APPLICATION AIDING RAPID SELECTION OF CUTTING PARAMETERS ON THE EXAMPLE OF ALUMINUM ALLOYS TURNING

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Abstract:
The work presents an application for rapid selection of cutting parameters. Cutting speed and feed rate are selected with regard to desired surface roughness. The program described matches the parameters to determined cutting conditions using the data form experimental research. Further, planned works to develop the application are also described.

Keywords
turning, cutting parameters, aluminum alloys, optimization

1 INTRODUCTION

The development of technology, both in the last years of the last century, as well as today was possible, undoubtedly, thanks to the achievements of materials engineering. Each year, the number of construction materials designed and implemented for industrial production increases. It is, however, worth remebering that their effective use is possible only after a difficult and time-consuming research. Part of these studies are undoubtedly the experiments leading to understanding the mechanisms of decohesion and describing machining properties of new construction materials. Examples are testing the machinability of composites [1,6] or nickel-based superalloys [4]. Also, the development of information technology had a huge impact on increasing the speed of technological development. Currently, experimental studies are supported or sometimes even replaced by computer simulations. IT tools are used at all stages of production, from design to verification of the results. Examples are attempts to model the cutting process using FEM [3] or the use of CAD software for designing cutting tools [2].

2 METHODOLOGY FOR SELECTION OF CUTTING PARAMETERS

Selection of optimal cutting parameters for the defined conditions of machining ensures the quality of the surface closest to the expected. Despite the fact that manufacturers provide recommended cutting parameters and modules for calculating the best cutting parameters, those should not be always believed blindly. It is related to the fact that the surface roughness is affected by many factors, including factors related to specific conditions such as machine tool [5]. It is therefore advantageous to develop programs aiding fast selection of parameters, especially for specific machining conditions. To create a program presented in the article the following actions were carried out :

- experimental turning test were conducted on aluminum alloys in accordance with parameters recommended by tool's manufacturer,
- based on the results of roughness measurements, the relations between cutting parameters and roughness parameters were determined,
- matrices of roughness parameters were calculated according to the functional dependences R(v_c) and R(f) and a computer application was built.

Additional advantage of the presented applications is the fact that it works in Office environment, which is known to almost everyone, and that it enables the use of its free versions.

3 EXPERIMANTAL TURNING TESTS OF ALUMINUM ALLOYS

3.1 Research conditions

Experimental test consisted in turning aluminium alloys with different hardness. Three materials with following designations and hardness were selected for the research:

- alloy 6082 – hardness 90HB,
- alloy 2017A – hardness 110HB,
- alloy 7075 – hardness 150HB.

Turning test were conducted on TUR 560MN universal machine tool. Each of the 300 mm long samples was prepared by separating on them 15 12 mm segments before the test were started. Wide range of cutting parameters was applied:

- cutting speed v_c - 200, 400, 600, 800, 1000m.min^{-1};
- feed rate f - 0,08, 0,13, 0,27 mm.rev^{-1};
- depth of cut a_p - 0,2; 0,5; 1 mm.

In the research, Sandvik insert TCGX16T304AI made of sintered carbide H10, was used. Measurements of the roughness parameters Ra, Rz, Rt was realized with use of Hommel Tester T1000 profile measurement gauge. Parameters were measured in three positions, then the average for each set of cutting parameters was calculated. Example test results, which were used to create the computer application, are presented in figures 1 and 2.

Results obtained in the experimental tests were consistent with those known from literature and practice. As feed was increased roughness also increased significantly whereas the increase of cutting speed had a slight positive influence on roughness. Significant effect of the depth of cut on the values of roughness parameters was not observed, however there were considerable differences when the machined material was changed

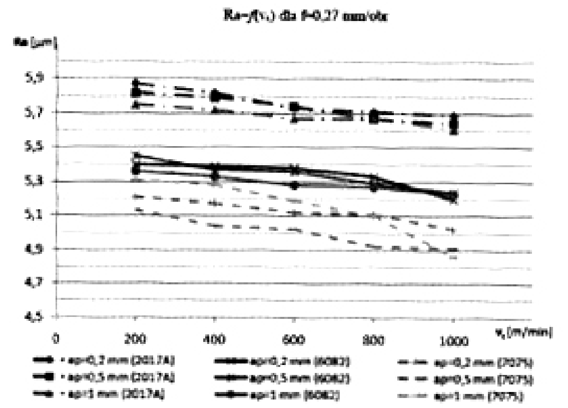

Figure 1 Influence of cutting speed and depth of cut on surface roughness Ra obtained after turning aluminum alloys

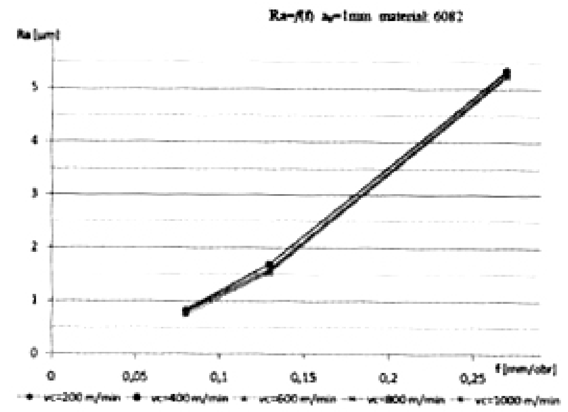

Figure 2 Influence of feed on surface roughness Ra obtained after turning aluminum alloys

4 COMPUTER APPLICATION AIDING THE SELECTION OF CUTTING PARAMTERES.

Based on the results of the conducted research a computer program for rapid selection of cutting parameters was created. Excel calculation sheet included in the Office package was used. The computer program selects cutting parameters with regard to the expected surface roughness. From the range of cutting parameters limited to the ones included in the experiment it selects those parameters which guarantee receiving a specified value of a chosen roughness parameter. The first step in building this application was determining the kind of functional dependence between cutting parameters and roughness parameters. In the simplest cases it is a linear or quadratic function. The next step was placing the results of the experiment in special tables. An example table for roughness parameter Ra after turning of the aluminum alloy 2017A with depth of cut 0.5 mm is presented in figure 3.

Ra	2017A głębokość skrawania 0,5 mm			
	z11	z12	z21	z22
1	1,01	1,56	0,97	1,52
2	1,56	5,82	1,52	5,79
3	0,97	1,52	0,95	1,5
4	1,52	5,79	1,5	5,74
5	0,95	1,5	0,94	1,45
6	1,5	5,74	1,45	5,67
7	0,94	1,45	0,91	1,42
8	1,45	5,67	1,42	5,64

Figure 3 Table „experiment" with the results from experiment..

The method for placing the data was determined by the way the program works. On the one hand, a relation between surface roughness and both cutting speed and feed occurred. On the other it was necessary to asses roughness for those cutting parameters, for which the turning test was not carried out. In the following part the rules for calculating recommended cutting parameters with the use of linear interpolation. Using it makes the program capable of finding optimal speeds in the range between 200 and 1000 m/min with 10m/min increment and feeds between 0,08 ÷ 0,27 mm/rev. with 0,01 mm/rev. increment. The program calculates roughness values using the following code:

*Cells(results_rows,results_columns)= z11 * (((x2 - x) / (x2 - x1)) * ((y2 - y) / (y2 - y1)))+ z12 * (((x2 - x) / (x2 - x1)) * ((y - y1) / (y2 - y1))) + z21 * (((x - x1) / (x2 - x1)) * ((y2 - y) /(y2 - y1))) + z22 * (((x - x1) / (x2 - x1)) * ((y - y1) / (y2 - y1))).*

In fact the program performs linear interpolation, which runs as follows, three times:

- for a combination cutting speed-x and feed-y program finds a neighbouring pair of known values x1, x2 and Leeds y1, y2 and reads the roughness values z11, z12, z21, z22;
- the first and second interpolation is carried out with regard to speed (x1=200 and x2=400), (x1=400 and x2=600), (x1=600 and x2=800), (x1=800 and x2=1000), at constant feed rates 0.008 and 0.13 or 0.13 and 0.27 and calculating intermediate values of zx1 and zx2 roughness;
- the third stage of interpolation is don with regard to feed rate with constant values of speed-x.

Calculations are written in a table (matrix) *results* (fig. 4), using the For.. Next loop where columns correspond to changing values of feed, and rows the values of cutting speed.

	0,08	0,09	0,1	0,11	0,12	0,13
200	5,970	6,406	6,842	7,278	7,714	8,150
210	5,928	6,370	6,812	7,254	7,696	8,138
220	5,885	6,333	6,781	7,230	7,678	8,126
230	5,843	6,297	6,751	7,205	7,660	8,114
240	5,800	6,260	6,721	7,181	7,642	8,102
250	5,758	6,224	6,690	7,157	7,623	8,090
260	5,715	6,188	6,660	7,133	7,605	8,078
270	5,673	6,151	6,630	7,109	7,587	8,066
280	5,630	6,115	6,600	7,084	7,569	8,054
290	5,588	6,078	6,569	7,060	7,551	8,042
300	5,545	6,042	6,539	7,036	7,533	8,030
310	5,503	6,006	6,509	7,012	7,515	8,018
320	5,460	5,969	6,478	6,988	7,497	8,006
330	5,418	5,933	6,448	6,963	7,479	7,994
340	5,375	5,896	6,418	6,939	7,461	7,982
350	5,333	5,860	6,387	6,915	7,442	7,970
360	5,290	5,824	6,357	6,891	7,424	7,958
370	5,248	5,787	6,327	6,867	7,406	7,946
380	5,205	5,751	6,297	6,842	7,388	7,934
390	5,163	5,714	6,266	6,818	7,370	7,922
400	5,120	5,678	6,236	6,794	7,352	7,910

Figure 4 Example fragment of the table of estimated values of roughness parameter.

In the obtained *results* table the program finds solutions for demanded conditions.

The program has one more function. Using the transformed Taylor formula (1) and the relation describing real periodic efficiency of machining, taking into account the drop in efficiency due to the increase in cutting speed, which shortens the cutting edge's life and makes it necessary to replace the tool more often, values of highest efficiency cutting speed - v_{cw} (2)- can be determined.

$$T_c = \left(\frac{C_v}{v_c}\right)^s \qquad /1/$$

$$v_{cw} = \frac{C_{v1}}{[t_z(s-1)]^m} \qquad /2/$$

4.1 Program's manual

User of the program has to go through the several following steps:

a) selection of hardness (or the designation) of the machined alloy using the *UserForm (fig. 5)*;
b) determination of the depth of cut using the *UserForm;*
c) selection of the roughness parameter with regard to which cutting paramteres will be selected;
d) determination of search accuracy for demanded conditions;
e) selection of the demanded value of a roughness paramter.

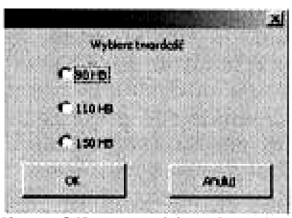

Figure 5 Selction of the machined material's hardness (select hardness) dialogue window.

After inputing the above-mentioned data in accordance with the presented methodology the program finds optimal cutting paramet and presents the in a calculation sheet (fig. 6).

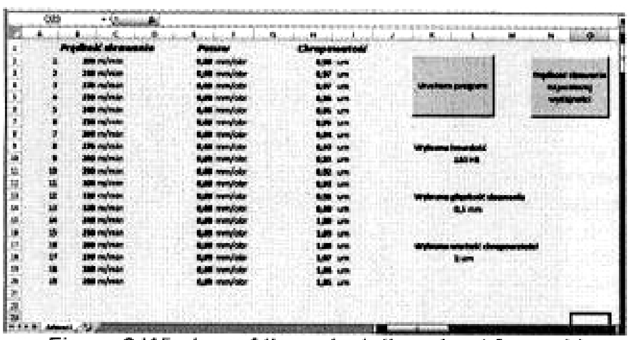

Figure 6 Window of the calculation sheet for rapid selection of the cutting parameters (prędkość skra-wania - cutting speed, posuw - feed rate, chropowatość - roughness, uruchom program - run program, pręd-kość skrawania największej wydajności - highest efficiency cutting speed, wybrana twardość - selected hardness, wybrana głębokość - selected depth of cut, wybrana wartość chropowatości - selected value of roughness).

Moreover, running the module for calculating highest efficiency cutting speed and giving a time value (in minutes) after which the tool should be changed the user will get a value of that cutting speed.

4.2 Consecutive stages of building a complex program aiding the selection of cutting parameters.

In the work the first version a program aiding rapid selection of cutting parameters with regard to surface roughness is presented. Next stages of its development are planned, which will cover:

- increasing the range of applications through adding a possibility to select cutting tools,
- adding functional dependences between surface roughness and hardness of the machined material or depth of cut, and linking them with the existing functions.
- the possibility to load data directly from a calculation sheet, without the need to 'manually' build the *experiment* table.
- creating dialogue windows in English ,
- improving the module for determining highest efficiency cutting speed,
- adding new criteria for searching, for instance based on manufacturing costs.

5 CONCLUSION

The program developed on the basis of conducted research is characterized by ease of use and fast parameter selection. It was developed in an environment known to the majority of computer users. Searched parameters are determined with high accuracy, which can be selected by the user. The program selects parameters from a wide range of solutions without the need for performing many time consuming measurements. Moreover, there is a possibility for developing the program through fast and easy supplementation of information in the data base. Undoubtedly, it can be used as a tool for optimization of cutting conditions, especially in the case of machining new construction materials. Program presented in the is article is just the first version. For full functionality additional research and developing new modules as well as improving the existing ones is needed.

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