Technological operators of series of types technology creating

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Analysis and modelling

ABSTRACT

Purpose: The result of this paper is verification of relation between constructional features and technological features. The basic tool of the series of types of technologies creating is algorithmic method. The worked out datum of these methods is already elaborated ordered families of construction in form of series of types or modular series of elements construction.

Design/methodology/approach: This paper shows algorithmic understanding of getting input data in the process of technology creating based on data of construction. Basic tool of realization of data selection for the process of manufacture is algorithmic method and use of advanced graphic programme.

Findings: The basic result of the analyzed problem is the realization of relations between construction and technology for specified series of types of elements of machine engines. Moreover the algorithmic method with its essential constituents which determine input date of algorithmization of processes of selection of technological features on bases of constructional features was introduced.

Research limitations/implications: Analyzed methods develop algorithmization of designing environment and support integration with the prepare production process (relational databases, theory of automatic classification).

Practical implications: Described methods were developed on practical examples of creating the technological module systems of hydraulic cylinders used in mining, slag cars used in metallurgy and gears series of types The represented methods are applied for the series of type of units of servo-motors hydraulic practical in mining.

Originality/value: Algorithmic method and CAM method are basis for selection of technological features in the process of already ordered technology families creating. This method is characterized with possibility of shortening time connected with preparation of manufacture.

Keywords: Technological design; Series of types

1. Introduction

This work represents the model of passage from ordered families of construction into ordered families of technologies whit use algorithmic method, Fig. 1 [2, 9, 12].

New requirements related to the constructional process assume that the project has to be executed quickly and adapted to user's demands.

The basic tools for creating series of technology on the basis of series of construction are [3, 4, 5]:
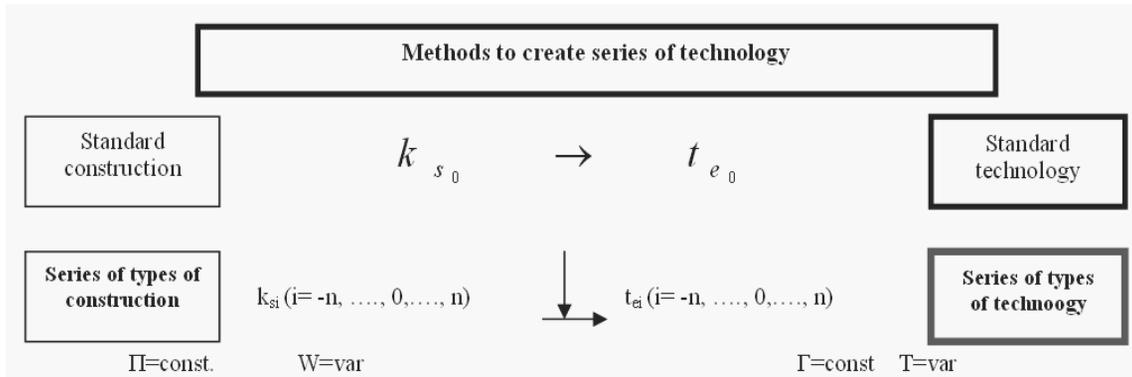
Fig. 1. Creating series type of technology

- knowledge acquisition in the range of construction and technology,
- methods application: algorithmic and CAM,
- methods application: construction with preparation of production database created out of technological working plan components [6, 7].

The algorithmic method is applied in process of defining technological features to generating process the parameters of processing.

These parameters concern the processes of machining: turning, hole making, milling. For series of type technology for one selected technology the parameters of process are calculated. Parameters can be calculated in different ways (algorithms, analytical programmes, norm). The parameters are defined like standard parameters (technological features) are selected on the basis constructional features [1, 2, 11].

All operations mentioned above, connected with description of methods of integrated transformations of constructional features into technological ones, create the methodological approach in the process of series of types of technology for series of types of construction. Elaborated methods are oriented on processes of machining: turning, drilling and milling.

Undertaken tasks are susceptible on algorithmization and computer aid. Moreover, it concerns both the methods of selection of quantitative and qualitative technological features. Working on defined reports between construction and technology the row of applications and computational programmes were elaborated. Visual BASIC programming language as well as AutoLISP used in AutoCAD programme were applied in preparing computational programmes. Access and I-DEAS programmes were applied to create the databases of tolls and instrumentations.

The possibility of creating series of types of technology was also verified with the use of graphic programmes of CAD and CAM ranks as working conditions for small and average productive institutions.

2. The algorithmic method

Algorithmic method realizes subordinating between elements of series of types of technology and elements of types of constructions on the basis of plan of production with operators' use (Equations 1).

Technological operators transform quantitative and qualitative constructional features $x_{m1}^{e_j}; (l = 1, lv_j)$ in sets of quantitative and qualitative technological features xt_{ia}^u in family of technology described by technological structures $\Gamma_{rw}^{te_j}; (j = 1, \ldots, jz)$.

$$CK^{te_j} \xrightarrow{\quad operator \quad} CTe^{tej}, (j = 1, \ldots, jz) \qquad (1)$$

Algorithmic method is considered in context of three basic ways defining technological features on basis of constructional features with the operators' use resulting from:
- mathematical dependence,
- graphs,
- the table of data,
- the decision boards (choice).

Defining with the operators use the technological features concerns quantitative questions in case of selection of parameters processing. In case of selection of machine tool, cutting tools and the semi-finished product at this point is qualitatively-quantitative.

The technological operators invest the qualifications of individual components of technology, Fig. 3. Among those technological operators there are:
- selection of semi-finished product O_{pf},
- selection of machine tool type O_o,
- selection of cutting tools On,
- selection of parameters of cut O_{ps}.

Scheme of the operators' use in the process of the creating series of types of technology is presented on Fig. 2. 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 the series of types of construction, and the typical plans of production are the final result PW_0^{te1}. In order to the obtainment the most effective integration of process of technologies creating with process of the creating of ordered construction performance undermentioned standards be required:
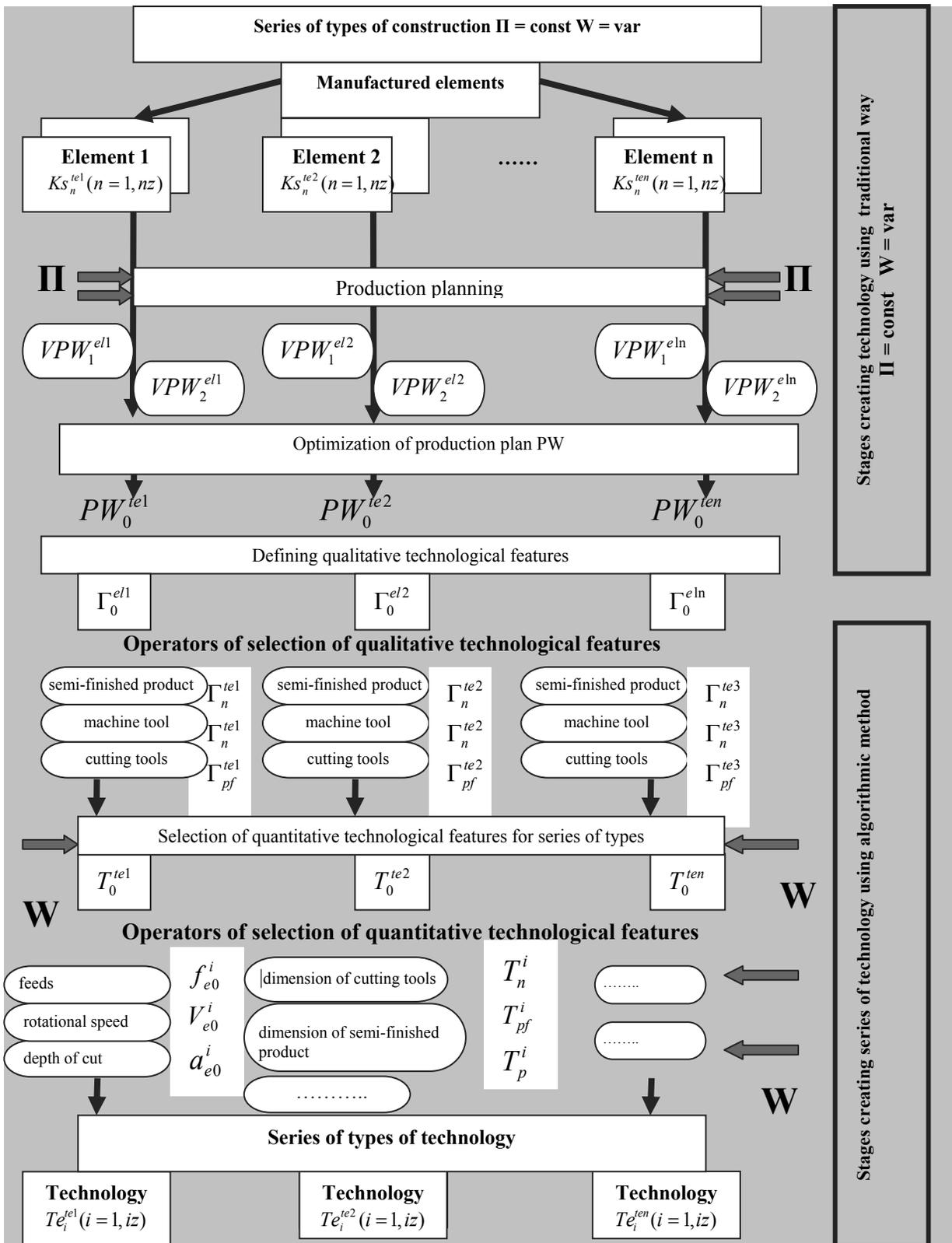
Fig. 2. Model of series of element constructions covering into series of technology
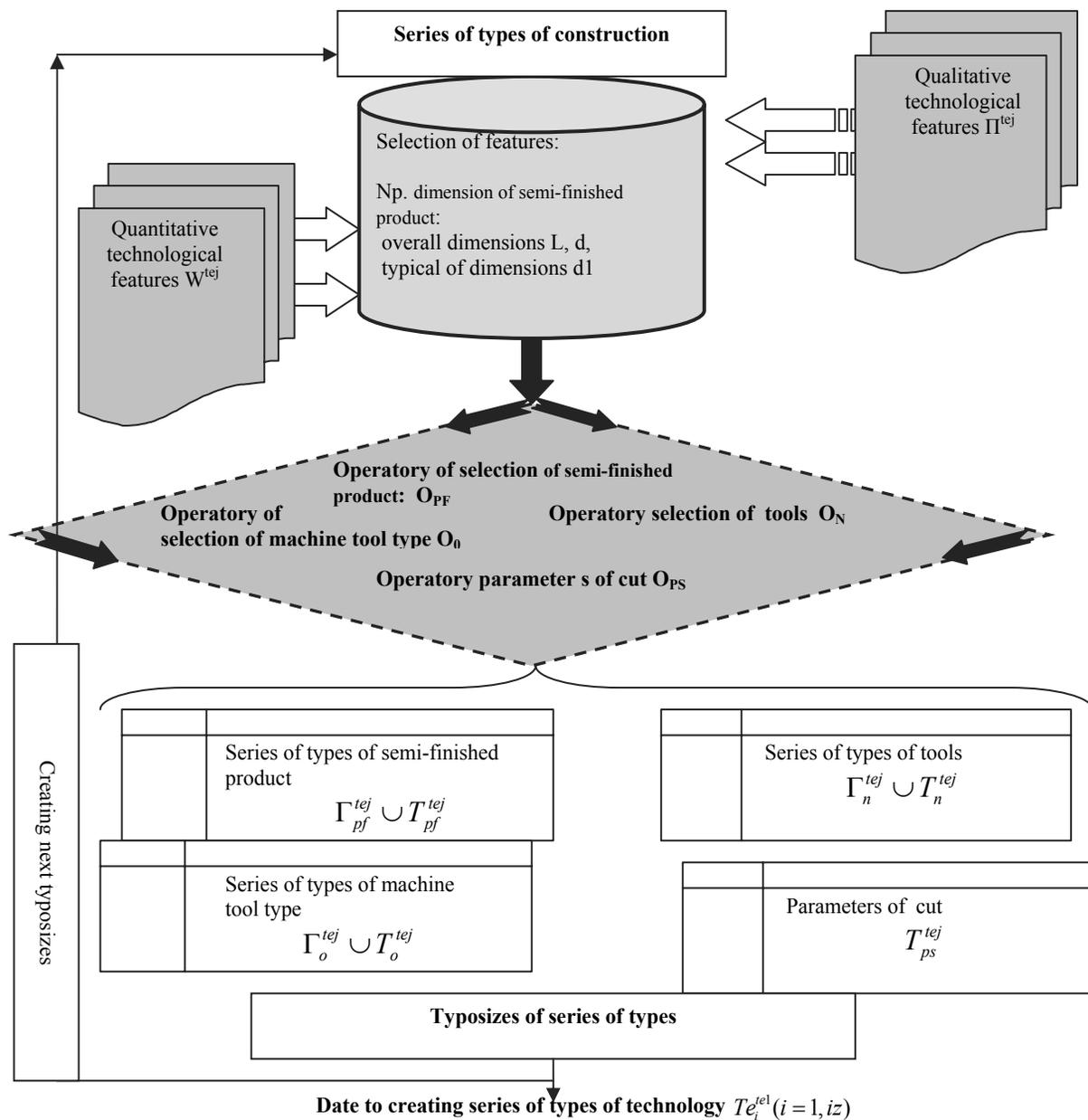
Fig. 3. Operators of selection of technological features

- sorting constructional data (constructional features) making up the basis to creating of technological components of ordered technology [9,10, 13]
- the maximum connection of constructional features with manufacturing technology,
- minimisation of redundancy of information,
- the development the relational database [8, 14, 15],
- developing computer programmes and their application in order of integrating the working environment process engineers and design engineers.

Next form of applying operators is decision tables. Decision tables serve for presentation of the decision one should take in existing conditions. They are disregarding remaining elements of the decision-making process (aren't describing the way or the addressee of a decision, processes of leading and deducing data). Cause-and-effect relationships are a base of their structure (**if … so**) [14].

The structure of boards consists of four fields. In left area they are presented:
1. descriptions (of list) of conditions - contains descriptions (names) of individual conditions,
2. states (of record) of conditions - contains all combinations of the value which can accept individual conditions (action).

In columns of right area are putted:

1. positions (of list) of conditions (of action) - contains the set of all possible variants of decision
2. states (of record) activities (of action) - contains indicated variants of the decision which should be taken for the determined combination of the value of conditions.

Tables about the expanded record are more brief and simpler to record in a definite programming language. That kind of tables in the algorithmic method mainly was used for determining quantitative technological features on account of simpler relations between individual conditions.

Tables with limited record were applied mainly for the recording of quality-quantitative technological features.

2.1. Operators selection of semi-finished product

Input date to the semi-finished product features creating with applying operators are:

- geometrical form of technical mean
  - geometrical design features Cg
- design of dimensions
  - overall dimensions,
  - characteristic of dimensions,
- serial of the production.

The scheme selection qualitative and quantitative features of semi-finished product present Fig. 4.

Selection features of semi-finished product is realize whit use standard technological structures.

The operators were distinguished:

- form of semi-finished product $O_{\Gamma pf}$,
- dimensions O_{Wpf},

The application selection dimensions of semi-finished product whit use Auto Lisp program show Fig. 5. Decision board part of program show Table 1. Dimensions value are rounding to overall number (typical dimensions of semi-finished product, rollers, pipes). Conditions are writing in the form of decision rule, Table 1.
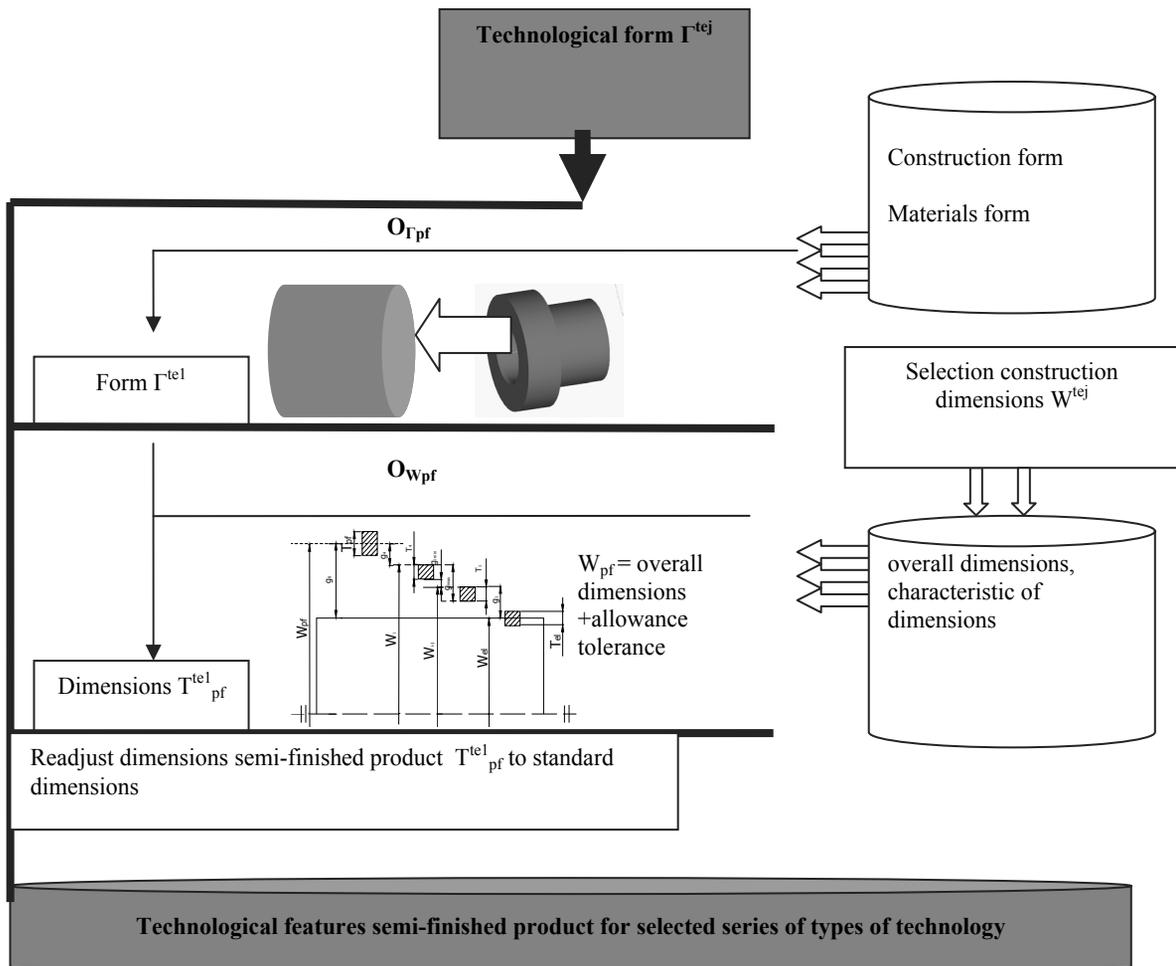

Fig. 4. The selection scheme of features of semi-finished product with operators use
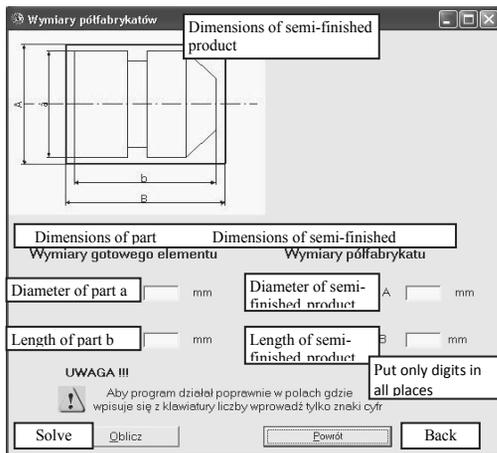
Fig. 5. Box of semi-finished product

Table 1.
Selection dimension of semi-finished product

```
1:    (defun fDoborPolfabrykatu(rWymiar)
2:      (setq lWymiaryPretow '(25 30 35
3:    38 40 45 48 50   55 60 63 65 68 70 75
4:    80 85 90 95 100 105 110 115 120 125
5:    130 135 140 145 150 155 160 165 170
6:    175 180 190 200)
7:            i  0)
8:      (while (< i (length
9:    lWymiaryPretow))
10:      (setq j i)
11:      (if (<= (nth i lWymiaryPretow)
12:    rWymiar)
13:        (progn
14:          (setq j (+ i 1))
15:    (setq rWymiarPolfabrykatu (nth j
16:    lWymiaryPretow))
17:        )  END: progn
18:      ) ; END: if
19:      (setq i (+ i  1))
20:      (setq rWymiarPol1 (- (+
21:    WymiarPolfabrykatu 1) 1))
```

The selection of the parameter is realized by the function of name fDoborPolfabrykatu. The function requires determining one parameter - rWymiar. This parameter is describe by overall dimensions of elements.

2.2. Operators selection of technological structure

Input date in process of series of types technology creating is typically   technological structure (form). Technological operators are connected with define typically   technological structure Γ^{tej}, modification and generation selection features of structure. In process created technological structure for series of types of construction is connected with selection technological structure for one **typosizes** (traditional way). Next element of series of types have the same structure (or slightly modified), Fig. 6.
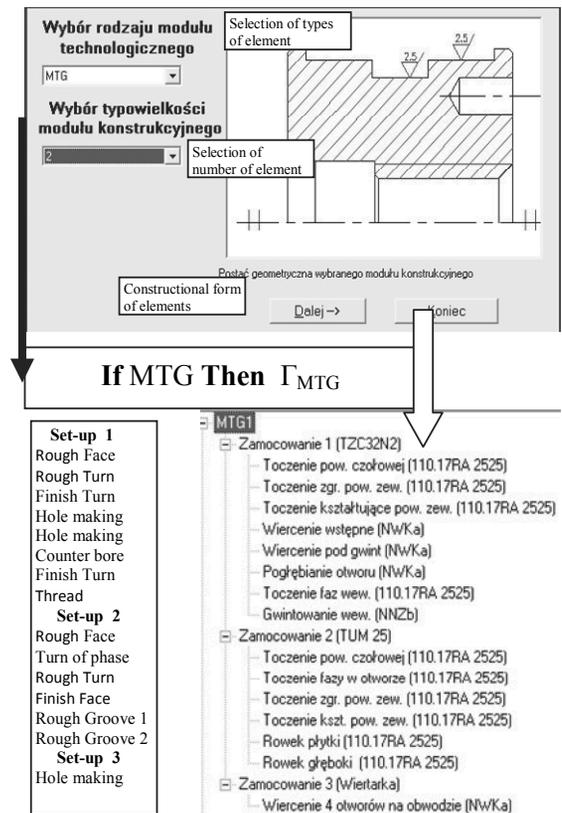

Fig. 6. Dialog box of technological structure

2.3. Operator selection of tools

Selection of tools is depended   from kind of machine processing. Use operators selection of tools results directly from determining preliminary parameters of processing

Determining tools in process series of types of technology is being carried out with applying relational databases and decision tables, Fig. 7. Tools is define on the basis input technological features: feeds f_i, minimum and maximum depth of cut a_{pi}, dimensions of semi-finished product, type of processing.

	R1	R2	R3	Rn
cks_i^{tel} (d_i)>	10	100	100	-
cks_i^{tel} (d_i)<	100	200	200	-
cks_i^{tel} (l_i)>	10	150	10	-
cks_i^{tel} (l_i)<	150	250	100	-
Machine	Turning lathe TKX-50N	Turning lathe TKX-50N	Turning lathe TUD 50x2000	-
Type of lathe chuck	A80	A200	A200	-
Lathe center	-	T	-	-
Kind of lathe chuck	three-jaw chuck	-	three-jaw chuck	-

Fig. 7. Decisions board of selection of cutting tools

2.4. Operators selection of cut

Technological operators connected with selection parameters of cut describe quantitative issues in process series of types of technology creating. Selection parameters of cut with mathematical operators is use and decision boards. Operators distinguished of cut parameters:

- selection depth of cut OPS_{ap},
- selection of feeds OPS_f,
- selection of rotational speed OPS_n,
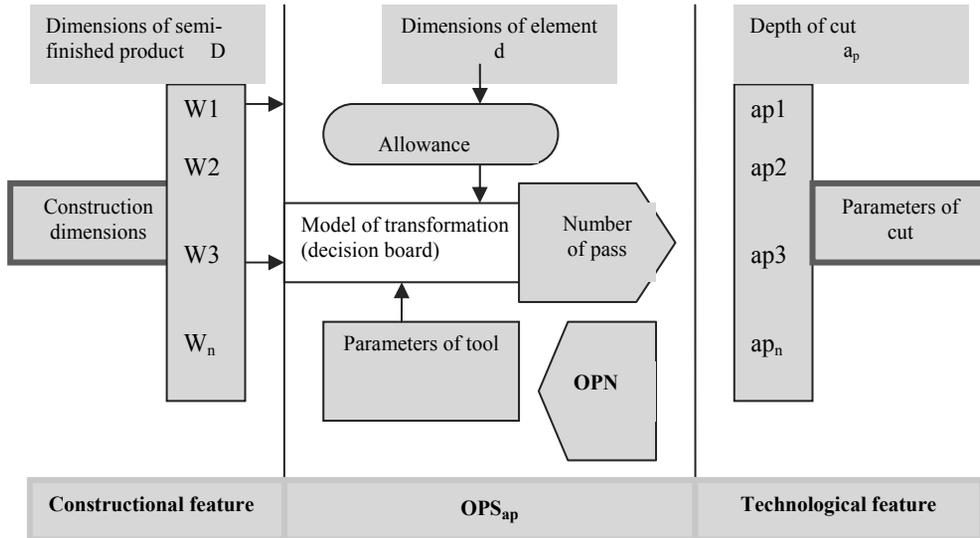- machining cutting speed OPS_v.

Fig. 8. Operators selection of minimum and maximum depth of cut
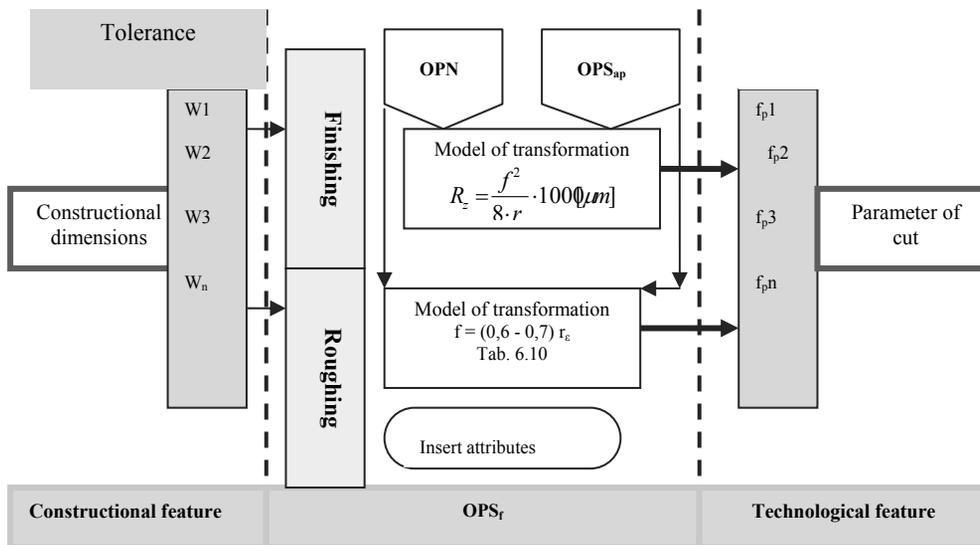

Fig. 9. Operators selection of feeds

The example of operator mathematical dependence selection of rotational speed and operator selection of feeds presented in Equations 2 and Equations 3, where:

d_i, R_z- constructional features,

v_i, n_i, f_i-technological features.

$$CK^{te_j}(d_i) \xrightarrow{\quad operators \quad of \quad n \quad} CTe^{tej}\left(n_i = \frac{1000v_i}{\pi d_i}\right) \qquad (2)$$

$$CK^{te_j}(R_{zi}) \xrightarrow{\quad operators \quad of \quad f \quad} CTe^{tej}\left(f_i = \sqrt{\frac{8R_z r_\varepsilon}{1000}}\right) \qquad (3)$$

The decision boards are the basic form of applying the operators. They were examined and apply decision board with limited record and decision board with extended record. Example of decision board with extended record is presented on Fig. 10.

	R1	R2	R3	R4	Rn
Range of feature $ck_i^{te1} >(d_i)$	50	60	70	90	-
Range of feature $ck_i^{te2} <(d_i)$	60	70	90	100	-
Range of feature $ck_i^{te3}(Ra_i)$	5	1,5	2,5	1,25	-
Value of feature $cte_i^{te1}(f_i)$	0,3	0,2	0,1	0,15	-
Value of feature $cte_i^{te2}(n_i)$	1500	1300	1400	1220	-
Value of feature $cte_i^{te3}(a_{pi})$	1	0,5	0,3	0,1	-

Fig. 10. Example of decision board with extended record used in application

The specified rule is applicable e.g.: R1, when the range of feature d_i comprises in range ck_i^{te1} (50)i ck_i^{te2} (60), and value $ck_i^{te3}(Ra_i) = 5$, then are defined technological features as $cte_i^{te1}(f_i)=0.3$, $cte_i^{te2}(n_i)=1500$, $cte_i^{te3}(a_{pi})=1$.

The process selection of feed and depth of cut with applying operators show Figs. 8, 9. Operator selection depth of cut is a post of the operator of the assortment of the tool. Feed operator results from the surface roughness.

3. Application of selection of technological features on the basis constructional features

In order to using worked out algorithms and methods of determining individual technological features, was worked out an application letting for semi-automatic generating quantitative elements of technological documentation „Technology" with applying algorithmic methods and technological similarity, Fig. 11. Working of the application is presented for ordered the family of the structure of plumbing servomotors made by Fazos company. The application allows to using created methods in cooperation with the program AutoCAD, the program Microsoft Excel and with the database in the program Access.

After starting the application a starting window is coming in. In next step they are making the choice of the method of the selection of technological features. It can be realized for singular experiments and for determined typosize of the cylinder S_ 51 _ 41 _ 12 _ 21 _ 32 _ 350. After making a choice of the first option we have the possibility of the selection of technological features resulting from the program

After starting the next bookmark, should be made a choice of typosize from produced elements of the plumbing servomotor. A next dialog box allows for the read-out of the information about the chosen module in area Structural Data.

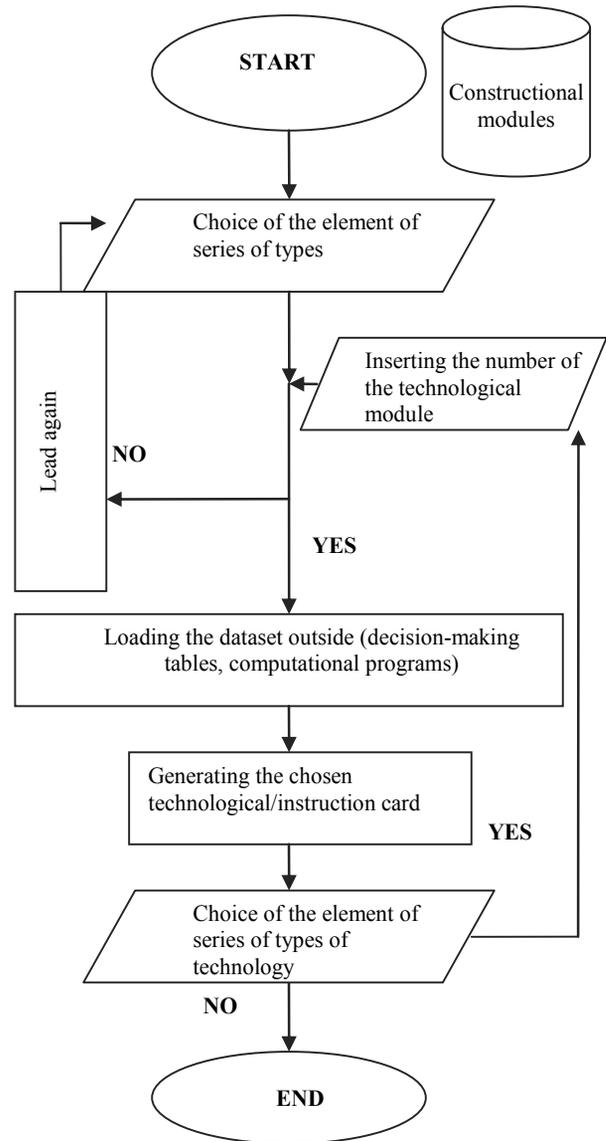**Implementing placing and determining program files**

Fig. 11. Scheme of application „Technology"

The user has the possibility to submit:

- picture 2 D of chosen typosize,
- picture 3 D,
- structural documentation of elements of the servomotor for whole typoseries in the form of working drawings in the program AutoCAD,
- structural dimensions in the form of the data table (Microsoft Excel).

Possible is generating technological documentation with applying the application AutoCAD. Program for chosen typosize generated the technological card and instruction cards based on operators.

4. Conclusions

The methods formation as well as their application concern the machining processes:

- turning,
- milling,
- drilling.
- Main conclusions from operators use are:
- the division of constructional features and technological ones on qualitative and quantitative features introduces the order among the definitions and notions as well as the worked out methods,
- qualitative technological features defined in the paper depending on qualitative constructional features allow for elaborations methods of their transformations,
- the distinguished technological operators allowed to create technology oriented on series of families types of construction,
- computational programmes used to select quantitative, technological feature are the result of algorithmic method.

References

[1] J. Dietrych, System and construction, WNT, Warsaw, 1985 (in Polish).

[2] P. Gendarz, Methodology of creating of ordered sets of construction of machine engines, The scientific exercise book of Silesian University of Technology, Mechanics, 141, Gliwice, 2002 (in Polish)

[3] Z. Adamczyk, K. Kociolek, CAD/CAM technological environment creation as an interactive application on the Web, Journal of Materials Processing Technology 109/3 (2001) 222-228.

[4] F. Gabryelewicz, Typification of production in engineering industry, WNT, Warsaw, 1976 (in Polish).

[5] A. Baier, Aiding of design, virtual creation and investigation of machine elements and group of elements, Proceedings of the 3rd Scientific Conference on Materials, Mechanical and Manufacturing Engineering, Gliwice – Wisła, 2005, 639-644.

[6] A. Buchacz, Modelling of robots by means the hypergraphs method. Achievements in mechanical and materials engineering, Proceedings of the 9th International Scientific Conference "Achievements in Mechanical and Materials Engineering" AMME'2000, Gliwice – Sopot – Gdańsk, 2000, 63-66.

[7] C. Grabowik, R. Knosala, The method of knowledge representation for a CAPP system, Journal of Materials Processing Technology 133 (2003) 90-98.

[8] J. Świder, K. Herbuś, P. Ociepka, The application of object methods for functional features representation, Proceedings of the 12th International Scientific Conference "Achievements in Mechanical and Materials Engineering" AMME'2005, Gliwice – Zakopane, 2005, 16-19.

[9] G. Pahl, W. Beitz, Science of construction, WNT, Warsaw 1984, (in Polish).

[10] Z Siuzdak, J. Wisniewski, Group Processing, Warsaw, 1964 (in Polish).

[11] R. Rząsiński, P. Gendarz, Methods of creation series of types of technology, Journal of Achievements in Materials and Manufacturing Engineering 36/2 (2009) 150-159.

[12] R. Rząsiński, P. Gendarz, The creation of ordered technologies on the basic of ordered constructions of machines, Proceedings of the 3rd Scientific Conference "Materials, Mechanical and Manufacturing Engineering" MMME'2005, Gliwice – Wisla, 2005, 203-207.

[13] P. Gendarz, P. Chyra, R. Rząsiński, Constructional similarity in process of ordered construction families creating, Journal of Achievements in Materials and Manufacturing Engineering 29/1 (2008) 53-56.

[14] F. Čus, B. Mursec, Databases for technological information systems, Proceedings of the 9th International Scientific Conference "Achievements in Mechanical and Materials Engineering" AMME'2000, Gliwice – Sopot – Gdansk, 2000, 271-274.

[15] S. Tkaczyk, M. Skucha, The application of the Balanced Scorecard Method in Organization Management, Proceedings of the 9th International Scientific Conference, "Achievements in Mechanical and Materials Engineering" AMME'2000, Gliwice – Sopot – Gdansk, 2000, 549-552.