ASPECTS CONCERNING THE OPTIMIZATION OF THE TECHNOLOGICAL PROCESSES

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Abstract: The fabrication technology of a product may satisfy the demands imposed by the construction, may assure the realization of the production plan in the conditions of using the existent material base (machine-tools, SDVs, semi-product goods etc.), respecting certain economic conditions (cost, work productivity) and social ones.
The paper presents the way to determine the cutting regime parameters values for the turning operation; there is made a comparative analysis of the values determined using the analytical calculus method and the automatic one.

Key words: optimization, technological process, cutting mechanical working

1. STAGES AND CRITERIA FOR THE OPTIMIZATION OF THE MECHANICAL WORKING PROCESSES

The optimization of the cutting process is made on the ground of a study that will precede the decisions that are going to be adopted in this direction. There may be distinguished the following stages of the optimization process [1]:
a) The technological process analysis, in order to establish the elements susceptible to the optimization. From this analysis it is find out which are the parts of the technological process that could be optimized depending on the adopted criterion: the productivity one or the economic efficiency one.
b) Classification of the optimization possibilities and the execution order of the optimization actions. To the realization of the technological process analysis the goal is to emphasize according to the optimization criterion the sizes that influence favorably the quantified value of the considered criterion.
c) The proper optimization supposes to establish the optimal values of every work parameters in the limits of some work conditions. The total optimization is obtained as a final result after that the optimization action embraced the entire content of the technological process.

That is why frequently the technological process optimization is made on stages and technological process operations. The application of the operational research methods by using a complex mathematic calculus algorithm assures the analytic solution of the optimization problem for certain stages of the technological process such as: the settlement of the cutting regime parameters in certain restrictive conditions and on the basis of maximal productivity criteria or minimal cost. The disadvantage of these methods is the fact that they are extremely laborious and need a big work volume.

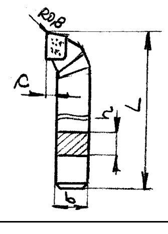
2. THE SETTLEMENT OF THE CUTTING REGIME PARAMETERS VALUES

2.1. The analytic calculus method, the calculus of the cutting regime to the turning operation $\Phi 100{,}5 \pm 0{,}8$ mm, L = 1000 mm

a) The selection of the cutting tool: for the working of the surface there is used a lateral boring tool STAS 6381-80, having the characteristics presented in the table 1, [2].

b) The settlement of the cutting depth. The cutting depth is adopted: $a_p = t = 2{,}0$ mm
c) The settlement of the cutting feed: according to [1] p. 341, tab. 10.7, it is recommended: $s = (0{,}2 \ldots 0{,}4)$ mm/rot. According to the machine-tools feed scale it is adopted: $s_a = 0{,}2$ mm/rot.

Table 1. Characteristics of the cutting tool.

Name of the cutting tool (STAS)	Scheme of the cutting tool	Technical characteristics
Boring tool STAS 6381-80 [2], p. 504		hxb = 32x32 (mm); L = 150 mm; R = 0,8 mm; c = 15 mm; $\alpha = 5^0$; $\gamma = 5^0$; $\chi_r = 90^0$; $\chi_r^{'} = 15^0$, Die-stock/plate P10, having the thickness of 10 mm Material: OLC45

d) The settlement of the cutting speed

In the case of the longitudinal turning, the cutting speed is established with the relation:

$$v = \frac{C_v}{T^m \cdot t^{x_v} \cdot s_a^{y_v} \cdot \left(\frac{HB}{200}\right)^n} \cdot K_1 \cdot K_2 \cdot K_3 \cdot K_4 \cdot K_5 \cdot K_6 \cdot K_7 \cdot K_8 \cdot K_9 = \frac{285}{90^{0,125} \cdot 2^{0,18} \cdot 0{,}2^{0,45} \cdot \left(\frac{148}{200}\right)^{1,75}} \cdot \quad (1)$$

$$\cdot 1{,}04 \cdot 0{,}66 \cdot 1{,}0 \cdot 0{,}912 \cdot 1{,}0 \cdot 0{,}9 \cdot 1{,}0 \cdot 0{,}9 \cdot 1{,}0 = 253{,}9 \; m/\min$$

[1] p.359, rel. 10.29.

where: C_v represents a coefficient that depends on the material characteristics that is going to be worked and on the cutting tool material: $C_v = 285$ [1] p. 361, tab. 10.30; T – durability of the cutting tool; $T = 90$ min [1] p. 335, tab. 10.3; m, x_v, y_v, n – exponents: $m = 0{,}125$ [1] p. 359, tab. 10.29; $x_v = 0{,}18$; $y_v = 0{,}45$ [1] p. 361, tab. 10.30; $n = 1{,}75$ [1] p. 361; K_1 – the coefficient that takes into account the influence of the boring tool transversal section: $K_1 = \left(\frac{q}{20x30}\right)^{\xi} = \left(\frac{32 \cdot 32}{20 \cdot 30}\right)^{0,08} = 1{,}04$ [1] p. 361, rel. 10.30; q – the surface of the boring tool transversal section: q =32 x 32 mm^2 table 1; ξ – the coefficient that takes into account the work material: $\xi = 0{,}08$ [1] p. 361; K_2 – the coefficient that takes into account the influence of the principal attack angle ($\chi_r = 90^0$): $K_2 = \left(\frac{45}{\chi_r}\right)^{\rho} = \left(\frac{45}{90}\right)^{0,6} = 0{,}66$ [1] p. 361, rel. 10.31; ρ – the exponent depending on the nature of the work material: ρ = 0,6 [1] p. 362; K_3 – the coefficient that takes into account the influence of the secondary attack angle ($\chi'_r = 15^0$): $K_3 = \left(\frac{a}{\chi_r^{'}}\right)^{0,09} = \left(\frac{15}{15}\right)^{0,09} = 1{,}0$ [1] p. 362, rel. 10.32; $a = 15$ for the cutting tool with metal die-stocks/plates of metal carbide [1] p. 362; K_4 – the coefficient that takes into account the influence of the joining radius of the center: $K_4 = \left(\frac{r}{2}\right)^{\mu} = \left(\frac{0{,}8}{2}\right)^{0,1} = 0{,}912$ [1] p. 362, rel. 10.33; r – the radius joining of the center: $r = 0{,}8$ mm tab. 1; μ – the coefficient that takes into account the type of the working and of the work material: $\mu = 0{,}1$ [1] p. 362; K_5 – the coefficient that takes into account the influence of the material from which it is made the active part of the cutting tool: $K_5 = 1{,}0$ [1] p. 362, tab. 10.31; K_6 – the coefficient that takes into account the work material: $K_6 = 0{,}9$ [1] p. 363, tab. 10.32; K_7 – the coefficient that takes into consideration the way of obtaining the semi-product good: $K_7 = 1{,}0$ [1] p. 363; K_8 – the coefficient that takes into account the

semi-product good superficial layer state: $K_8 = 0{,}9$ [1] p. 363; K_9 – the coefficient that takes into consideration the form of the recess surface: $K_9 = 1{,}0$ [1] p. 364.
e) The calculus of the work number of rotations is established with the relation:

$$n = \frac{1000 \cdot v}{\pi \cdot D} = \frac{1000 \cdot 253{,}9}{\pi \cdot 100{,}5} = 804{,}1 \ rot/\min \tag{2}$$

From the machine tools scale of number of rotations it is adopted: n_a = 800 rot/min, [3].
f) The calculus of the effective cutting speed is established with the relation:

$$v_{ef} = \frac{\pi \cdot D \cdot n_a}{1000} = \frac{\pi \cdot 100{,}5 \cdot 800}{1000} = 252{,}5 \, m/\min \tag{3}$$

g) The calculus of the turning effective power is established with the relation:

$$N_e = \frac{F_z \cdot v_{ef}}{6000 \cdot \eta} = \frac{12{,}27 \cdot 252{,}5}{6000 \cdot 0{,}9} = 0{,}573 \, \text{kW} < \text{N}_\text{m} = 3 \text{ kW}, \ [1] \text{ p. } 365 \tag{4}$$

where: F_z represents the main component of the cutting power:

$$F_z = C_4 \cdot t^{x1} \cdot s_a^{y1} \cdot HB^{n1} = 35{,}7 \cdot 2^{1{,}0} \cdot 0{,}2^{0{,}75} \cdot 148^{0{,}35} = 122{,}7 \text{ N} = 12{,}27 \text{ daN}, \ [1] \text{ p.347, rel. 10.7} \tag{5}$$

h) The calculus of the basic time
The basic time is established with the relation [4, p. 345, tab. 12.1]:

$$t_b = \frac{L}{n \cdot s} \cdot i = \frac{l + l_1 + l_2}{n \cdot s} \cdot i = \frac{1000}{800 \cdot 0{,}2} \cdot 1 = 6{,}25 \text{ (min)} \tag{6}$$

where: l_1 represents the cutting input length: $l_1 = \frac{t}{tg\,\chi} + (0{,}5...2) \ (mm)$; a_p – the cutting depth; χ – the main attack angle; l_2 – the cutting output length: l_2 = (1…5) mm; l – the effective worked length; i – number of roughing passes; n – work number of rotation; s – the cutting feed.

2.2. Automatic method

In order to establish the cutting regime parameters values there was used a specialized software type data base (made by SANDVIK Coromant CoroGuide) that allows the settlement of the optimal work values for: the cutting fees, the cutting tool durability, the cutting main speed, the working productivity, the effective power of the machine tools. The study was made with the help of Max-Muller Company from Germany using cutting tools made by Koromant Sandvik Company.

The work stages for obtaining the optimal cutting regime parameters values are: the settlement of the turning - mechanical working operation; the selection of the application field; the selection of the work conditions; the selection of the cutting die-stock/plate; the selection of the turning conditions, of the cutting fees values scale, of the cutting depth; the selection of the cutting plates characteristics, the settlement of the values for the cutting fees *f*, the main cutting speed v_c, the number of rotations of the part *n*, the working length *L*, the consumed power P_c, basic time t_b (fig. 1).

3. CONCLUSIONS

The selection of the cutting regime to the turning is realized depending on the work conditions, on the material of the cutting tool and of the semi-product good, on accuracy etc.

The settlement of the cutting regime parameters values by the two methods (calculus analytical and the automatic one) shows the correspondence between the calculated sizes (table 2).

The use of the automatic method allows the quick calculus of the cutting regime parameters values toward the calculus analytical method which is more laborious.

Table 2. The comparative analysis of the cutting regime parameters.

No.	Operation	Work method	i	t (mm)	f (mm/rot)	v_c (m/min)		n (rot/min)		t_b (min)
						calculated	real	calculated	real	
1	Turning	Calculus analytical	1	5	0,13	253,9	252,5	804,1	800	6,25
2		Automatic	1	5	0,133	257	257	815	815	6,13

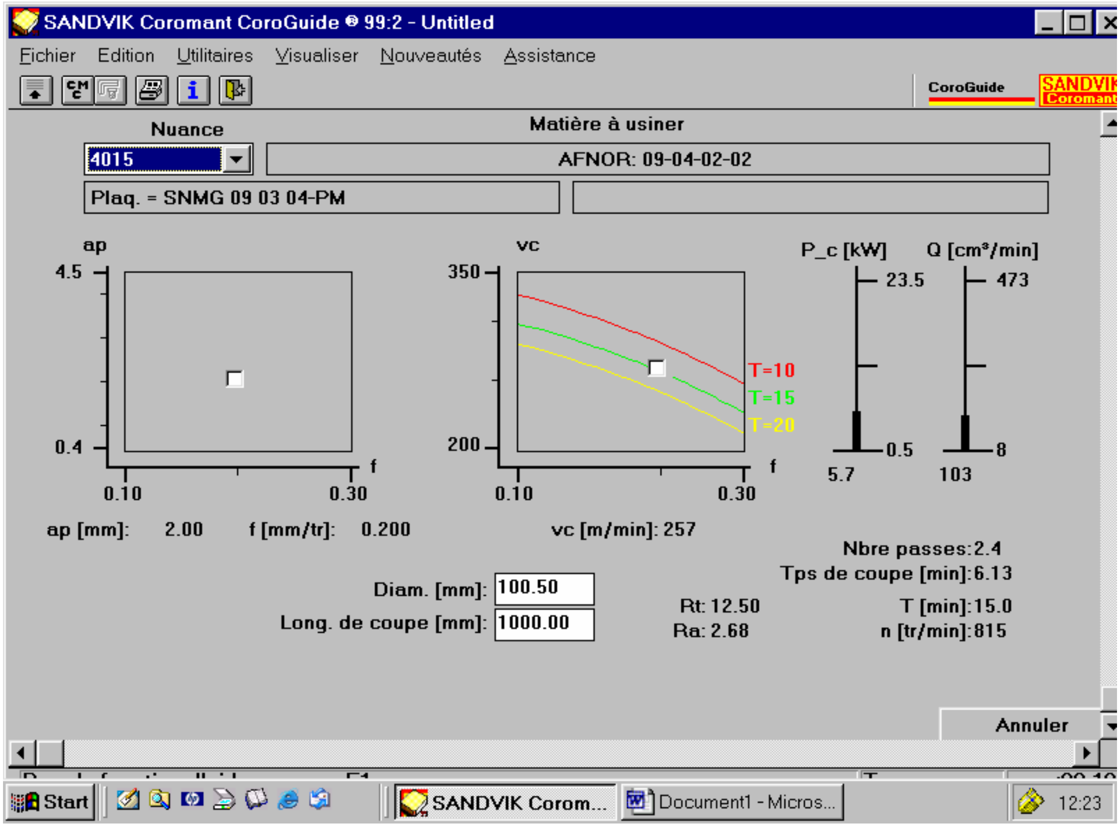


Fig. 1. The settlement of the values for the cutting feeds f, the main cutting speed v_c, the part number of rotations n, the working length L, the consumed power P_c, basic time t_b.

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