of servo-motor

Standard structure is used to generate further technological structures by modification of chosen parameters. The selection and transformation of parameters is realized after having defined the system of relations and the system of connections and technology Γ^{tej} and the variation of technological parameters T_a^{tej} (Equation 11).

$$te_n^{te_j} = (\Gamma^{te_j})_{const} \cup (T_a^{te_j})_{var} \quad (13)$$

This problem is analysed in later part of the paper. In order to obtain the most effective integration of process creating series of technology including a process creating the ordered construction performance under-mentioned standards, the following must be required:

1) sorting constructional data (constructional features) making up the basis to create technological components of the ordered technology,
2) transferring from construction the greatest number of data to the process of production,
3) maximum connection of constructional features with manufacturing technology,
4) minimisation of information redundancy,
5) development of the relational database,
6) minimization of variety of construction and technological processes particularly along with constructors and technologists' subjective feelings,
7) developing computer programmes and their application in order to integrate the working environment process engineers and design engineers [13],
8) typical constructional solutions and technological processes, which modules computational programmes should be presented.

The process of technology ordering is realized for series (Equation 14) or module series (Equation 15), applying them in identical possible operations, cuts, parameters of processing, seizing, tools, gears.

$$ts_m^{te_j};(m = 1, mz_j) \quad (14)$$

$$mk_m^{rwe_j};(m = 1, mz_j) \quad (15)$$

Scheme of the technological similarity in the process of series of technology creation is presented in Figure 5.

Considering the series of types elements manufactured ($Ks_n^{te1}(n = 1, nz)$, $Ks_n^{te2}(n = 1, nz)$, $Ks_n^{ten}(n = 1, nz)$).

The plans of production on basis of constructional form of unit are created. Plans can be presented in form of variants of solutions plan production (VPW_1^{el1}, VPW_0^{el2}, VPW_i^{el1}). These plans of production are also the object of optimization for each series of construction, and the typical plans of production are the final result PW_0^{tel}.

The next stage is the creation of qualitative features of technology, which includes the selection of a typical:

- technological form Γ_s,
- form of semi-finished product Γ_{pf},
- form of tools Γ_n.

The selection of quantitative features begins with the technological determination of these features for the technology standard.

The next stage of the method includes creating the conditions for technological similarity. Are the basis of technology to maintain identical conditions for the entire range of technology created.

On the basis of conditions similarity are determined technological parameters of another technological components ($Te_n^{tel}(n = 1, nz)$, $Te_n^{te2}(n = 1, nz)$, $Te_n^{ten}(n = 1, nz)$).

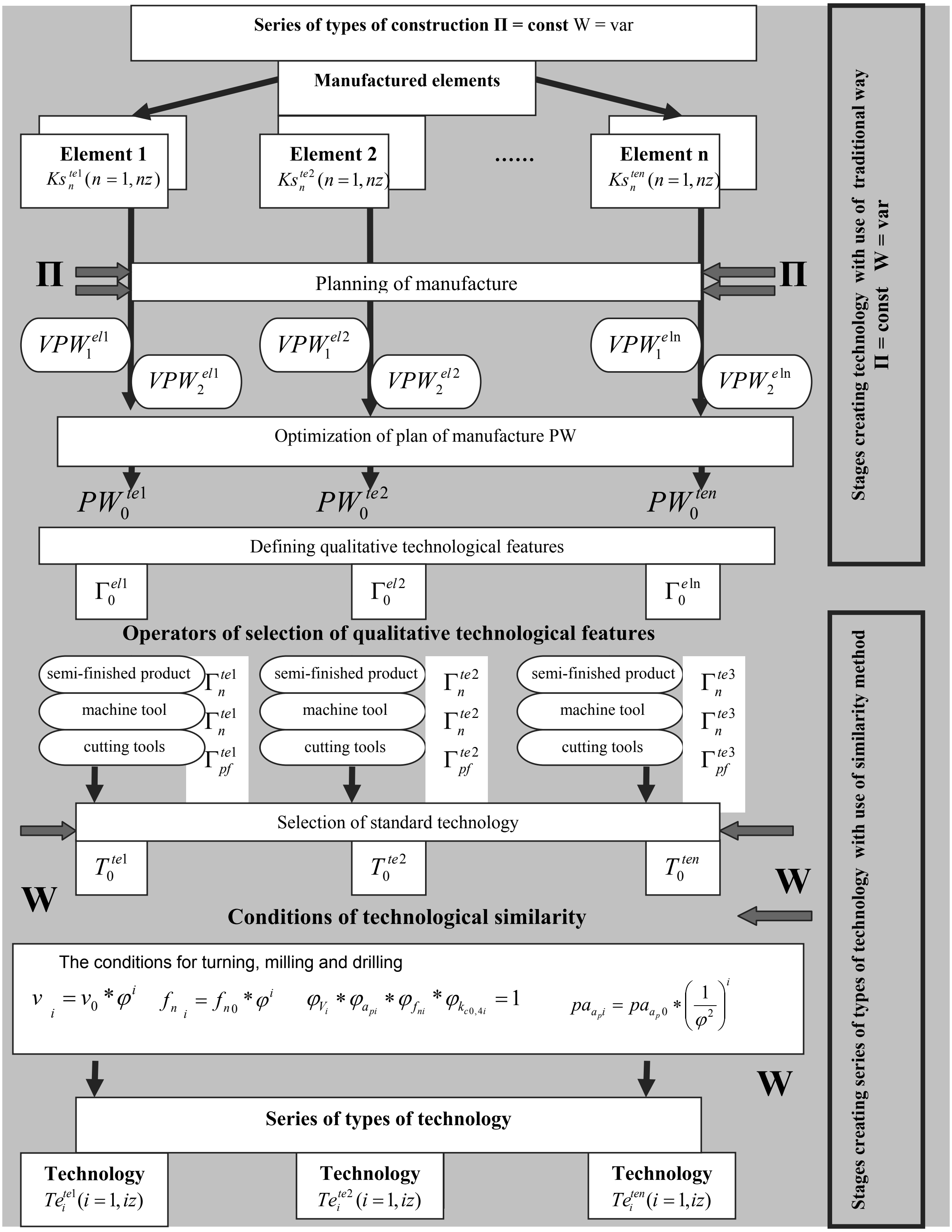

Fig. 5. General model of series of element creating white use technological similarity

3.1. Condition of technological similarity

This paper analyses the similarity of constructional parameter (entrance data presenting constructional quantitative feature, marked as pi) and the similarity of parameter of processing (exit data presenting the quantitative parameter of process, marked as wi).

- similarity of constructional parameter

$$\varphi_{ik} = \frac{p_{ik}}{p_{0k}},$$

- similarity of parameters of processing

$$\varphi_{it} = \frac{w_{ik}}{w_{0k}}$$

The generalized model of transformation of selected constructional features (quantitative):

1. Mathematical functions describing technological states

$Q = v_c * a_p * f \quad F_c = R_m * A_w$

$$P_c = \frac{v_c * a_p * f_n * k_{c0.4}}{240 * 10^3}$$

2. Similarity conditions resulting from assumed technological states:

$$\varphi_{Pc} = \frac{P_{ci}}{P_{c0}} \qquad \varphi_{Pc} = \varphi_{V_i} * \varphi_{a_{pi}} * \varphi_{f_{ni}} * \varphi_{k_{c0,4i}}$$

$$\varphi_{Qc} = \frac{Q_{ci}}{Q_{c0}} \qquad \varphi_{Q_c} = \varphi_{R_m} * \varphi_{a_p} * \varphi_{f_n}$$

$\varphi_{Pc} = 1 \quad \varphi_Q = 1 \quad \varphi_{Fc} = 1$

process of transformation

equation of similarity

$$\varphi_{V_i} * \varphi_{a_{pi}} * \varphi_{f_{ni}} * \varphi_{k_{c0.4i}} = 1$$

3. The conditions of similarity describing dimensions of similarity for parameters of processing

$$v_i = v_0 * \varphi^i \qquad pa_{a_pi} = pa_{a_p0} * \left(\frac{1}{\varphi^2}\right)^i \quad f_{n\,i} = f_{n0} * \varphi^i$$

$$for\ i = -7, -6, \ldots, 0, \ldots, 6, 7$$

where:

i – number of element of series of type,

φ- number of similarities.

In the paper the transformation of the quantitative constructions features (dimension) into quantitative features of technology (technological parameters) with the assumption of constant qualitative features in considered domain is proposed. On the basis of elaborated technological processes the following stages of creating the ordered family of technology on the basis of ordered construction. According to defined measures of similarity value of parameters of processing are specified according to constant technological states.

The values of parameters are generated one after another using following elements: constant power machining, solid efficiency of processing or strength of cutting.

The obtained values of parameters should be optimized into the range of applicable values.

In accordance to the chosen machine tool and productive possibilities the value of given parameter should be adapted to definite series of value. Section 2.2 shows process of creating the conditions of similarities.

3.2. Standard technology

The definition of standard technology is connected with definition basic qualitative and quantitative technological features. The qualitative features concern the structures of process of production directly and they depend of the type of processing and form constructional machined element. For standard construction practically and experimentally verified constructions were accepted.

Transformation the standard features shown in Figure 6.

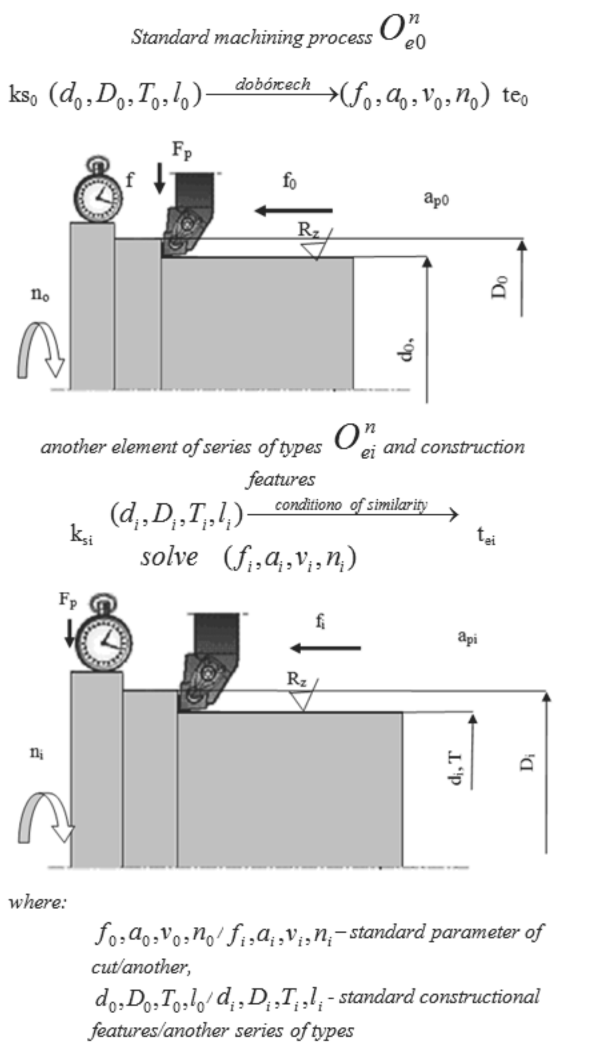

Fig. 6. Model of transformation constructional features

The assumption between a set of construction and technology is represented by equation 16.

$$Te_n^u\left\{te_k^{ej};(k=1,kz)(j=1,jz)\right\}<= \\ <= Ks_n^u\left\{(ks_k;(k=1,kz)\right\} \qquad (16)$$

The constructional form the states the invariable qualitative feature of set of construction K_s whereas the technological form- the constant qualitative technological feature of set of technology T_e. Manufacturing form, (which contained the invariable data of record of specified qualitative technological features), contains conditioned in dependence from:

1) constructional form of element,
2) specified process of manufacture,
   Standard values of technological parameters

- force of machine cutting Pa_{Fc}
- power of machine cutting Pa_{Pc}
- volumetric efficiency of machine cutting Pa_{Qc}

Standard values of parameters of processing

- standard feeds f_{e0}^i
- standard speed of machine cutting V_{e0}^i
- standard depth of machine cutting a_{e0}^i
- rotational standard speed n_{e0}^i

where:
i – number of operation,
e0 – number of element of series of type.

Example of creating a standard technology is presented in Figure 7. Constructional form of the sleeve MTU is described by the dimensions of the TU5 to TU1. Series of types consists of 10 elements.

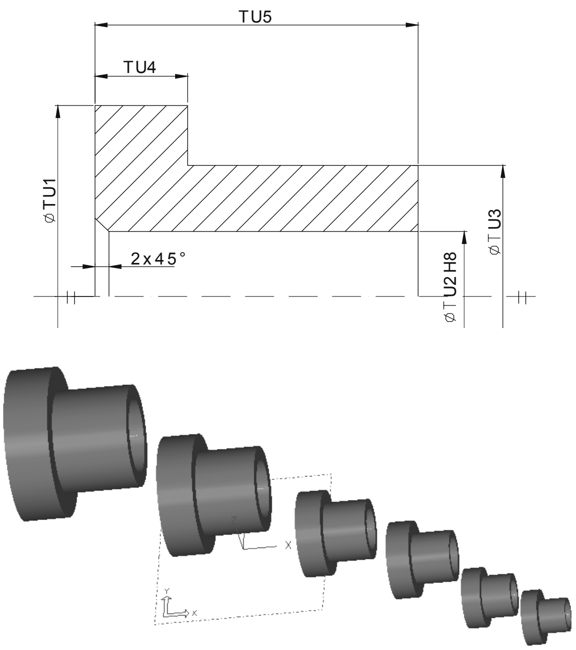

Fig. 7. Constructional form of element MTU

Values of quantitative features design elements shall be determined based on a relationship and are created accordance with the conditions of similarity.

The values of dimensions of the sleeve TU are created by equation 17.

$$TU_i = TU_0 * (\varphi_w)^i \qquad (17)$$

The value of similarity φ_W equal to 1.12, is compatible with a range of numbers of normal R20. Variable of parameters *i* is in the range <-4; 5> .The values of the dimensions of the sleeve are ordered using the operator numbers of normal O_N and matched elements operator O_D, Table 1.

Table 1.
The values of construction dimensions

	TU1 [mm]	TU2 [mm]	TU3 [mm]	TU4 [mm]	TU5 [mm]
-4	63,55	31,78	44,49	19,07	50,84
-3	71,18	35,59	49,82	21,35	56,94
-2	79,72	39,86	55,80	23,92	63,78
-1	89,29	44,64	62,50	26,79	71,43
i = 0	100,00	50,00	70,00	30,00	80,00
1	112,00	56,00	78,40	33,60	89,60
2	125,44	62,72	87,81	37,63	100,35
3	140,49	70,25	98,34	42,15	112,39
4	157,35	78,68	110,15	47,21	125,88
5	176,23	88,12	123,36	52,87	140,99

$O_N; O_D$

	TU1 [mm]	TU2 [mm]	TU3 [mm]	TU4 [mm]	TU5 [mm]
-4	64	32	40	19	50
-3	70	36	50	22	56
-2	80	40	56	24	64
-1	90	45	60	27	72
i = 0	100	50	70	30	80
1	112	56	80	34	90
2	126	62	90	38	100
3	140	70	100	42	112
4	158	78	110	48	125
5	176	88	120	52	140

The verification standard technology carried out with using NX program. Some operations of this process are shown in Figures 8, 9, 10, 11, 12.

3.3. The conditions of similarity for drilling operation

The input data to determine the technological parameters in the area of quantitative features are variable constructional features of series of types of elements.

Examples the input features WE may be constructional features of holes:

- hole diameter D_i [mm],
- length of the hole L_i[mm],
- tolerance To_i,
- material features $k_{ic\ 0.4}$ [N/mm^2].

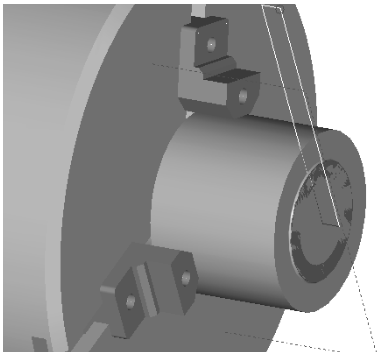

Fig. 8. Finish face Z_{e0}^{1}

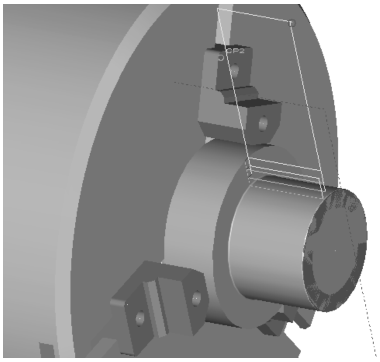

Fig. 9. Rough turn Z_{e0}^{2}

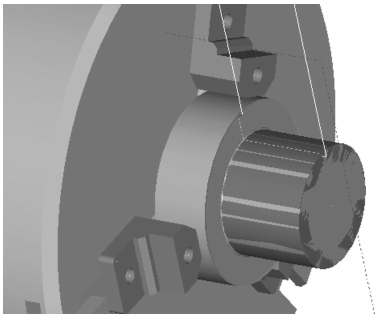

Fig. 10. Finish turn Z_{e0}^{3}

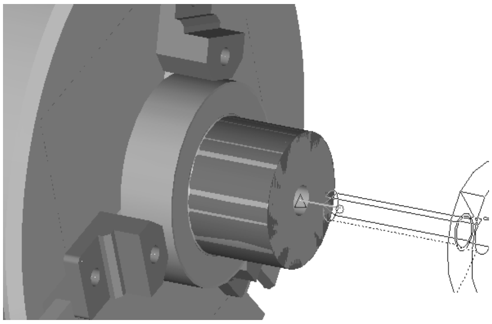

Fig. 11. Drill and bore Z_{e0}^{4}

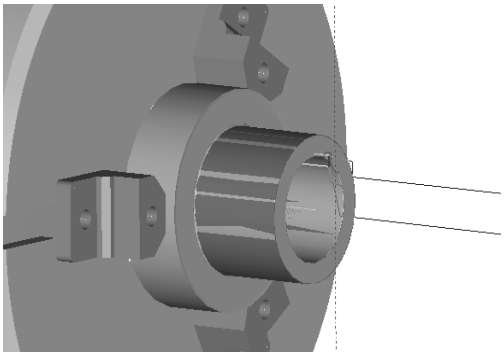

Fig. 12. Finish bore Z_{e0}^{7}

Specify technological parameters (WY) calculated on the basis of construction:

- feeds f_i [mm/obr],
- cutting speed V_i [m/min],
- depth of cut a_{pi} [mm],
- speed n_i [obr/min],
- dimension of tools.

where:
i – element number from the series.

Standard values of technological parameters:

- force of machine cutting **Pa_{Fc}**,
- power of machine cutting **Pa_{Pc}**,
- volumetric efficiency of machine cutting **Pa_{Qc}**.

Conditions resulting from the power cut

Cutting power value is calculated on the basis cut parameters, equation 18.

$$P_c = \frac{v_c * a_p * f_n * k_{c0.4}}{240 * 10^3} [kW], \tag{18}$$

where:
P_C –power of cut,
v_c – cutting speed,
f_n – feeds,
$k_{c\,0.4}$ – cutting force for the chip 0.4 mm,
a_p – depth of cut.

The number of similarities power cut φ_{Pc} is defined as the ratio of power Pc_i to standard cutting technology Pc_0,

$$\varphi_{Pc} = \frac{Pc_i}{Pc_0}, \tag{19}$$

It follows that:

$$\varphi_{Pc} = \frac{\dfrac{v_i * a_{pi} * f_{ni} * k_{c0.4i}}{240 * 10^3}}{\dfrac{v_0 * a_{p0} * f_{n0} * k_{c0.40}}{240 * 10^3}} . \tag{20}$$

Number of similarities technological parameters are determined from the dependence, equation 21.

$$\varphi_v = \frac{v_i}{v_0}, \qquad \varphi_{a_p} = \frac{a_{pi}}{a_{p0}},$$
$$\varphi_{f_n} = \frac{f_{ni}}{f_{n0}}, \qquad \varphi_{k_{c0.4}} = \frac{k_{ci}}{k_{c0}}. \tag{21}$$

Number of similar power cut takes the following form

$$\varphi_{Pc} = \varphi_{V_i} * \varphi_{a_{pi}} * \varphi_{f_{ni}} * \varphi_{k_{c0.4i}}. \tag{22}$$

According to the assumption of the method $\varphi_{Pc} = 1$, assumed the same cutting power for all range of technology. No change of the material therefore it is assumed $\varphi_{k_{c0.4}} = 1$. Finally, a condition resulting from the power cut has the form

$$\varphi_{V_c} * \varphi_{a_p} * \varphi_{f_n} = 1 \tag{23}$$

Conditions resulting from the cutting efficiency

Cutting efficiency specified for the standard technological parameters is calculated from the dependence 24.

$$Q = vc * ap * f, \tag{24}$$

where:
v_c – cutting speed,
f_n – feeds,
a_p –depta of cut.

The number of similarities resulting from the cutting efficiency is defined as,

$$\varphi_{Qc} = \frac{Q_{ci}}{Q_{c0}}. \tag{25}$$

After substituting dependency (24),

$$\varphi_{Q_c} = \frac{v_i * a_{pi} * f_{ni}}{v_0 * a_{p0} * f_{n0}} \tag{26}$$

After the substitutions and transformations we have,

$$\varphi_{Q_c} = \varphi_{V_i} * \varphi_{a_{pi}} * \varphi_{f_{ni}}. \tag{27}$$

According to the assumption of the method $\varphi_{Q_c} = 1$,

$$\varphi_{V_i} * \varphi_{a_{pi}} * \varphi_{f_{ni}} = 1. \tag{28}$$

Conditions resulting from the cutting forces

The condition represents the state of technological tools is power cut. Value of the consideration for the drilling will be pushing force. Force values is defined from the dependence 30.

$$Fc = 0.5 * \frac{D_c}{2} * f_n * k_{cfz} * \sin \kappa_r, \tag{30}$$

where:
D_c – drill diameter [mm],
k_{cfz} – unit cutting force [N/mm^2],

$$k_{cfz} = k_{c0.4} \left(\frac{0.4}{f_z * \sin \kappa_f} \right)^{0.29} \quad \left[\frac{N}{mm^2} \right],$$

κ_r – approach angle [^{o}],
f_n – feedrate [mm/obr].

The number of similarities is defined as the ratio of power Fc_i to standard cutting technology Fc_0,

$$\varphi_{Fc} = \frac{F_{ci}}{F_{c_0}} \tag{31}$$

After substituting dependency (30),

$$\varphi_{Fc} = \frac{0.5 * \frac{D_c}{2}_i * f_{ni} * k_{cfzi} * \sin \kappa_{ri}}{0.5 * \frac{D_c}{2}_0 * f_{n0} * k_{cfz0} * \sin \kappa_{r0}}. \tag{32}$$

No change of the material and tolls therefore it is assumed $\varphi_{k_{cfz}} = 1$, $\varphi_{\sin\kappa_r} = 1$. According to the assumption of the method $\varphi_{Fc} = 1$. Finally, a condition resulting from cutting forces has the form

$$\varphi_{D_c} * \varphi_{f_n} = 1. \tag{33}$$

Global conditions for technological similarity

When considering equations (23), (28), (33) finally we achieved a global technological conditions of similarity. Depth of cut for drilling is equal to half diameter $a_p = \frac{1}{2} D_i$

$$\varphi_{a_p} = \varphi_{D_c} \tag{34}$$

From equation (33) we get,

$$\varphi_{a_p} = \frac{1}{\varphi_{f_n}} \tag{35}$$

Substituting (35) to equation (23) we can write

$$\varphi_V * \frac{1}{\varphi_{f_{ni}}} * \varphi_{f_n} = 1. \tag{36}$$

Finally, we have,

$$\varphi_v = 1 \tag{37}$$

From the equation on the cutting speed and the relation (34) we can write,

$$\varphi_v = \varphi_{a_p} * \varphi_n. \tag{38}$$

Substituting (35) to equation (38) we can write,

$$\varphi_v = \frac{1}{\varphi_{f_n}} * \varphi_n \rightarrow \varphi_{f_n} = \varphi_n. \quad (39)$$

Finally, technological similarity conditions can be written in the form of four conditions: 40, 41, 42, 43.

W1 – depth of cut $\varphi_{a_p} = \varphi_{D_c}$ (40)

W2 – feeds $\varphi_{f_{ni}} = \frac{1}{\varphi_{D_c}}$ (41)

W3 – cutting speed $\varphi_v = 1$ (42)

W4 – spindel speed $\varphi_n = \frac{1}{\varphi_{D_c}}$ (43)

4. Conclusions

As an example of technology similarity verification is the holes drilling in hydraulic actuators. The series of types with complete technology similarity was considered. Construction similarity number for hole D series of types is $\boldsymbol{\varphi_D = 1.12}$, which corresponds to R20 preferred numbers. Amount range is determined by number *i* which, for technology model, is equal to zero. Adopted values range i=(-10,10).

The following data was defined to determine the technology parameters:

- construction parameters model → D_0 = 12, material C15 with hardness 125 to 150 HB,
- technology parameters model → a_{p0} = 6 mm, f_{n0} =0.2 [mm/obr], v_0 = 110 [m/min], n_0 = 2900 [obr/min],
- drilling tool Sandvik (CoroDrill Delta-C – R840 R850 R415), unit cutting force for feed per blade → $k_{c\ 0.4}$ = 1900 [N/mm^2].

Drilling operation parameter values was obtained for whom technology states was defined. It was found that the processing power F (Fig. 13), and processing efficiency (Fig. 14), for global technology similarity conditions is constant for whole hole series of types. Technology parameters values should meet the additional criteria, such as adaptation to:

- series of preferred numbers,
- recommended technological parameters for the tools,
- recommended technological parameters of the machine.

These criteria are the reason for derogation from the full technological similarities, as a result, obtained corrected values of technological parameters and values describing the technological conditions such as the power of cutting, cutting forces and cutting performance. So the adjusted variable is called the adjusted values.

These adjustments, however, are insignificant. The maximum value of derogations for a whole series ranges from 15%, as shown in Figures 13, 14.

As a result of the analysis were obtained a number of processing parameters, which are input to the simulation of drilling holes in solid material. These results may be retrieved from the table and put into a specific process.

In the case of drilling, which was dealt with in this chapter, the main features of the subsidiaries required to determine the parameters for drilling include hole diameter and features plastic element in which the hole is machined.

Selecting the cutting parameters with this method can reduce the diversity of tools and equipment in the series of technology. The process for selecting technological parameters in the development phase of technological documentation is also a lot faster and gives a guarantee that, for given parameters do not cross the boundary strength of the tool or machine power.

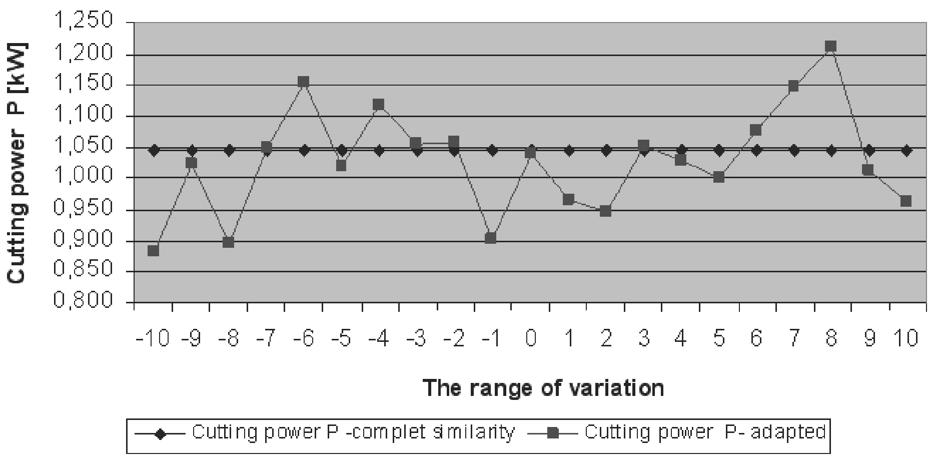

Fig. 13. Variation of cutting force

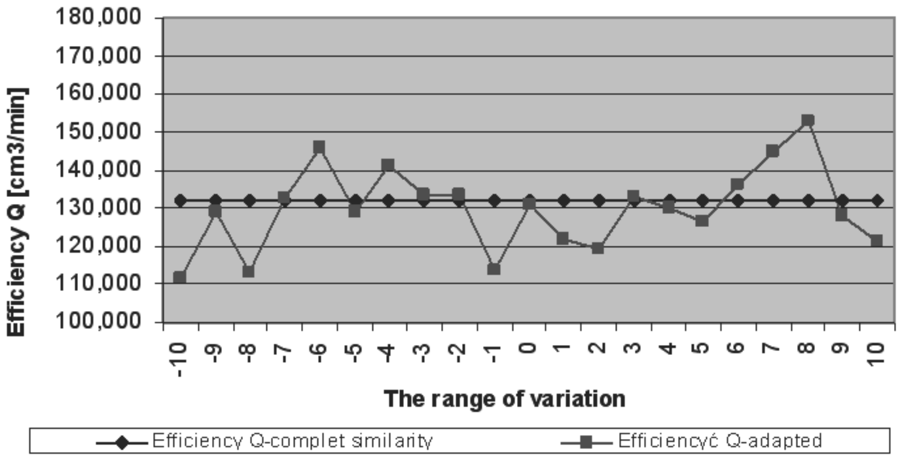

Fig. 14. Variances of cutting efficiency

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