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Aspects on Setting Cutting Regime Parameters

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Abstract

In a technological process of production, setting the correct cutting regime parameter values influences productivity processing, manufacturing cost and product quality.

Setting the cutting regime parameters (regardless of cutting scheme) require complex computations and large amount of work.

This paper shows how to determine the parameter values for the milling operation regime cutting keyways, using comparative analytical calculation method (classical) and automatic method (methods specialized computer).

Key words: *analytical method calculation, automatic method, cutting system parameters*

General Considerations

Modern manufacturing processes by machining require the fulfillment of basic requirements relating to: increase the precision of production, increase labor productivity, reduce the cost of manufacturing the product, reducing energy consumption for processing [1, 3, 4]

In the process of execution of a piece, technology-decider formulate decision problems from basic documentation (drawings of the piece, the volume of production) and technical conditions provided by the designer.

Any technological process of machining requires optimum production conditions to determine the parameters of the cutting regime.

When designing cutting regime is adopted or calculate its parameters, namely: cutting depth a_p (mm), working advance f (mm/rev or mm/min), cutting speed v (m/min) speed n (rev/min), torque M_t (N·m) and power consumption machine tools P_c (W) [1, 2, 5].

Determination of cutting regime parameters is performed according to the material being processed, the material and the geometry of the active part of cutting tools and cutting conditions (Table 1).

Part of the information necessary to determine parameter values are obtained by cutting regimes experimental determinations. In this context have developed the following tests: experimental-statistical method, analytical method and automatic method.

If modern production - using CNC machine tools (MUCN) - statistical data obtained by experimental determinations were processed using the analytical method of calculation, processed and correlated with the technical characteristics of machine tools, specialized software resulting parameter choice cutting conditions [6].

In this way, it has been developed an automated method for calculating the parameters cutting conditions (fig. 1).

Table 1. Working conditions and parameters determining cutting conditions

The analysed part	Features
The preform	• The preform type (laminated, molded, forged, etc.) • Type of material (steel, cast iron, alloys, etc.) • The preform stiffness (rigid, non-stiff) • Geometric shape (round, square, disc, flange etc.)
Cutting tools	• The shape and construction of cutting tools (cutting tools in one piece with removable pads) • Active part geometry (geometry negative/positive one/two surfaces to use special chip breaker for long-chipping materials, cutting edge angle curve offsets, chamfer, specially adapted protector for finishing operations, etc.) • Clamping and fastening system
Machine tool	• Machine tool power • The rigidity of technological system-Machine-tool-piece device (MUDSP) • Precision Machining • Mechanical processing productivity • Energy consumption
Cooling-lubrication conditions	• Mechanical processing with or without the use of coolant-lubricant

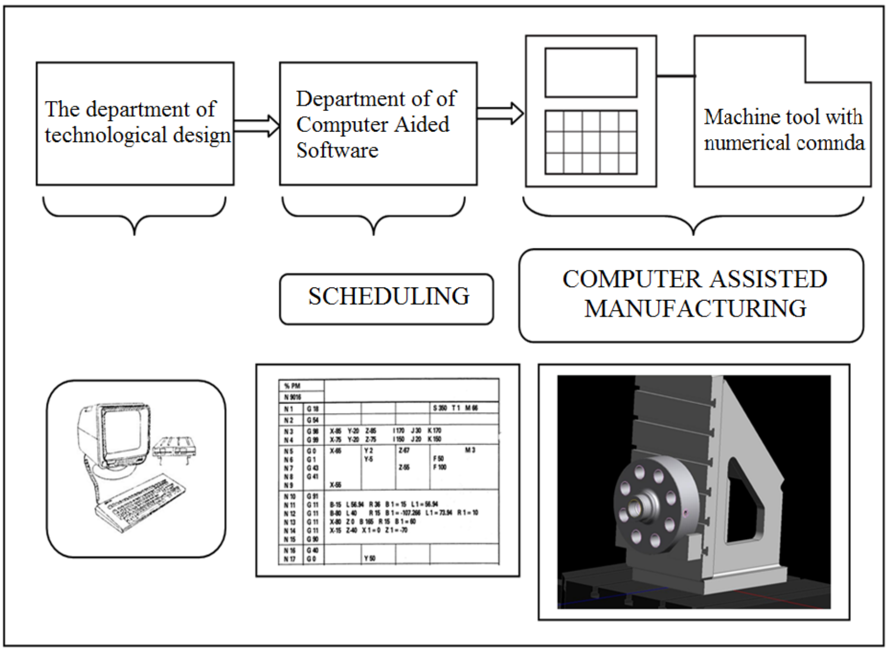


Fig. 1. The problem of machining processes

Methods for Determining the Parameters of the Cutting Regime

Experimental-statistical method. Cutting regimes parameter values, in this case, by adopting achievement (choice) of their size from regulations, tables, charts, diagrams etc. These sources of information are obtained as a result of collecting and systematizing results of similar works and processing operations.

Sources of information include:
- personal experience of technologists and operators;
- by compared with existing rules in economic unit used in papers and similar operations;
- on the basis of statistical data used in the past for similar operations.

Disadvantages of the experimental-statistical method are:
- the values (the data) obtained reflect the technical level of a past period;
- limiting the introducing of technical progress;
- shows a certain degree of subjectivity (given by way of appreciation of each operator);
- do not take into account the specific peculiarities of the machining process, the additions with high values.

The main advantage of the method is the speed with which parameter values are obtained for cutting regime.

Analytical method. In this method parameter values for cutting regimes are determined by calculation formulas, tables and graphs. Each operation is decomposed into its component elements. For each element of the operation is determined, based on a critical analysis of , its optimal structure, resulting parameter values based on the calculation algorithm set (relationships calculation, specific formulas - [2]).

Cutting regime design is recommended to be performed in the following order [2]:

1. Choice of cutting tools. The cutting tool is determined based on the following factors: the shape and type of surface processing; size and type of machine tools available; size and type of the parts; type and mechanical characteristics of the processed material.

2. Establishing of cutting tool durability. The value of sustainability is depending on a number of variables: material characteristics of the work piece and cutting tool material, geometric parameters of the active part of cutting tools, cutting regime parameters, coolant-lubricant characteristics etc.

3. Establishing of depth of cut (a_p) and number of passes (i). Cutting depth (a_p) cutting depth is determined according to the machining allowance processing, the preform material hardness, quality and cutting tool size. If the machining allowance cannot be removed in a single pass, determine the number of passes (*i*) will be divided machining allowance to be removed in optimal conditions.

4. Establishing of advance cutting f.
The cutting advance is determined depending on the nature of processing and depth of the cutting previously established.

If the roughing aimed at removing a larger depth of cut, using values as high advance to obtain high productivity processing.

When finishing processing which shows the high quality lens surface generated, choose the advance criterion to ensure accuracy and surface roughness prescribed.

Advance values are determined by calculation or adopt the normative [2,5].

After choosing the advance as described in the literature, are done a series of checks that take into account the working conditions and finally adopt the advance work by choosing from the range of machine tools advances nearest value of the close (immediately inferior to a superior system for roughing or finishing at)

5. Establishing of cutting speeds v.
Cutting speed is determined based on the following factors: the material is processed, the material and the geometry of the active part of cutting tools, cutting tool toughness, cutting depth, advance work, processing scheme etc.

The value of the cutting speed may be determined analytically for each machining process [2].

6. Establishing of working speed n.
The speed of the machine tool spindle is determined by the relationship [2]:

$$n = \frac{1000 \times v}{\pi \times d} \text{ (rev/min)}, \quad (1)$$

where: *d* is the diameter of the preform, in mm; *v* - cutting speed in m/min.

The value obtained by equation (1) must be reported to existing speed range (machine tools), so be adopted in accordance with the range of machine tools speeds immediate value closest to the calculated (upper or lower). This achieves the effective speed (real) work n_{ef} After determining the actual speed, determine the actual speed cutting with the relationship [2]

$$v_{ef} = \frac{\pi \times d \times n_{ef}}{1000} \text{ (m/min)}. \quad (2)$$

7. Establishing of effective power P_c.
Effective power is determined by the relationship [2]:

$$P_c = \frac{F_c \times v_{ef}}{60 \cdot \eta_{m-u}} \text{ (W)}, \quad (3)$$

where: F_c represents the main cutting force, in N; v_{ef} - effective cutting speed in m/min; η_{m-u} the yield of the machine tools.

Cutting power to compare with actual engine power P_m drive. If $P_c \leq P_m$, then consider cutting regime can be done on that machine tool.

The advantages of this method are:
- reflects the technical level of the current period using advanced technology work;
- provides continuous improvement of relations computational modelling work operations;
- offer broad applicability because it is an exact method.

The main disadvantage of this method is that it uses complex computations that require a heavy workload.

Automatic method. This method uses two practical principles presented methods (experimental method, statistical and analytical) to obtain maximum efficiency in terms of cutting regime parameters calculation. In this method, using specialized software that allows you to quickly obtain information through icons.

The advantages of this method are: technical reflect the current period using advanced technology work, provides continuous improvement of computational modelling relationships work operations, shows wide applicability because it is an exact method, speed in getting the system parameter values for cutting scheme various machining (turning, drilling, milling, etc.).

Application

Based on the above, it further shows how to apply the principles of working for the analytical method and automatic method. Illustration is made on a case study for milling operation channel to a piece of shaft class (Table 2).

Working conditions (input) are shown in Table 2.

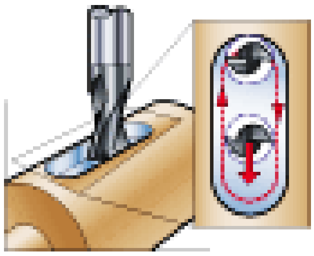
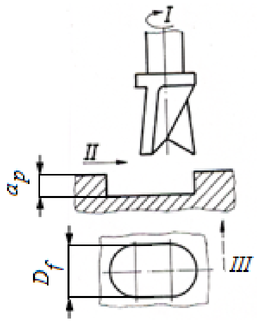
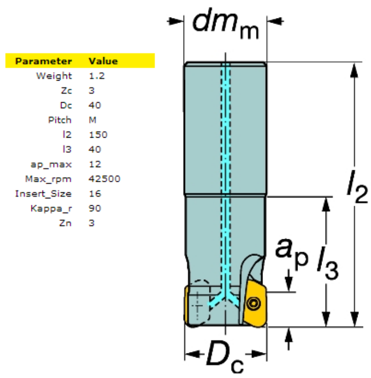
Establishing the algorithm for calculating the analytical method

a) The choice of cutting tools: Milling grooved with the characteristics listed in Table 2.

b) Determination of depth of cut. According processing scheme shown in Table 2 are established: $a_p = 6$ mm - depth of cutting; $D_c = 40$ mm - length of contact.

c) Determination of advance work. According to [2], depending on the bit diameter (D_f = 50 mm) and cutting depth on race (a_p / stroke = 2 mm) size of feed per tooth is adopted: $f_d = 0.038$ mm / tooth

Table 2. Baseline Work

<table>
<tr><td rowspan="4">Preform features</td><td colspan="2">Material: 42CrMo4-DIN 17200</td></tr>
<tr><td colspan="2">HB = 220</td></tr>
<tr><td colspan="2">Depth of cutting a_p = 6 mm</td></tr>
<tr><td colspan="2">Contact length D_c = 50 mm</td></tr>
<tr><td></td><td colspan="2">Working cutter diameter D_f = 50 mm</td></tr>
<tr><td colspan="3">Milling cutters features grooved with plates-P20 [6]</td></tr>
<tr><td colspan="2">

</td><td>
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d) Determining the cutting speed. Cutting speed is determined by the relationship [2]:

$$v = \frac{350 \cdot D_c^{0.44}}{T^{0.37} \cdot D_f^{0.30} \cdot f_d^{0.20} \cdot a_p^{0.1} \cdot z^{0.13}} = \frac{350 \cdot 40^{0.44}}{120^{0.26} \cdot 40^{0.3} \cdot 0.038^{0.20} \cdot 6^{0.1} \cdot 3^{0.13}} = 214.17\,(\text{m/min}) \tag{4}$$

e) Determination of speed work.

Speed cutting tool is determined by the relationship [2]:

$$n = \frac{1000 \cdot v}{\pi \cdot D_c} = \frac{1000 \cdot 214.17}{\pi \cdot 40} = 1704 \text{ (rot/min)} \tag{5}$$

f) Determination of actual effective power milling.

Effective power to the milling operation is determined by the relationship [2]:

$$P_c = \frac{F_t \cdot v}{6000} = \frac{27.026 \cdot 214.17}{60 \cdot 1000} = 0.096 \text{ (kW)} \tag{6}$$

where F_t is tangential force:

$$F_t = \frac{C_F \cdot D_f^{xF} \cdot f_d^{yF} \cdot a_p{}^{uF} \cdot z}{D_c{}^{qF} \cdot n^{wF}} \cdot K_{mF} = \frac{6.5 \cdot 40^{0.85} \cdot 0.038^{0.75} \cdot 6^{1.0} \cdot 3}{40^{0.3} \cdot 1704^{0.11}} \cdot 0.8 = 27.026 \text{ (N)} \quad (7)$$

where: C_F – tangential force coefficient is: C_F = 6.5; x_F, y_F, u_F, q_F, w_F – coefficients: x_F = 0.85; y_F = 0.75; u_F = 1.0; q_F = 0.3; w_F = 0.11; K_{mF} – correction coefficient depending on the material being processed K_{mF} = 0.8 [2].

The calculated values of the parameters of the cutting regime using MathCAD program are presented in Figure 2.

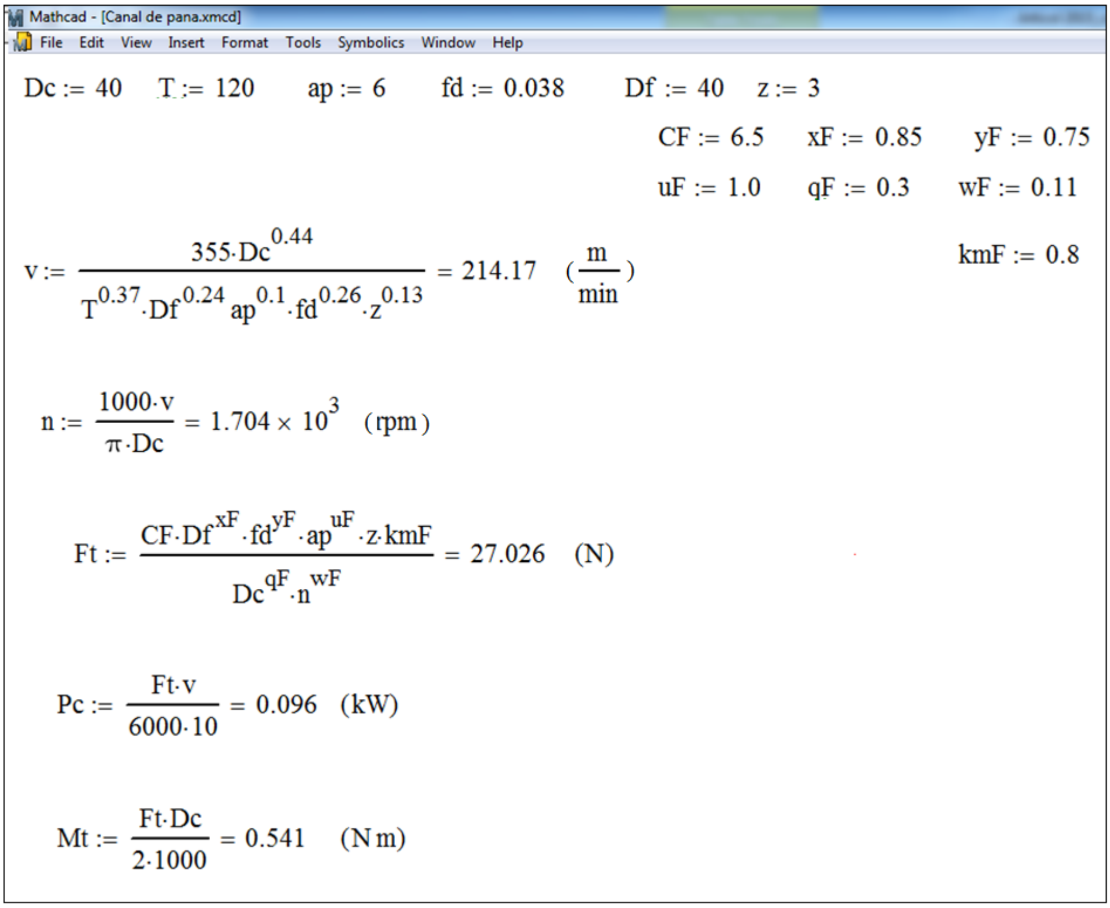


Fig. 2. The calculation algorithm for the analytical method

Determination of the algorithm for the automatic method

Automatic method. Along with the transition to manufacturing of machine tools with numerical control (CNC), for setting the parameters of the cutting regime, the machine building enterprises have realized, based on its own data obtained in the field of machining, specialized software base type data. SANDVIK Coromant Company has developed specialized software CoroGuide [6] which allows setting the cutting regime parameters: the main speed cutting, the effective speed of work, processing productivity, machine tools power effective time basis, machined surface roughness etc.

Workflow for getting cutting system parameter values are [6]:

- select operating range (machining) - milling channel up (figure 3);
- select cutting scheme used (figure 3);
- setting cutting tool type (figure 4);
- select working technical characteristics of cutting tools (figure 5);
- determining (by viewing these dialogs windows) cutting system parameter values: a_p cutting depth, feed per tooth f_d, main cutting speed v_c, speed n, cutting torque M_c, the cutting power consumption P_c (figure 6).

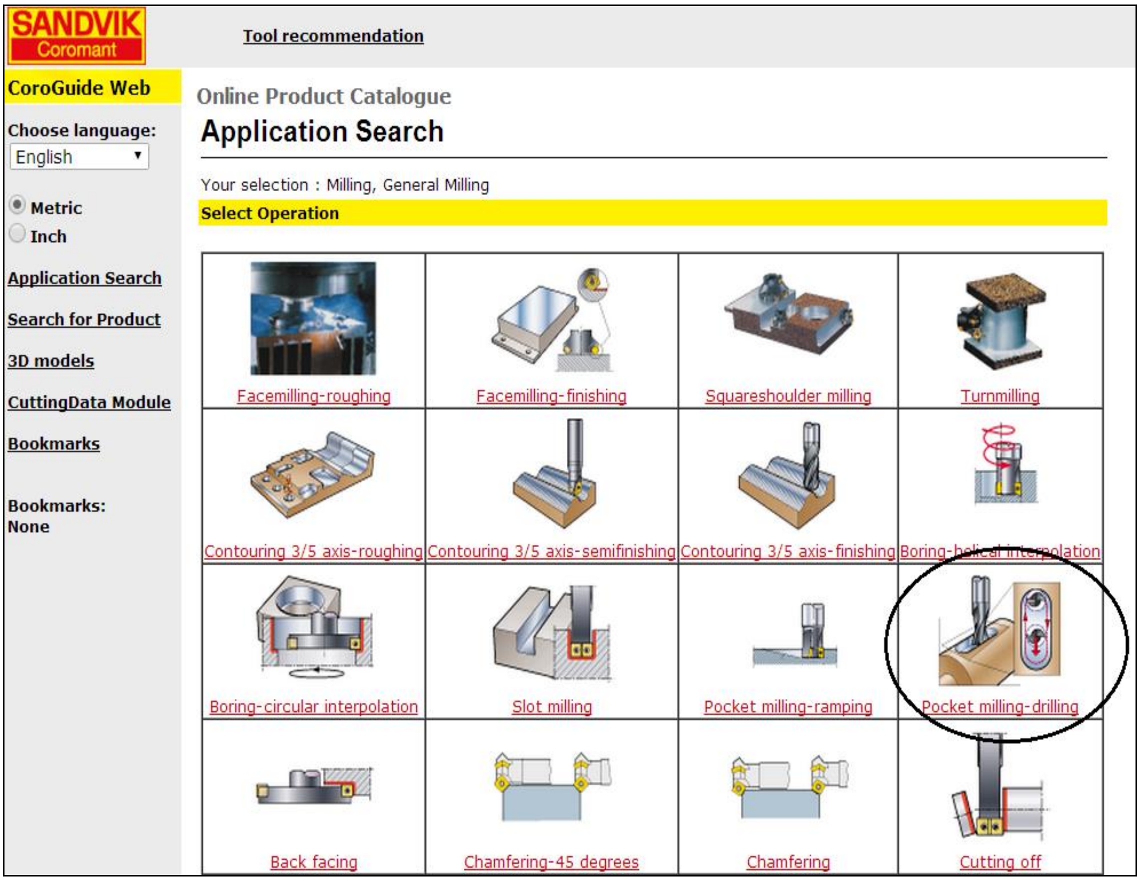


Fig. 3. Selecting the operating range

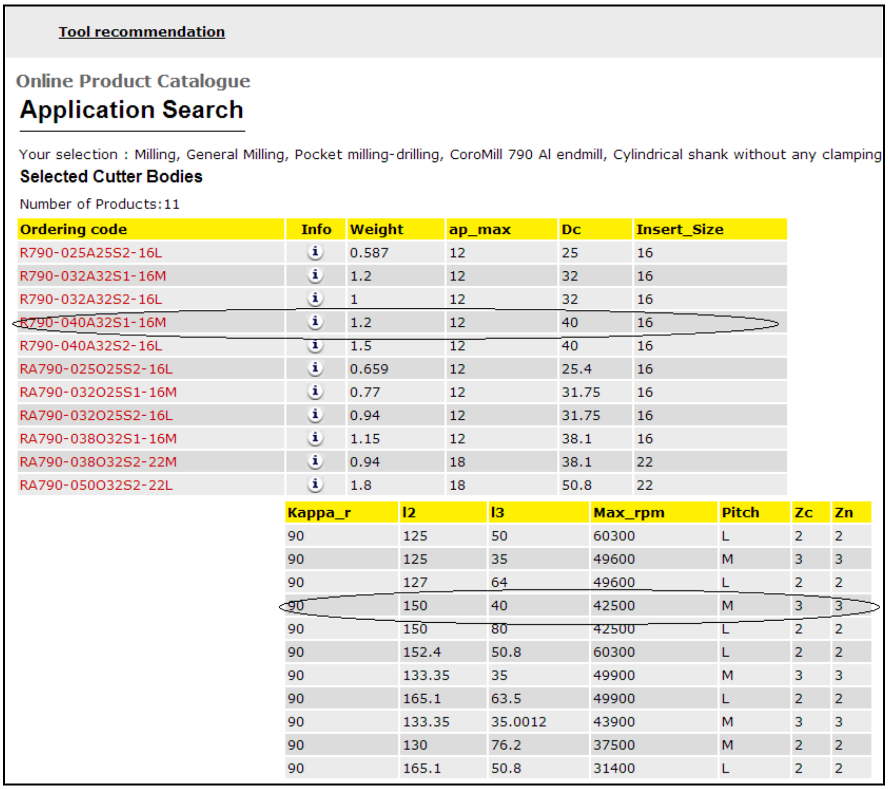
Based on the results obtained in the proposed application, the results are summarized in Table 3. From the results obtained are close to the values found by the two methods analysed, leading to the conclusion that can be used in the same measure. Of the two methods obviously automatic method has the advantage of faster working facilities.

It also can increase the speed of work and analytical method of calculation when using specialized numerical applications - MathCAD program (as explained in the paper).

Table 3. Comparative analysis of analytical calculation method and automated method in order to determine the parameters of the cutting regime

No.	Operation	Method	a_p (mm)	f_d (mm/rot)	v_c (m/min)	n (rot/min)	P_c (kW)	M_c (N·m)
1	Pocket milling drilling	Analytical	6.0	0.038	214.17	1704	0.096	0.541
2		Automatic	6.0	0.04	215	1711	0.1	0.4

Fig. 4. Determining the type of cutting tool [6]



Tool recommendation

Online Product Catalogue

Application Search

Your selection : Milling, General Milling, Pocket milling-drilling, CoroMill 790 Al endmill, Cylindrical shank without any clamping

Selected Cutter Bodies

Number of Products:11

Ordering code	Info	Weight	ap_max	Dc	Insert_Size	Kappa_r	l2	l3	Max_rpm	Pitch	Zc	Zn
R790-025A25S2-16L	i	0.587	12	25	16	90	125	50	60300	L	2	2
R790-032A32S1-16M	i	1.2	12	32	16	90	125	35	49600	M	3	3
R790-032A32S2-16L	i	1	12	32	16	90	127	64	49600	L	2	2
R790-040A32S1-16M	i	1.2	12	40	16	90	150	40	42500	M	3	3
R790-040A32S2-16L	i	1.5	12	40	16	90	150	80	42500	L	2	2
RA790-025025S2-16L	i	0.659	12	25.4	16	90	152.4	50.8	60300	L	2	2
RA790-032025S1-16M	i	0.77	12	31.75	16	90	133.35	35	49900	M	3	3
RA790-032025S2-16L	i	0.94	12	31.75	16	90	165.1	63.5	49900	L	2	2
RA790-038032S1-16M	i	1.15	12	38.1	16	90	133.35	35.0012	43900	M	3	3
RA790-038032S2-22M	i	0.94	18	38.1	22	90	130	76.2	37500	M	2	2
RA790-050032S2-22L	i	1.8	18	50.8	22	90	165.1	50.8	31400	L	2	2

Fig. 5. Establish technical characteristics of the cutting tool [6]

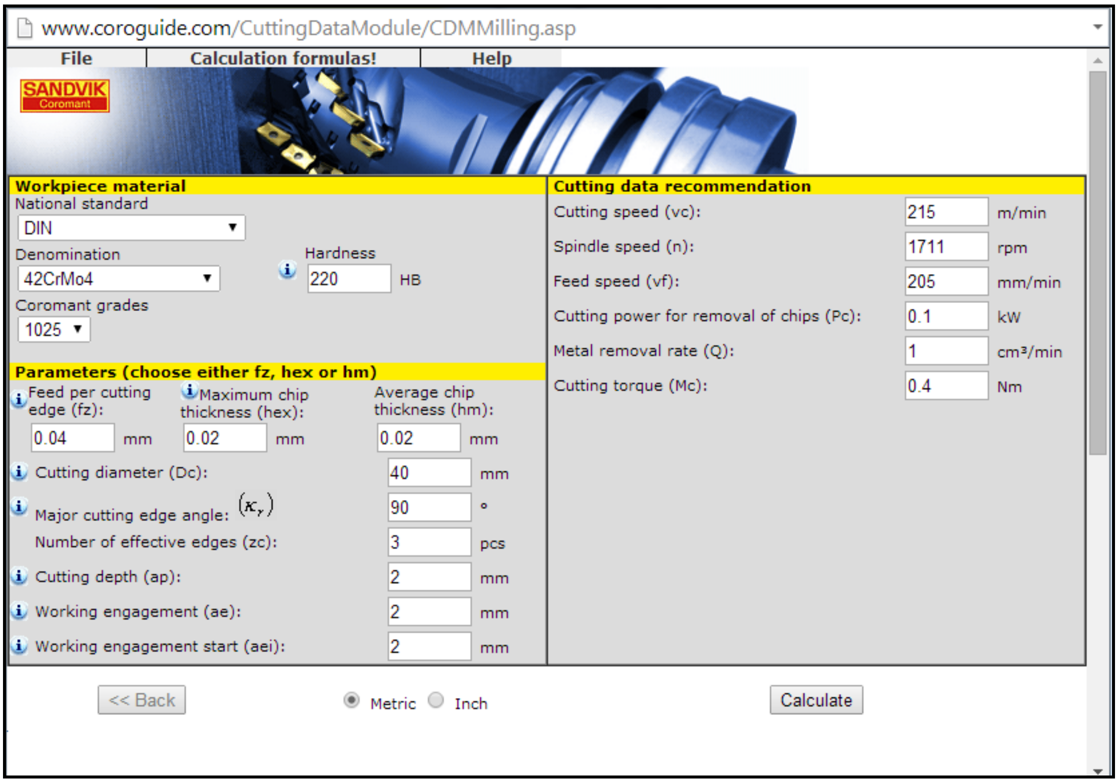


Fig. 6. Setting cutting regime parameters: depth of cutting a_p, feed per tooth f_z, main cutting speed v_c, speed n, cutting torque M_c, the cutting power consumption P_c [6]

Conclusions

The choice of cutting regime on cutting machining operations is performed according to working conditions, cutting tool and the preform material, precision etc.

This paper shows how to determine the parameter values of cutting regimes by the two methods used in practice: analytical method of calculation and automatic method.

According to the two methods for determining the values of cutting regime parameters analyzed in the paper, there is a good correspondence between analytical method of calculation and automatic method.

Determining the cutting regime parameters by two methods method (analytical method and automatic method) shows the correspondence between the calculated parameters. The use of the automated method allows rapid calculation of parameter values to cutting regime to analytical method which is more laborious.

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Aspecte cu privire la stabilirea parametrilor regimului de aşchiere

Rezumat

În cadrul unui proces tehnologic de fabricație, stabilirea corectă a valorilor parametrilor regimului de așchiere influențează productivitatea prelucrării, costul de fabricație și calitatea produsului.

Stabilirea valorilor parametrilor regimului de aşchiere (indiferent de schema de așchiere) necesită calcule laborioase și un volum mare de lucru.

Lucrarea prezintă modul de determinare a valorilor parametrilor regimului de aşchiere pentru operaţia de frezare a canalelor de pană, utilizând comparativ, metoda de calcul analitică (clasică) și metoda automată (programe de calcul specializate).