MANUFACTURING STATION SELECTION RULES IN MACHINING PROCESS PLANNING SYSTEM

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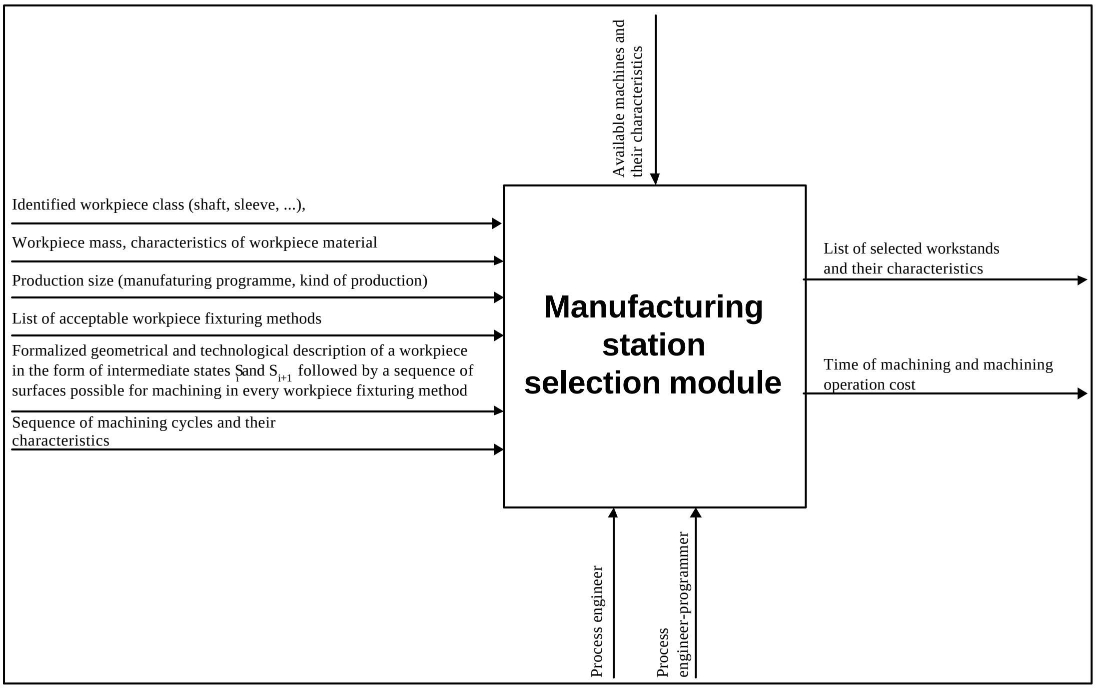
SUMMARY: *This paper presents the description of manufacturing station selection module in machining process planning system. Principal planning activities included in this module, set of selection rules forming knowledge database and essential databases are discussed.*

1 Introduction

Manufacturing station selection procedure is one of the principal modules of the machining process planning system [1]. As a result of this procedure, set of manufacturing stations that meet requirements of a specified machining operation is selected. General schema for manufacturing station selection module is shown in Fig. 1. Input information of that module includes:

?? identified workpiece class (shaft, sleeve, ...),
?? workpiece mass, characteristics of workpiece material,
?? manufacturing programme of a product followed by part a production size (manufacturing programme, kind of production),



Firure 1. General schema of manufacturing station selection module

?? list of acceptable workpiece fixturing methods,
?? formalized geometrical and technological description of a workpiece in the form of states S_i and S_{i+1} followed by a sequence of surfaces possible for machining in every workpiece fixturing method,
?? sequence of machining cycles and their characteristics.

Output information of that module includes:

?? list of selected manufacturing stations and their full characteristics,

?? time of machining and machining operation cost for every selected manufacturing station.

2 Manufacturing station selection module characteristics

Detailed schema of manufacturing station selection module is presented on Fig. 2. It includes of basic planning activities allowing selection of manufacturing station contained in a database according to the specified criteria and in conformity with their significance. The basic planning activities are:

?? manufacturing station selection in respect to:

  ?? acceptable workpiece mass,

  ?? type of workpiece material,

  ?? overall workpiece dimensions,

  ?? workpiece production size,

?? manufacturing station selection in respect to the accepptable workpiece fixturing methods,

?? manufacturing station selection in respect to the surface machining realisability (sequence of machining cycles) for selected acceptable workpiece fixturing methods,

?? manufacturing station selection in respect to the:

  ?? required motor power of applicable drives,

  ?? power utilisation coefficient (permissible load factor) of a motor for the given production size,

  ?? machining operation cost per unit.

The primary database of the module is machine database which is used by manufacturing station selection module. This database contains information concerning machine characteristics and information concerning available workpiece instrumentation and tooling. Module uses also auxiliary databases – workpiece instrumentation database, tooling database and alternatively tool database and subsystems of: formalised workpiece description, formalised technological activities (machining cuts) description, machining process structure description, workpiece fixturing method selection, machining parameters selection, determining machining operation cost per unit.

Planning knowledge base includes set of manufacturing station selection rules because machines with tooling and workpiece instrumentation i.e. manufacturing stations are selected. The primary rules are:

?? manufacturing station selection rules in respect to the allowable workpiece mass, type of workpiece material, overall dimensions and production size specified by production type and production programme of a given workpiece (i-th workpiece in a product) P_i [2], [3], [5]. Production programme P_i results from

$$P_i = P\, n_i \left(1 + \frac{z}{100\%}\right)\left(1 + \frac{b}{100\%}\right) \qquad (1)$$

where: n_i – number of pieces of the i-th workpiece in a product, z – percentage of spare parts, b – percentage of expected defective workpieces.

?? manufacturing station selection rules in respect to the machining realisability of surface sets (machining cycles sequence) for selected acceptable workpiece fixturing methods [2], [3], [4], [5], [6]. These rules concern especially machining realisability of individual surfaces with specified parameters (depth of cut, rate of feed, speed of cut) and specified linear and angular displacement. Selected manufacturing stations should allow realisation of machining cuts sequence with parameters determined by machining parameters selection subsystem,

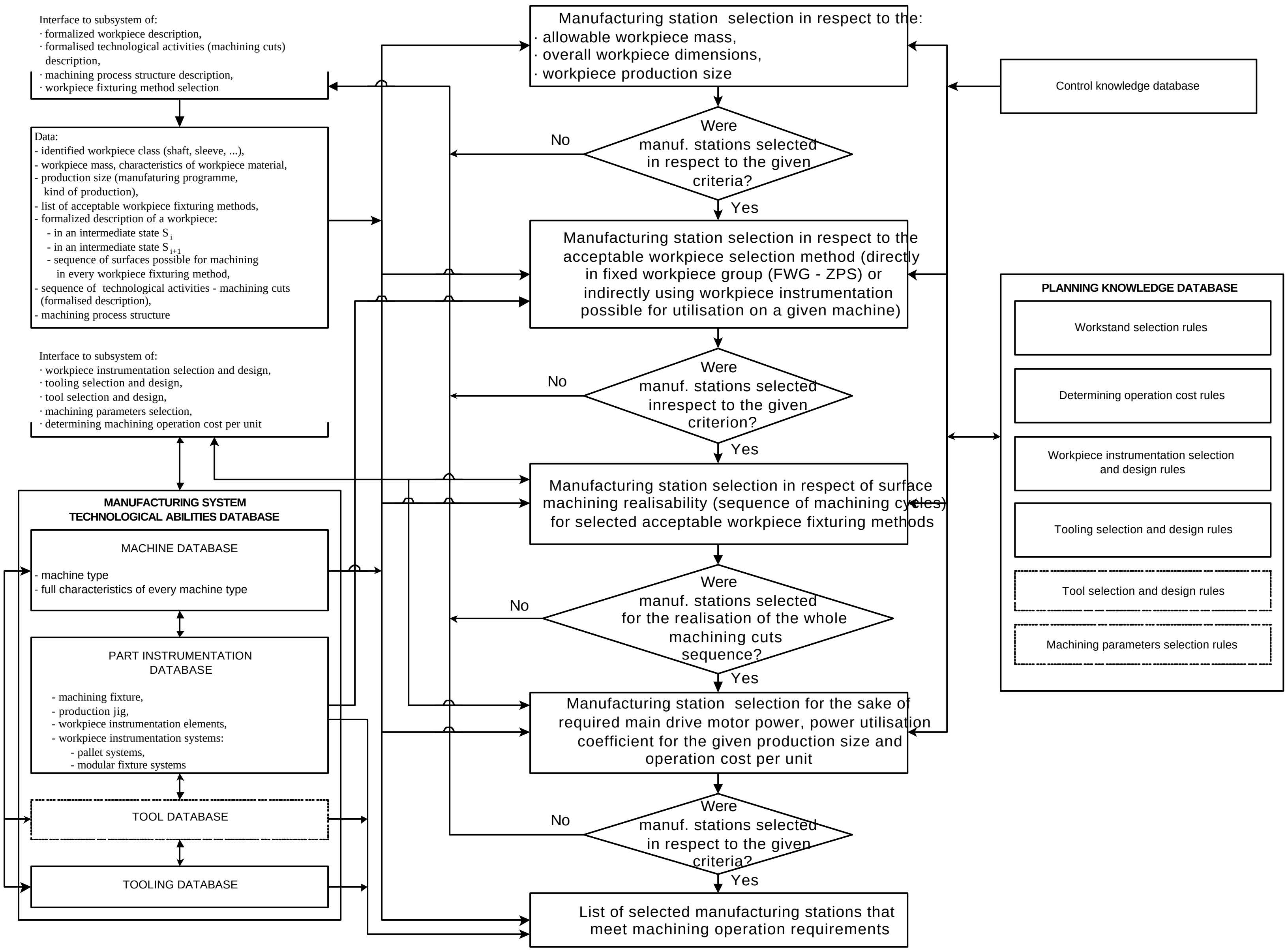


Figure 2. Schema of manufacturing station selection subsystem in machining process planning system

?? manufacturing station selection rules in respect to the motor power of applicable machine drives and power utilisation coefficient (permissible load factor) of a motor for the given production size. Required motor power P_{sw} (formula 3) results from the effective cut power P_e [4]

$$P_e ? \frac{F_c v_c}{60\,000} ? \frac{C_z f^{u_z} a_p^{e_z} ? \; K_F v_c}{60\,000} \quad kW \tag{2}$$

where: F_c – main cutting force in N, $?_c$– speed of cutting in m/min, f – feed in mm/revolution, $?_p$– depth of cut in mm.

$$P_{sw} ? \frac{P_e}{?} \tag{3}$$

where: ? - driving motor and machine capacity coefficient equal to 0,75 ? 0,85.

Power utilisation coefficient is calculated from the formula:

$$? \; ? \; \frac{P_{sw}}{P_{sd}} \tag{4}$$

where: P_{sd} – motor power of machine

Depending on production size, different values of power utilisation coefficient ? are used:

?? unit and low-serial production: ? = 0,4 ? 1,0,

?? serial production: ? = 0,6 ? 1,0,

?? high-serial and mass production: ? =0,8 ? 1,0.

If the value of the coefficient (calculated according to the formula (4)) is in the one of the specified ranges then the selected machine meets selection criterion. Thus energetic constraint (condition of full power utilisation) arising from the formulas above should be also meet

$$P_e(a_p, f, v_c) ? P_{sd} ? ? \tag{5}$$

In the case of rough machining, condition of full power utilisation, while minimising machining cost per unit, is calculated from

$$\begin{array}{c} P_e(a_p, f, v_c) ? P_{sd} ? ? \\ K_j(a_p, f, v_c) ? K_{j\,min} \end{array} \tag{6}$$

As a result of selection procedure we have:

?? set of manufacturing station meeting all requirements (all selection criteria) of the given machining operation,

?? null set, if none of the requirements is meet,

?? set of manufacturing station meeting some requirements (some selection criteria).

In this case, selected manufacturing stations could be used for realisation of a specified machining operation after modification of requirements which were not meet. This is possible thanks to interface between computer programme and subsystems of:

?? formalized workpiece description,

?? formalized technological activities (machining cuts) description,

?? machining process structure description,

?? machining parameters selection,

?? workpiece fixturing method selection,

?? workpiece instrumentation selection and design,
?? tooling selection and design,
?? tool selection and design,
?? determining machining operation cost per unit.

3 Conclusion

Manufacturing station selection rules, presented in this paper, were used to develop experimental versions of computer software. First two versions were implemented with of Microsoft Access 97 (Figures 3, 4, 5) and Borland Delphi 3.0 (Figures 6, 7) [7]. At present we are working on manufacturing station selection programme that uses client-server architecture [8]. Developed software could be utilised in technological offices as modules of process planning systems or as separate manufacturing station selection programme.

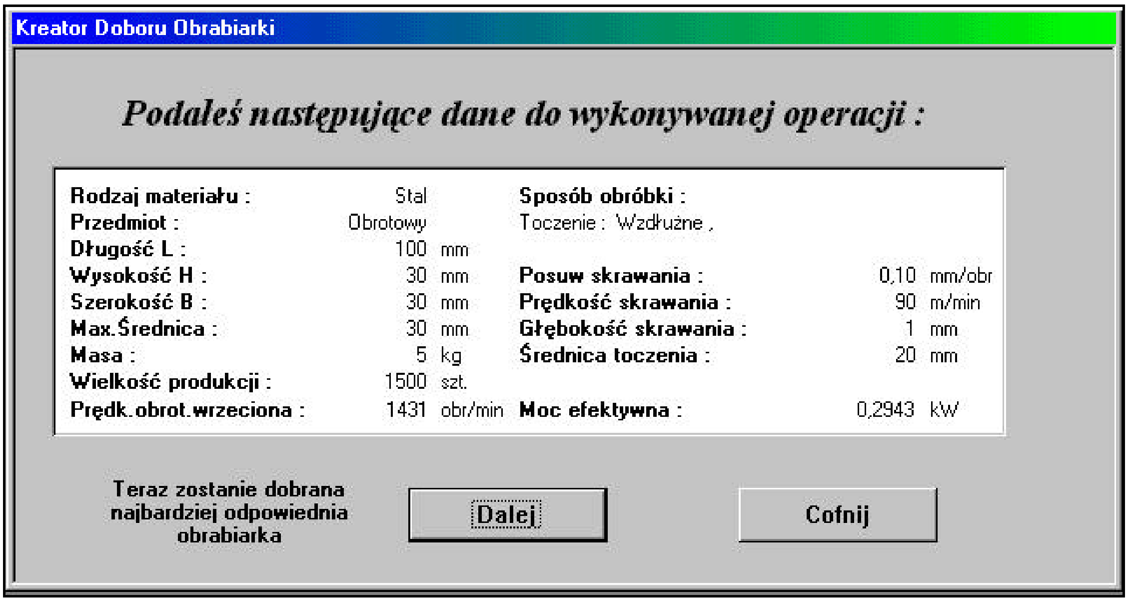


Figure 3. Data for turning operation (first version)

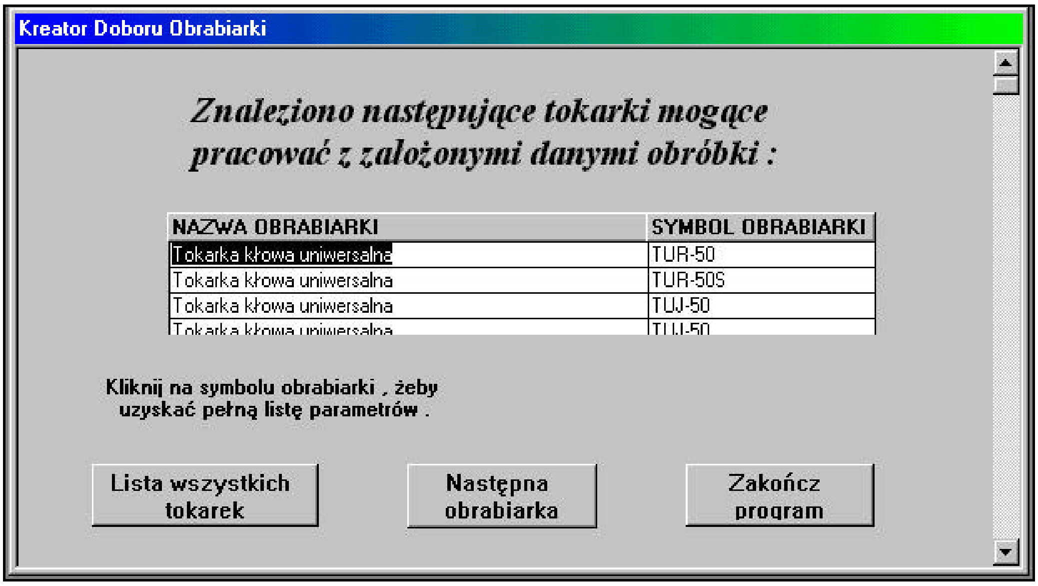


Figure 4. List of selected machines that meet specified criteria (first version)

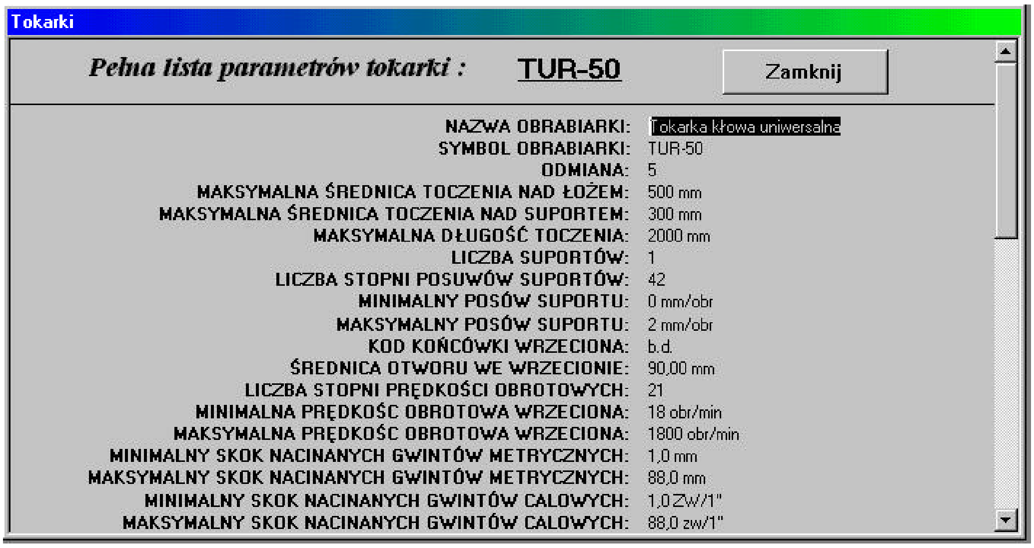


Figure 5. Characteristics of a first machine from the list of selected machines (first version)

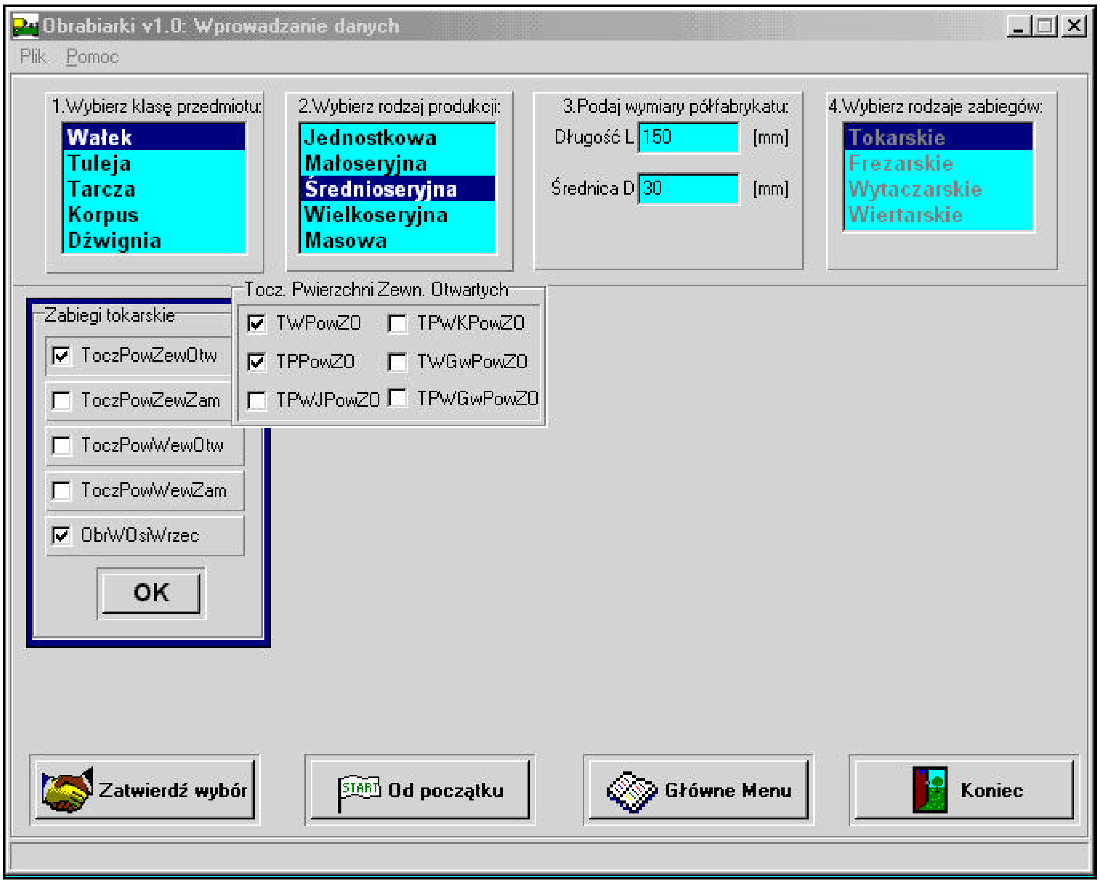


Figure 6. Data for turning operation (second version)

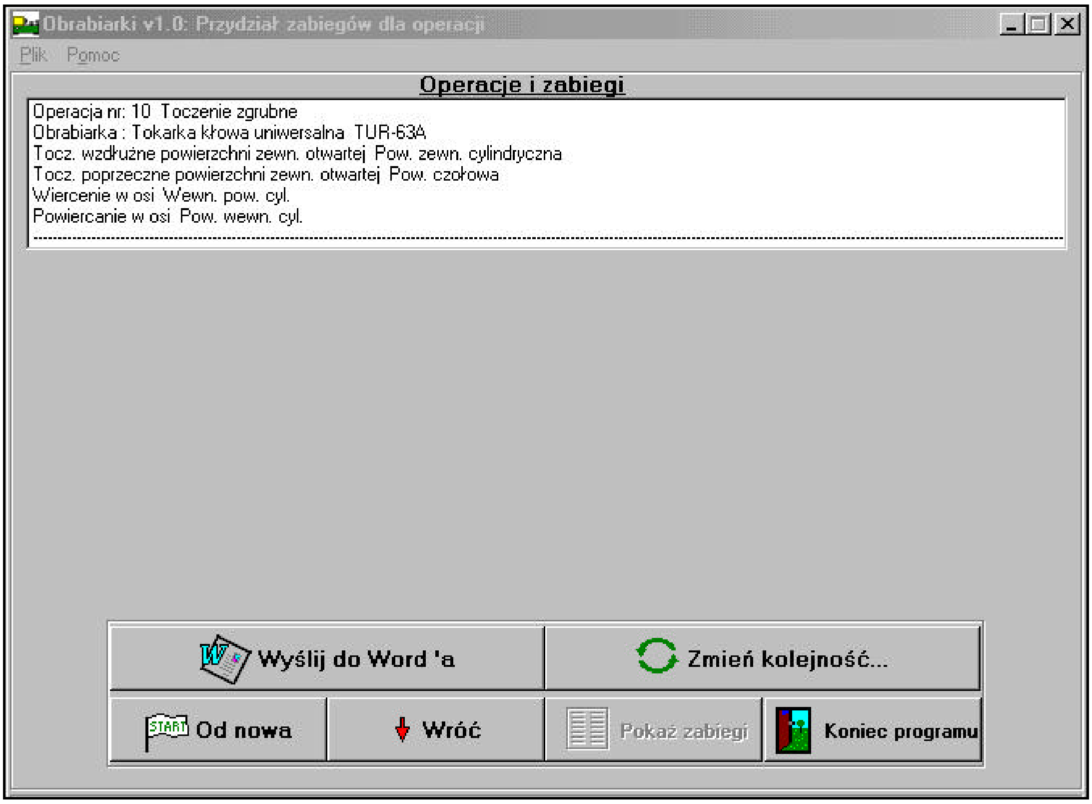


Figure 7. Machine selection results for rough turning operation (second version)

4 Literature

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