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A SYSTEM FOR CHOOSING LATHE KNIVES AND OPTIMIZATION OF THE CUTTING MODES WHEN TURNING

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ABSTRACT: *The task of choosing lathe knives with removable laminas and optimi8zation of cutting modes while turning is viewed as one stage of the production process design. The paper offers a computer programme system, comprised of two interconnected sub-systems. The first one, aided by the developed arithmetic and logical procedures, is used for choosing a set of knife – holders and hard-alloy laminas appropriate for the particular type of turning. The second sub-system performs optimization of cutting modes using a mathematical model with object function prime cost and efficiency.*
KEYWORDS: *optimization, model, system, cutting modes, turning*

INTRODUCTION

The development of the manufacturing production is characterized by constant growth of the nomenclature and the complexity of the manufactured products. At the same time there are higher requirements for their technological and economical level as well as their quality. These circumstances influence directly on the time and quality of the technological setup of the production. The choice of cutting tools and the determination of cutting modes are essential stages in designing the technological processes. Most often the choice of tool holders and inserts is done manually using the reference information given in [4] and [5]. This is a labour intensive activity and thus it is advisable that the choice is automated. When the lathe knife (tool holder and insert) is chosen, then the optimization of the cutting modes when turning may be done using the algorithm and the computer programme given in [3]. The main goal of the present work is to present a computer programme system for choosing lathe knives and optimization of the cutting modes when turning.

The proposed computer programme system consists of two subsystems. The first subsystem is used for choosing lathe knives, and the second one – for optimization of the cutting modes (OCM).

DESCRIPTION OF THE SYSTEM FOR CHOOSING LATHE KNIVES AND OPTIMIZATION OF THE CUTTING MODES

The choice of lathe knives requires solving two interdependent tasks – sorting of cutting tools and choice of the necessary size of the tool. The sorting task is a preliminary one and this is why it is performed beforehand. Specific tables, containing data about various types of lathe knives and inserts, have been developed and are given in [4] and [5]. The data base is presented in the form of reference and logical tables. Specifying the size of the tool holder requires the completion of the following sub-tasks:

- □ *Determining a multitude of alternative solutions.*
- □ *Determining the technically acceptable solutions.*
- □ *Assessment of the solutions based on technical and economical criteria.*

The method for choosing a tool holder, presented in [5] has been used to solve this task. The necessary details and specification of the goals of the automated choice have also been done. According to the developed methodology the task is divided into two main stages. During the first stage, related to choosing a tool holder, the following tasks have been completed:

- □ *Preliminary choice of a tool holder – all tool holders that can be used to perform the specific processing are determined.*
- □ *Specifying the size of the tool holder – it is done using a data base and depending on the chosen insert.*

The second stage- selection of a cutting tip (insert), consists of the following tasks:

- □ *Determining the shape of the insert.*
- □ *Determining the type of the insert – this unambiguously determines the way of fixing the insert to the tool holder.*

- *Determining the length of the cutting edge (for round inserts - the diameter of the insert).*
- *Determining the geometrical parameters – choice of the thickness of the insert and the radius at the tip; for non-standard inserts – also the geometrical parameters, given in [5].*
- *Determining the grade of the tool material – the decision depends on the properties of the machined material and the cutting conditions.*

Solving the tasks on both stages is performed with the aid of the developed arithmetic and logical procedures.

The second subsystem for optimization of the cutting modes uses a mathematical model, given in [1]. Eleven technical limitations have been formulated:

$$\begin{array}{llll} 1. & f \ge f_{min} & 7. & F_p \le F_{pmax} \\ 2. & f \le f_{max} & 8. & F_f \le F_{fmax} \\ 3. & v_c \ge v_{cmin} & 9. & R_a \le R_{amax} \\ 4. & v_c \le v_{cmax} & 10. & T \ge T_{min} \\ 5. & P_c \le P_{cmax} & 11. & T \le T_{max} \\ 6. & F_c \le F_{cmax} & & \end{array} \qquad (1)$$

As the target function can be used either the technological cost

$$K = C_1.v_c^{-1}.f^{-1} + C_2.v_c^{n_T-1}.f^{y_T-1}, \text{ BGN/min.,} \qquad (2)$$

or the technological productivity

$$Q = 1/\left(t_m + \frac{t_{cM}}{T}.t_m\right), \text{ parts/min.} \qquad (3)$$

The optimal cutting mode is determined using the 'directed search' method [2]. Figure 1 shows the structure of the system for choosing lathe knives and OCM. The process begins (block 1) with selection of the working mode of the system: KZ = 1 – choice of a lathe knife; KZ = 2 - choice of a lathe knife and optimization of the cutting modes, and KZ = 3 - optimization of the cutting modes. Depending on the selected working mode of the system, the necessary input information is entered using the computer (operations 1, 2, 13). The working sequence of the subsystem 'choice of a lathe knife' is shown in blocks 3, ..., 12. When KZ = 2 (block 12), in order to optimize the cutting modes for the selected cutting tool, the control of the system is transferred to block 14. If the problem being solved is only 'choice of a lathe knife', then in block 20 a text file of the results is generated. This file can be viewed on the monitor or printed using a printer.

The 'optimization of the cutting modes' subsystem works in three modes, based on the target function(s): technological cost, technological, or both. The working mode of the subsystem is being input depending on the preferences of the user.

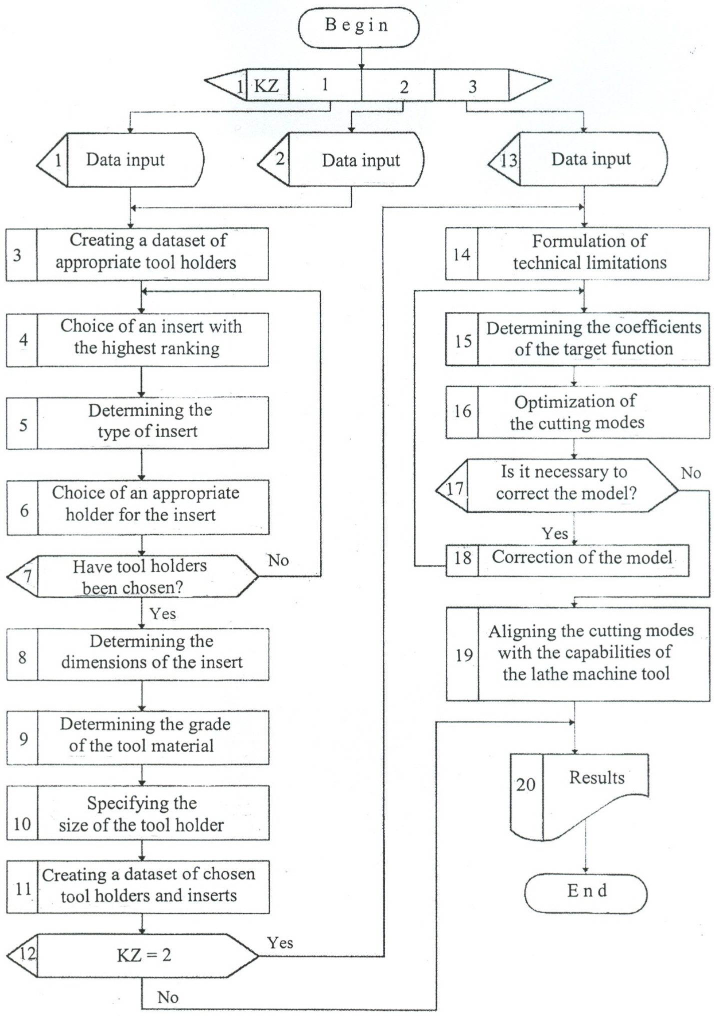

Figure 1. Structure of the system for choosing lathe knives and optimization of the cutting modes when turning

The computer programme system has been developed using the algorithm language FORTRAN.

Table 1 presents the typical input data for the solved example and the results obtained for a selected working mode – choice of a cutting tool and optimization of the cutting modes, based on both criteria – technological cost and technological productivity.

Table 1

INPUT DATA	
Machined material	- Cast iron
Brinell hardness, HB	- 200
Diameter of the machined surface D, mm	- 55,00
Depth of cutting a_p, mm	- 2,80
Length of the machined surface l_c, mm	- 100,00
Roughness of the machined surface R_z, mm	- 40
Type of machining	- lengthwise outside
Character of machining	- semi-fine
Machine tool	- C10M
LATHE KNIVES	
Tool holders - ISO	**Cutting tips (inserts) - ISO**
PSSNR 1616 J09	SNMM 090308
PSDNN 1616 J09	SNMM 090308
CSDNR 2020 K12	SNGN 120408
CSBNR 2020 K12	SNGN 120408

Optimization criterion: TECHNOLOGICAL COST			
Parameters		**Optimal**	**Real**
Cutting speed	v_c, m/min	65,668	69,080
Feed	f, mm/rev.	0,510	0,510
Technological cost	A, BGN/part	0,053	0,054
Technological productivity	Q, part/min	2,523	2,635
Time for machining	t_m, min	0,26	0,25
Rotation speed	n, 1/min^{-1}	380,0	400,0

Optimization criterion: TECHNOLOGICAL PRODUCTIVITY			
Parameters		**Optimal**	**Real**
Cutting speed	v_c, m/min	104,077	86,350
Feed	f, mm/rev.	0,510	0,510
Technological cost	A, BGN/part	0,112	0,128
Technological productivity	Q, part/min	3,278	3,265
Time for machining	t_m, min	0,16	0,20
Rotation speed	n, 1/min^{-1}	602,3	500,0

CONCLUSIONS

1. *The developed system for choice of lathe knives with changeable inserts and optimization of the cutting modes when turning provides a many fold reduction of the time for technological setup of production.*
2. *The system is an improvement since it takes into account the technical and economical production conditions in the companies.*

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