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Modern Method for the Determination of the Mechanical Working Cutting Regime Parameters

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Abstract

The work shows how the values of the parameters are determined in the cutting regime parameters for the turning operation; therefore, the comparative analysis of the values of the parameters is applied, by using the method of analytic calculus and the automated method.

Key words: *technological process, comparative analysis, technological system*

The Decisional Technological Process

During technological process of a piece's execution, the technical expert makes a plan starting from the basic documentation (the drawing of a piece) and from the technical conditions presented by the table 1.

Table 1. Analyzing the initial data

No. crt.	The criterion	Analyzing elements
1	2	3
1	The constructive and functional specific features of a product and it's constituent pieces.	The constructive and functional specific features are presented in the documents which defines the product and its exploitation parameters. All constituents elements are defined by drawing and technical conditions: the size, shape, admixed deviations, the materials thermical treatments and other specific features.
2	The production volume which must be provided	The production volume which must be provided is defined by production plan and represents the quantity factor which determines quality changes in organizing the technological process. So, while the production volume is increasing, the passing from the individual production to the series one become more efficient.
3	The material base	Data concerning the material base must be point at: semi manufactured, the tool-cars, the equipments, eventually the SDV's available. If the technological process is established for an already existent society we must take into consideration it's equipment.

Table 1. (continuer)

1	2	3
4	The economical and social conditions	Economical conditions established if the planning will be made, looking and the minimum cost or the maximum productivity. The social condition may refer at solving the labor man power problems, the place at the economical society etc.
5	The environment conditions	It implies the impact the technological process has upon the environment. In this case the processing technology doesn't have any influence upon the environment.

These being said the technological process design piece has the following stages: the critic analysis of the execution drawing and of the technical conditions imposed; establishing the last processing mechanic operation on the ground of rigging and economical accuracy described in the execution dewing; choosing the right semi manufactured; establishing operation' succession stage for every discussed area; establishing ways of fastening and fixing the piece which will be processed; choosing the tool-cars, cutting system equipment, measure and control equipments; determination of the cutting system; finding out the technical rate of time; the cost calculi of mechanic processing; manufacturing quality control; making the technological execution documentation.

A very important stage in designing the technological mechanic process is the established of the cutting's parameter's values.

The Establishment of the Cutting Regime Parameters Values

The calculus analytical method, the cutting regime calculus at the turning operation $\Phi 100{,}5 \pm 0{,}8$ mm, L = 1000 mm

a) The choice of the cutting tool: for the surface working it is used a lateral cutter STAS 6381-80, having the characteristics presented in the table 2.

b) The establishment the cutting depth:
The cutting depth is adopted: a_p = 2,0 mm.

c) The establishment of the working feed:
In the case of the turning operations, the feed value depends on: the resistance of the cutter corpus, the resistance of the metal carbide plate, the efforts admitted by the feed mechanisms of the machine tool, the torsion moment admitted by the main movement mechanism of the machine - tool.

According to [1] p. 341, tab. 10.7, it is recommended: f = (0,2 ... 0,4) mm/rot
According to the feed gamut of the machine - tool it is adopted: f_a = 0,2 mm/rot (table 3).

*c.*1) *The verification of the feed from the point of view of cutter shaft resistance*
For the cutters with rectangular section, the feed is determines with the relation:

$$f = \sqrt[y_1]{\frac{b \cdot h \cdot \left(\frac{h}{L}\right) \cdot R_{a,\,i}}{6 \cdot C_4 \cdot HB^{n_1} \cdot a_p^{x_1}}} = \sqrt[0{,}75]{\frac{32 \cdot 32 \cdot 0{,}67 \cdot 55}{6 \cdot 35{,}7 \cdot 148^{0{,}35} \cdot 2^{1{,}0}}} = 38 \text{ mm/rot} > f_a = 0{,}2 \text{ mm/rot}$$

[1] p. 348, rel. 10.8

where: h x b represents the section of the cutter shaft: h x b = 32 x 32 mm^2 (tab. 2); L – the length in console of the cutter, in mm; it is recommended: $L = 1{,}5 \cdot h$ [1] p. 345

It is obtained: $\frac{h}{L}=\frac{h}{1{,}5h}=0{,}67$; $R_{a,\ i}$ - unitary tensions admissible to the bending of the cutter shaft material. For OLC 45, $R_{a,\ i}$ = 55 daN/mm^2 = 550 N/mm^2 $[6]$ p. 97, tab. 3.6; C_4 – coefficient that takes into account the worked material and the material of the active part of the cutting tool: C_4 = 35,7 $[1]$p. 347, tab. 10.15; HB – Brinell hardness of the worked material: HB = 148

x_1, y_1, n_1 – exponential: x_1 = 1,0; y_1 = 0,75 $[1]$p.353, tab. 10.21

n_1 = 0,35 $[1]$p.353, tab. 10.22

Table 2. The characteristics of the cutting tool

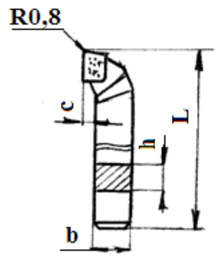
Name of the cutting tool (STAS)	The cutting tool draft	The technical characteristics
Lateral cutter STAS 6381-80 [2], p. 504		h x b = 32x32 (mm) L = 150 mm R = 0,8 mm c = 15 mm α =5^0; γ=5^0; χ_r =90^0; χ_r' = 15^0 Plate P10, having the thickness of 10 mm Shaft material: OLC45

Table 3. The establishment of the technical characteristics of the machine - tool

Name of the machine tool	Technical characteristics	
Normal lathe SN 320 [4], p.132, tab. 5.1.	Turning maximum diameter	D_{max} = 320 mm
	Distance between tops	L_{max} = 500…750 mm
	Number of rotations steps	n = 18 steps
	Gamut of number of rotations of the main axle (rot/min)	79; 100; 124; 155; 194; 242; 302; 377; 471; 590; 736; 800; 920; 1150; 1433; 1792; 2240; 2800.
	Number of feed steps	n = 36 steps
	Gamut of longitudinal feeds (mm/rot)	0,045; 0,051; 0,058; 0,066; 0,076; 0,086; 0,098; 0,112; 0,128; 0,146; 0,167; 0,20; 0,216; 0,247; 0,281; 0,32; 0,36; 0,42; 0,48; 0,54; 0,62; 0,7; 0,8; 0,92; 1,04; 1,2; 1,35; 1,54; 1,75; 2,0; 2,3; 2,6; 3,0; 3,4; 4,0; 4,5; 5,0.
	Gamut of transversal feeds (mm/rot)	0,015; 0,017; 0,019; 0,022; 0,025; 0,028; 0,033; 0,037; 0,042; 0,048; 0,055; 0,063; 0,072; 0,082; 0,094; 0,107; 0,122; 0,140; 0,158; 0,180; 0,200; 0,235; 0,28; 0,30; 0,35; 0,40; 0,45; 0,52; 0,58; 0,67; 0,76; 0,87; 1,0; 1,14; 1,30; 1,47; 1,66.
	Power of the main engine	P = 3 kW
	Net weight	m = 1100 kg

c.2) *The verification of the feed from the point of view of the metal carbide plate resistance*
The verification relation is determined:

$$f=\frac{8{,}3\cdot C^{1,8}}{{a_p}^{0,3}\cdot R_m}=\frac{8{,}3\cdot 10^{1,8}}{2^{0,3}\cdot 35}=12{,}1\ \text{mm/rot}>f_a=0{,}2\ \text{mm/rot} \qquad [1]\ \text{p.348, rel. 10.12}$$

where: C represents the thickness of the metal carbide plate: C = 10 mm (table 2); R_m fracture resistance to traction of the worked material: R_m = min. 350 N/mm^2

c.3) The verification of the double torsion moment admitted by the main movement mechanism of the machine tool
The calculus relation is:

$$2M_t^* = \frac{F_z \cdot D}{1000} = \frac{122{,}7 \cdot 100{,}5}{1000} = 12{,}3\, N \cdot m$$ [1]p. 355, rel. 10.26

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

$$F_z = C_4 \cdot a_p^{x_1} \cdot f_a^{y_1} \cdot HB^{n_1} = 35{,}7 \cdot 2^{1{,}0} \cdot 0{,}2^{0{,}75} \cdot 148^{0{,}35} = 122{,}7 \text{ N} = 12.27 \text{ daN}$$

[1]p.347, rel. 10.7

D – cutting diameter: D = 100,5 mm

The double torsion moment that may be realized to the machine tool is determined with the relation:

$$2M_t = \frac{19500 \cdot N_m \cdot \eta}{n} = \frac{19500 \cdot 3 \cdot 0{,}9}{800} = 65{,}8\, N \cdot m > 2M_t^* = 12{,}3 \text{ N·m}$$ [1] p. 355

where: N_m represents the engine power: N_m = 3 kW (tab. 3); η - the machine tool efficiency: η = 0,85…0,95 [1] p. 355, it is adopted η = 0,90; n – the main shaft number of rotations: n = 800 rot/min according to pct. e)

d) The determination of the cutting speed:
In the case of the longitudinal turning, the cutting speed it is determined with the relation:

$$v = \frac{C_v}{T^m \cdot a_p^{x_v} \cdot f_a^{y_v} \cdot \left(\frac{HB}{200}\right)^n} \cdot K_1 \cdot K_2 \cdot K_3 \cdot K_4 \cdot K_5 \cdot K_6 \cdot K_7 \cdot K_8 \cdot K_9 =$$

$$= \frac{285}{90^{0{,}125} \cdot 2^{0{,}18} \cdot 0{,}2^{0{,}45} \cdot \left(\frac{148}{200}\right)^n} \cdot 1{,}04 \cdot 0{,}66 \cdot 1{,}0 \cdot 0{,}912 \cdot 1{,}0 \cdot 0{,}9 \cdot 1{,}0 \cdot 0{,}9 \cdot 1{,}0 = 253{,}9\, m/\min$$

[1]p.359, rel. 10.29

where: C_v represents a coefficient that depends on the material characteristics that is worked and of the cutting tool material: C_v = 285 [1]p. 361, tab. 10.30; T – cutting tool endurance: 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 – coefficient that takes into account the influence of the cutter 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 - surface of the cutter shaft transversal section: q =32 x 32 mm^2 table 2
ξ - coefficient that takes into account the worked material:

$$\xi = 0{,}08$$ [1]p. 361

K_2 – coefficient that takes into account the influence of the main 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 - exponent depending on the nature of the worked material:

$$\rho = 0{,}6$$ [1]p. 362

K_3 – coefficient that takes into account 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 tools with metal carbide plates; [1]p. 362

K_4 – coefficient that takes into account the influence of the cutter top connection ray:

$$K_4 = \left(\frac{r}{2}\right)^{\mu} = \left(\frac{0,8}{2}\right)^{0,1} = 0,912$$ [1]p. 362, rel. 10.33

R – cutter top of the connection ray: R = 0,8 mm table 2

μ - coefficient that takes into account the working type and the worked material: μ = 0,1 [1]p. 362; K_5 – 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 – coefficient that takes into account the worked material: $K_6 = 0,9$ [1]p. 363, tab. 10.32; K_7 – coefficient that takes into account the obtaining way of the semi - product: $K_7 = 1,0$ [1] p. 363; K_8 – coefficient that takes into account the semi - product superficial layer state: $K_8 = 0,9$ [1]p. 363; K_9 – coefficient that takes into account the evolving surface form: $K_9 = 1,0$ [1]p. 364.

e) The determination of the work number of rotations

The number of rotations of the main shaft of the machine tool is determined with the relation:

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

From the gamut of the machine tool number of rotations it is adopted: n_a = 800 rot/min, table 3

f) The determination of the cutting effective speed

The cutting effective (real) speed is determined with the relation:

$$v_{ef} = \frac{\pi \cdot D \cdot n_a}{1000} = \frac{\pi \cdot 100,5 \cdot 800}{1000} = 252,5\ m/\min \qquad (2)$$

g) The determination of the cutting tool effective endurance

The cutting tool effective hardness is determined with the relation:

$$T = T_{ec} \cdot \left(\frac{v}{v_{ef}}\right)^{\frac{1}{m}} = 90 \cdot \left(\frac{253,9}{252,5}\right)^{\frac{1}{0,125}} = 94\ \min \qquad (3)$$

h) The determination of the effective power at turning

The effective power is determined with the relation:

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

i) The calculus basic time

The basic time is determined with the relation [7, p. 345, tab. 12.1]:

$$t_b = \frac{L}{n \cdot f} \cdot i = \frac{l + l_1 + l_2}{n \cdot f} \cdot i\ (\min) \qquad (4)$$

where: l_1 represents the in-put length in the cutting:

$$l_1 = \frac{a_p}{tg\ \chi} + (0{,}5...2)\quad (mm) \tag{5}$$

a_p– cutting depth; χ – main attack angle; l_2 – the out-put length from the cutting: l_2 = (1…5) mm; l – the worked effective length; i – the number of pulls; n – the work number of rotations; f – the work forward flow.
Replacing the known data, the basic time is determined:

$$t_b = \frac{L}{n \cdot f} \cdot i = \frac{1000}{800 \cdot 0{,}2} \cdot 1 = 6{,}25\ \min \tag{6}$$

The Automatic Method of Establishing the Cutting Regime Parameters

For this method has been used a specialized soft (designed by SANDVIK Coromant CoroGuide [8]) which allows the most propitious values of working for: promoting labor, duration of cutting tools, the cutting main speed, productivity at the process, car-tools' effective power.
The study has made with the help of Max-Muller firm from Germany using cutting tools executed by Koromant Sandvik [9].

The work stage for obtain optimal values of cutting's parameters are: establishing the mechanical operation design lathing (fig. 1) [9]; establishing at advance – f, the main speed of cutting – v_c, piece rotation – n, the processing length – l, the power consumed – P_c, the basis time – t_b (fig. 2) [9].

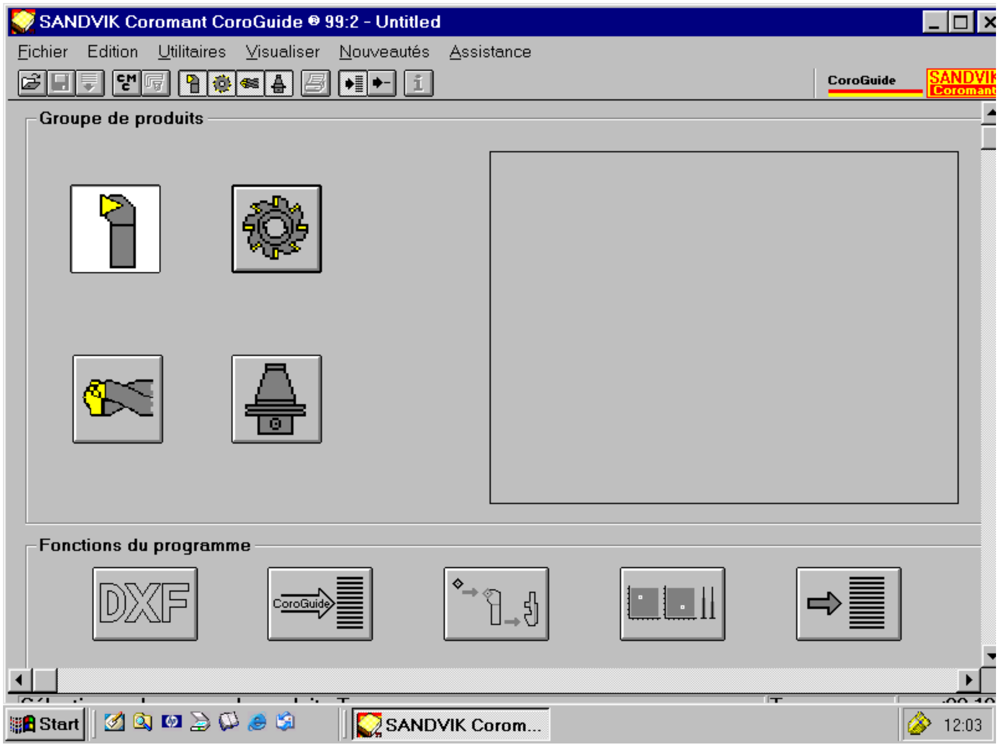


Fig. 1. Establishing the mechanical operation design lathing [9]

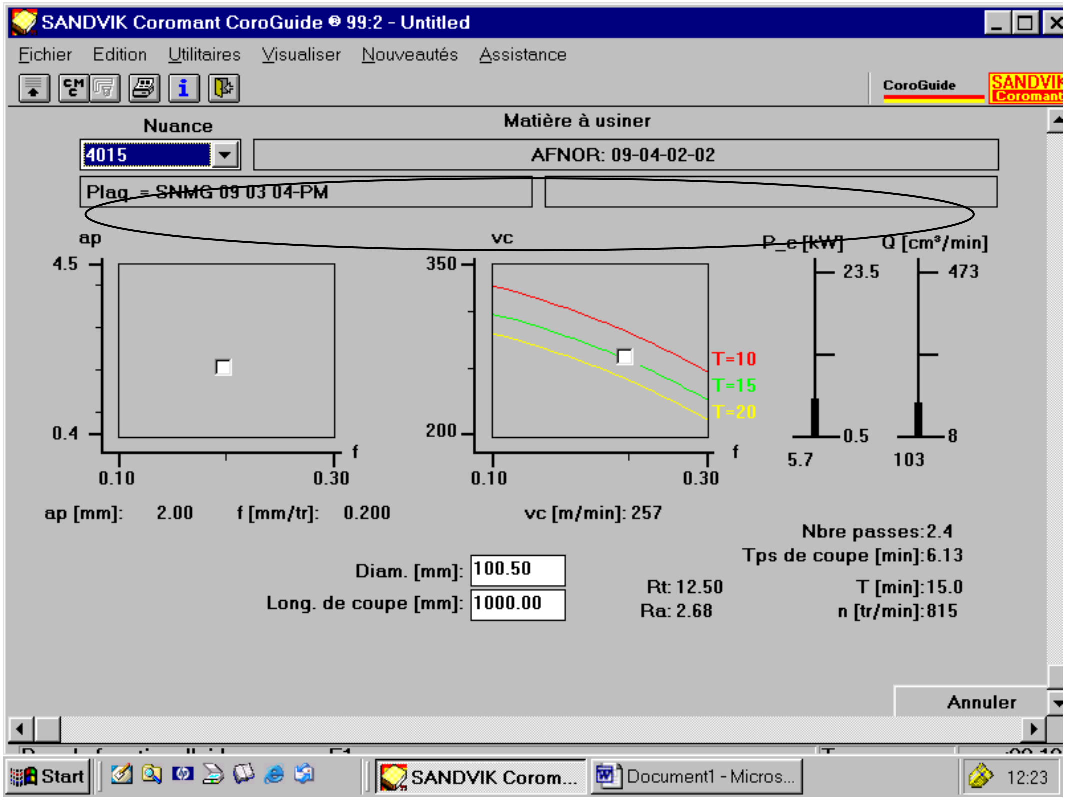


Fig. 2. Establishing at advance – *f*, the main speed of cutting – v_c, piece rotation – *n*, the processing length – *l*, the power consumed – P_c, the basis time – t_b [9]

Comment, Conference

The choosing of cutting parameters is made according to working conditions, the material of cutting tool and semi manufactured accuracy etc.

The classical calculi method of cutting system allowed the affiliation of the parameters presented into table 4.

The fixing of cutting parameters with both methods (analytics – for calculus and automatic) shows affinity with determined figures.

Table 4. The analysis of analytics calculi method and automatic method for establishing parameters of cuttings system

Nr. crt.	Type	Method	*i*	a_p (mm)	*f* (mm/rot)	v_c (m/min)		*n* (rot/min)		t_b (min)
						calculated	real	calculated	real	
1	Lathing	Analytical calculus	1	2,0	0,19	253,9	252,5	804,1	800	6,25
2		Automatic	1	2,0	0,20	257	257	815	815	6,13

There are established the following aspects from comparative analysis:

- the affinity between the number of passing (*i*) and depth's cutting is evident because there are measures for establishing of the other parameters;
- the differences recorded at work feed advance (*f*) and cutting speed (v_c) and implicative revolution speed are caused by choosing, in case of classical method, of these values from advance range, respectively from speed range of tool-car adopted, up against the automatically method where these values are being fluctuate.

Using the automatic method provides a faster calculus of parameters values of cutting system up against analytics calculi method, which is more laborious.

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Metodă modernă de determinare a parametrilor regimului de aşchiere la prelucrarea mecanică

Rezumat

Lucrarea prezintă modul de determinare a valorilor parametrilor regimului de aşchiere pentru operatia de strunjire; se efectuează analiza comparativă a valorilor determinate utilizând metoda de calcul analitică şi metoda automată.