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Cost Optimization of Machining in Turning a Material Steel S400N Approach to Experimental Gilbert

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ABSTRACT

In this work, we investigate one of the current concerns of the problem of the formatting of the material by removal of material. It is the optimization of the machining costs in the filming of a steel material S400N by the experimental approach of GILBERT for an operation of turning outside.

In fact, the increase of the temperature of the active part of the cutting tool during machining leads to a decrease in hardness and subsequently premature wear.

This wear and tear (the degradation of the tool) to significantly affect the productivity by reducing the quality and accuracy of the work piece or by increasing machining costs.

It is therefore to control the evolution of such phenomena, the degradation of the tool relative to the cutting conditions (cutting speed, the feed of the tool, depth of cut etc...) for a good optimization of the costs of machining.

KEYWORDS: *optimization, machine cost, experimental approach and filming.*

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1. INTRODUCTION

One of the major concerns in the process of shaping material by removal of chips, it is to seek to improve the productivity and quality of machined parts in a time of reducing costs and production defects, which can lead to the non-compliance of the states of the surfaces of the machined parts [1]. That is why, it is important to determine the cutting parameters that affect the criterion of the time service status of the tool life of the tool).

The chips are formed by the interaction between the workpiece and the cutting tool leading to a strong heat caused by the friction of these chips that slide on the rake face of the tool and also on the front of the body [2][3].

It occurs in the tool – chip interface of the phenomena, which are mechanical, thermal and physico-chemicals that act on the tool. The edge of the cutting tool which is the active element of the machining undergoes strong pressure of these phenomena leading to its wear and tear. These phenomena are characterized by: adhesion, abrasion, cracking, plastic deformation, corrosion, and diffusion.

The purpose of this article is the understanding of the process of shaping material by removal of material in the optical optimization of the machining costs of a material in the form of cylindrical steel **S400N** by experimental approach of GILBERT, for an operation of turning off with a carbide tool metal brazed grade P20 with like components: tungsten (W), titanium carbide (TiC), tantalum or niobium (Nb) and a connecting element between the carbide particles (size 0.2 to 1 μm) .[3]

It will then be necessary to analyze the capacity of the cutting tool relative to its destruction, because its duration of life in the face of the workpiece is related

to the degree of wear and it is important to control its evolution in relation to machining parameters. [4]

2. APPROACH EXPERIMENTAL STUDY

For getting to estimate the life of the tool (the time service tool) according to the machining conditions fixed or defined, it is generally considered the criterion of wear (V_B (even flank wear of the tool) or K_T (for crater wear).

In the context of this article, we have considered the criterion V_B , which is a wear and tear due to high temperatures and friction of the workpiece on the opposite flank of the cutting tool. Among various methods to measure this wear V_B tool [5], we chose the one that is mechanical, using a stylus with the needle of a gauge framing

The objective consists in the improvement of the cutting performance compared to the criteria cost of machining, the production time by using the cutting parameters chosen in relation to the nature of the workpiece material and the shade of the cutting tool. A mathematical model approach of GILBERT will be established and will allow us to plot the different curves related to the cost of machining and at the time of production.

2.1. Component material and its properties

The component material is a cylindrical steel S400N. According to the standard ISO 15608, it is part of the group 2.1 of grain steels for heat treatment with a minimum yield strength specified: 360 N/mm2 ≤ R_e ≤ 460 N/mm2, with a mechanical strength: Rm = 650 N/mm2

Table 2.1: chemical composition of the steel S400N [ISO 15608]

Elements	Symbols	- Content (%)
Carbon	(C	0,25
Silicon	S_i	0,60
Mn	Mn	1,70
Molybdenum	Mo	0,70
Sulfur	S	0,045
Phosphorus	P	0,045
Copper	Cu	0,40[b]
Nickel	N_i	a 0.5[b]
Chrome	C_r	0,3
Niobium	Nb	0,05
Titanium	T_i	0,05

2.2. Tool and tool holder

We used a tool carbide uncoated grade P20 brazed on a door-tool (see figure 2.1)



Fig. 2.1: a Tool charioter with insert brazed [6]

2.3. Measurement of wear (V_B of the tool

The method of measurement of the wear (figure 2.2) is chosen in the framework of this article, is nothing other than the mechanical method using a probe with a needle of a gauge framing.



Fig. 2.2: test tubes used and method of wear measurement

3. THE PARAMETERS OF CUTTING USED

The cutting parameters are values that define the displacement of the tool and the workpiece (kinematic parameters) and on the other hand, the values that determine the depth (thickness of the chip), and dimensions of the cutting tool (geometrical parameter). [3] [7]

3.1. Criterion on the selection of the cutting parameters

The criteria considered are the following: the quality of the machine, the power of the machine, the field of work that has impact on the choice of the material of the tool (cutting tool), the quality of the material of the tool must be harder than the workpiece, the machining operation (turning to dry), the shape of the tool (geometric shape of the tool relative to its characteristic angles) [8].

The cutting conditions chosen are the following :

- Ahead of the cutting tool f = (0.4 to 0.8) mm/rev;
- the depth of cut a = (1 to 4) mm;
- the cutting speed v_c = (80 to 250 m/min)

3.2. Results

Before presenting the results, we recall that the model of Gilbert used in a general way is nothing other than the model Taylor generalized.

The model of the life of the tool according to Taylor, is given in the form:

$$T = C_V . V_c^n \qquad (3.1)$$

While the model of Gilbert is represented by the expression :

$$T = C_V . f^x . has^{there} . V_c^n \qquad (3.2)$$

The coefficients x , y and n depend on the nature of the cutting tool, and f, a and Vc are respectively (the advance of the tool ,the depth of cut and cutting speed); C_V is a coefficient expressing the theoretical time of the duration of tool life for a cutting speed V_C of 1 m/min compared to Taylor. [2] [9] [10]

After calculation, the model of Gilbert becomes:

$$T = 10^{0,48} . f^{-2,4} . a^0 . V_c^{-4} \qquad (3.3)$$

3.2.1. Curve flank wear (VB of the tool as a function of time

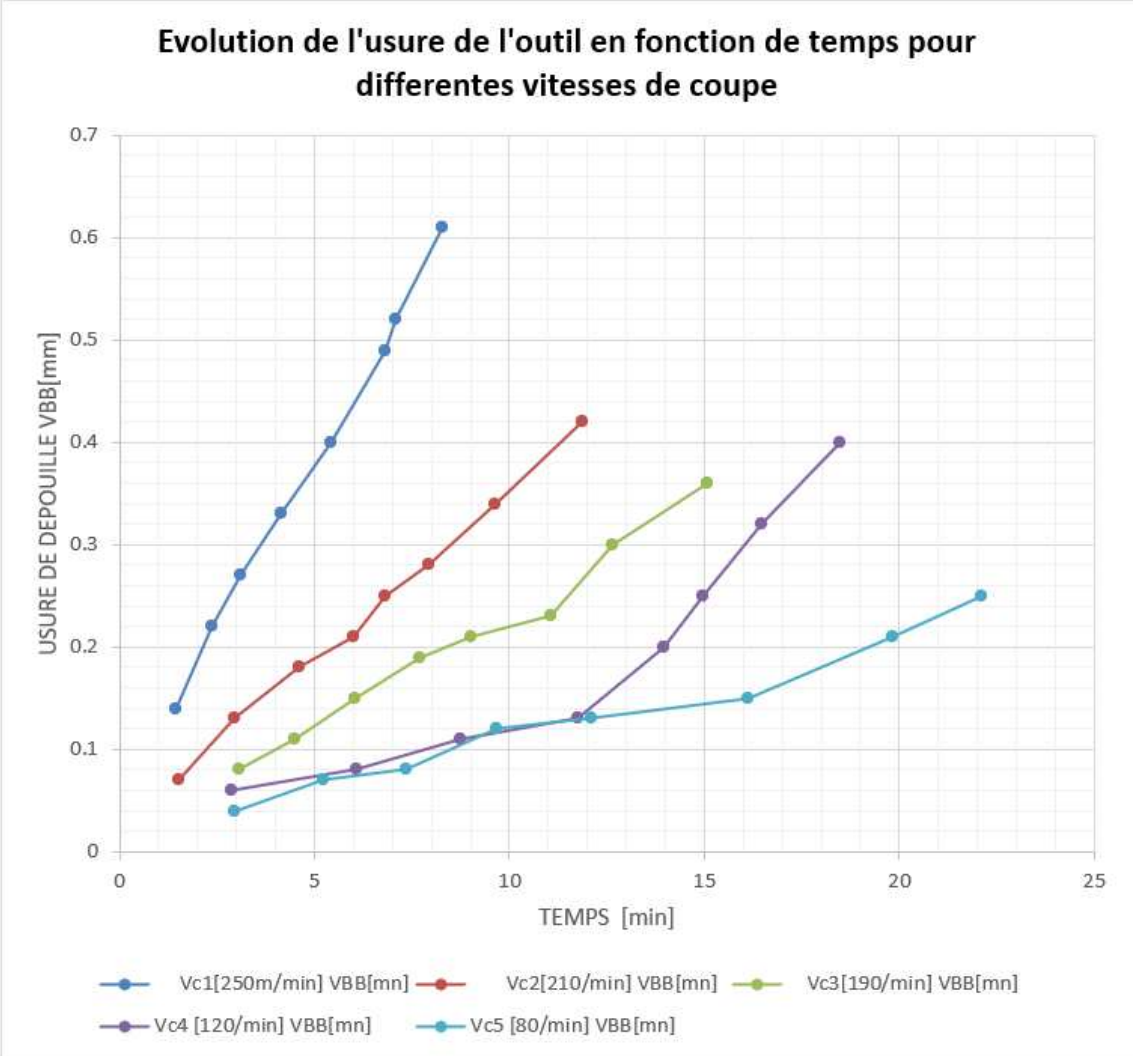


Fig.3.1: evolution of tool wear as a function of time, for different cutting speeds

Figure 3.1 represents the evolution of tool wear as a function of time, for different cutting speeds

According to the standard NF 66 – 505, the criterion of flank wear is considered as V_B = 0,3 mm. [2]

3.2.1. The curve T= f(Vc)

From the figure 3.2 with the operation of the axes logarithmic, we can plot the curve T= f(Vc) and out of the trend curve.

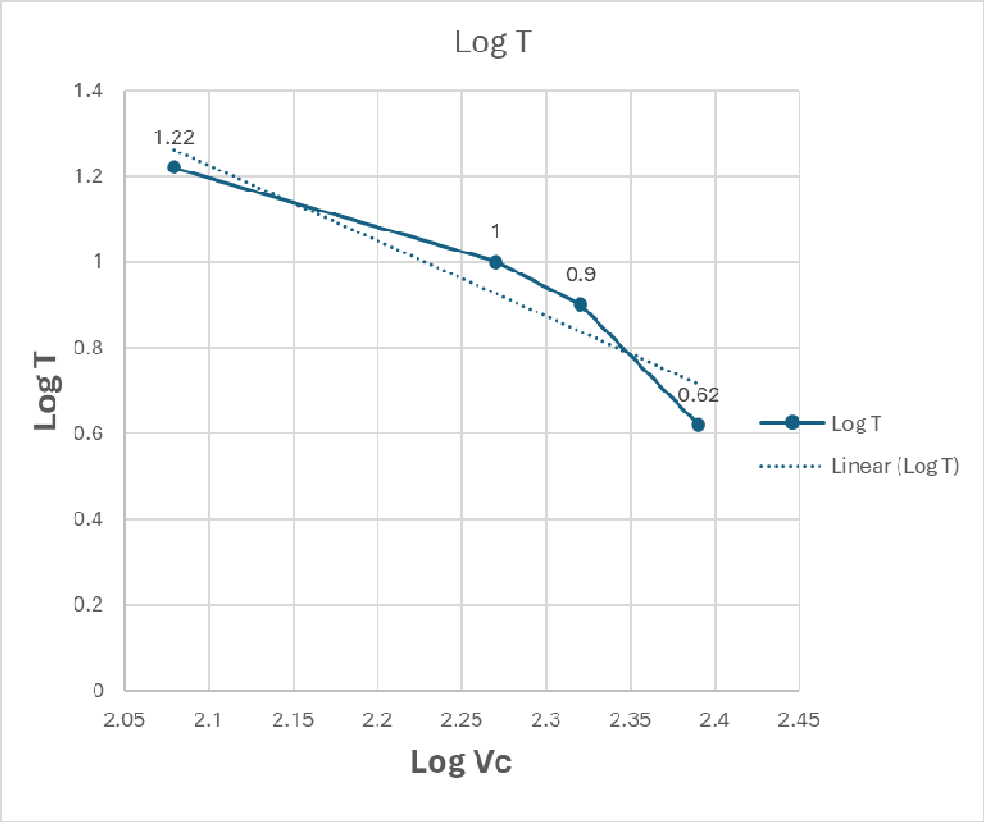


Fig. 3.2: trend

The trend line is linear and has the form:

$y = a.\ x + b$ (3.4)

However, the model Taylor given in the form:

$T = C_V . V_c^n$

It can also write in logarithmic form below:

$\text{Log T} = \log (C_V . V_{(c}^n)$

$\text{Log T} = \log C_V + \log V_c^n$

$\text{Log T} = \log C_v + n \log V_c$ (3.5)

3.2.2. Calculation of the cost of production

To determine the cost of production per piece following a machining operation, it would be necessary to take account of the costs for: machining, tooling and set-up times of the tool, the rapid return of the tool, the assembly and disassembly of the room. [9]

The cost of production generally is determined by the equation [4][9]:

$C_t - P_a + T_c . P_m + P_o \frac{T_c}{T} + T_R$ (3.6)

P_a=: cost of installation and adjustment to a room;
T_c: the machining time for a room;
P_m: the cost of a machine operator per minute ($/min);
P_o: the cost of a stop cutting and setting tool;
T: the duration of life of the tool by approach of Gilbert;
T_R: Time for a speedy return of the tool.

After calculation, the cost of production of a piece with the approach of Gilbert gave us the following model:

$C_t = 3{,}440.\ 10^{-9} . V_c^3 + 7{,}85.\ V_c^{-1} + 1$ (3.7)

Figure 3.3 shows the evolution of the cost of production compared to the plan of cutting.

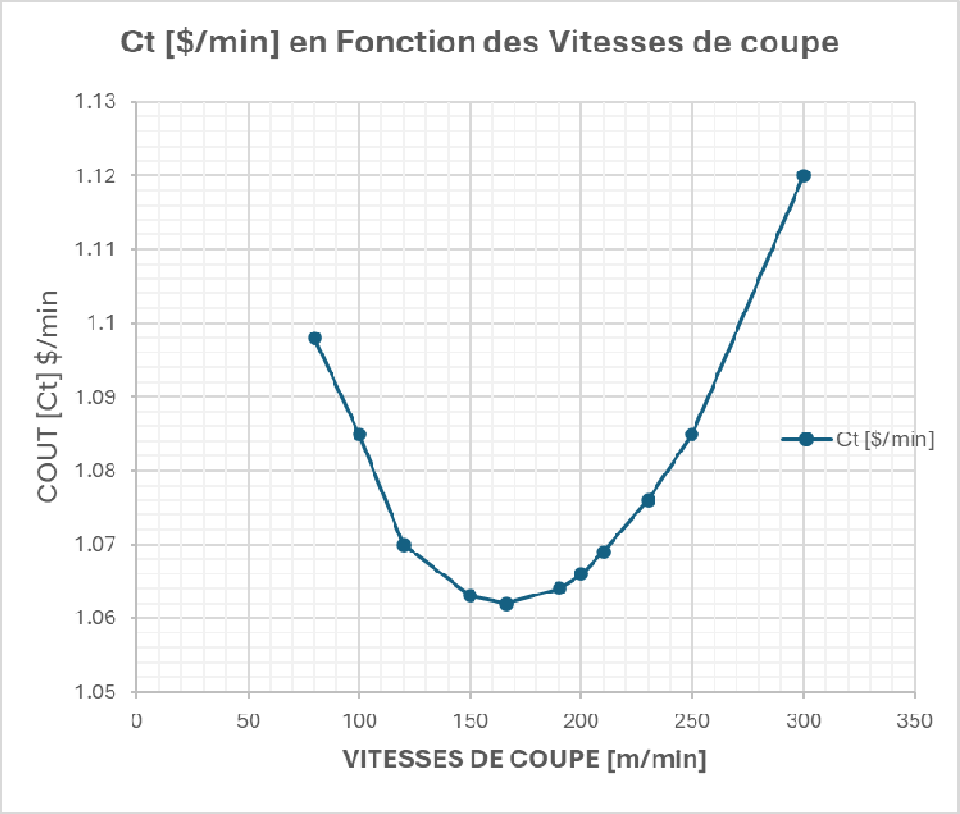


Fig. 3.3: Evolution of the cost of production compared to the regimes of cup

From the curve above, we can already determine the speed of cut that is optimal or economic, and the cost of producing a minimum corresponding to the criterion of wear. The cost and the cutting speed must be determined by the tangent point to the horizontal plane [9].

In figure 3.4 below, we have represented the trend in order to get the tangent point, which is found by the intersection of the two curves in the coordinates (166; 1,062), see figure 3.4.

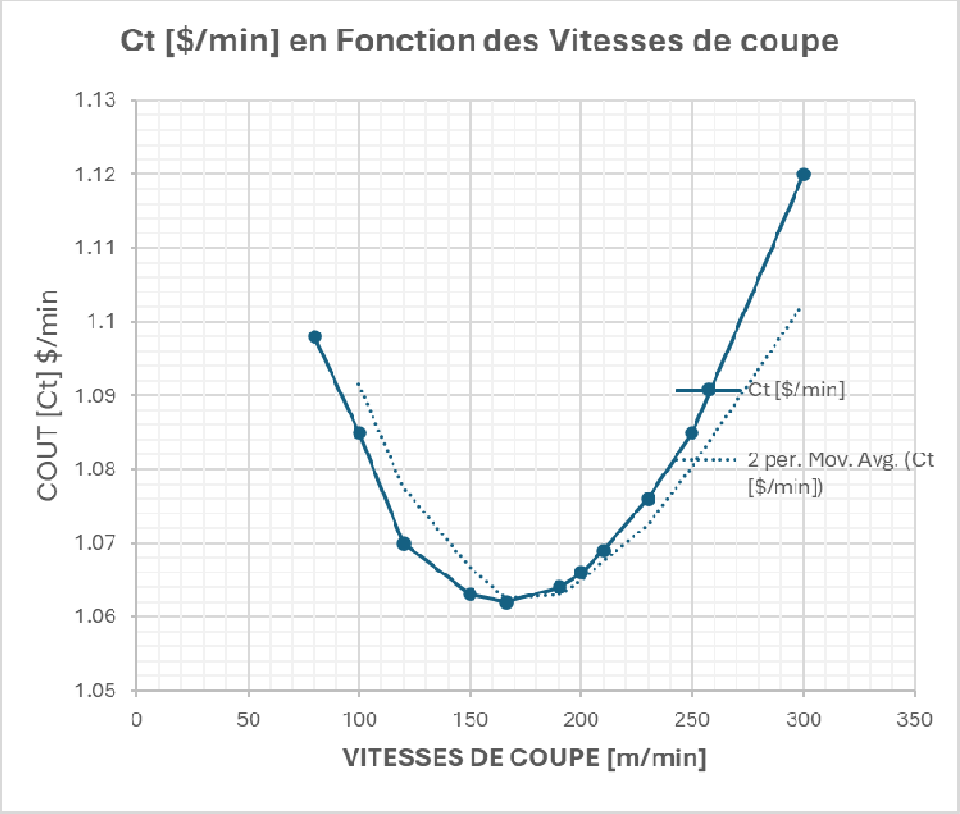


Fig. 3.4: the trend of changes in the cost of production compared to the regimes of cup

3.2.3. The time of production minimum

The production time of at least one part of the series is determined by the equation [4] [9] :

$$T_t = T_r + T_c + \frac{T_{Vb}}{T}.T_c + T_R \qquad (3.8)$$

T_t: time of production.
T_r: time of assembly and disassembly by piece;
T: duration of life of the tool by approach of Gilbert;
T_{Vb}: time adjustment of the tool;
T_c:- time of cutting or machining time;
T_R: time for a speedy return of the tool.

After calculation, the production time minimum of a piece with the approach of Gilbert's :

$T_t = 237{,}57.10^{-9}\ V_c^3 \mid 86{,}35.V_c^{-1} \mid 10 \qquad (3.9)$

Figure 3.5 represents the cost of production, the production time minimum, for each plan of cut.

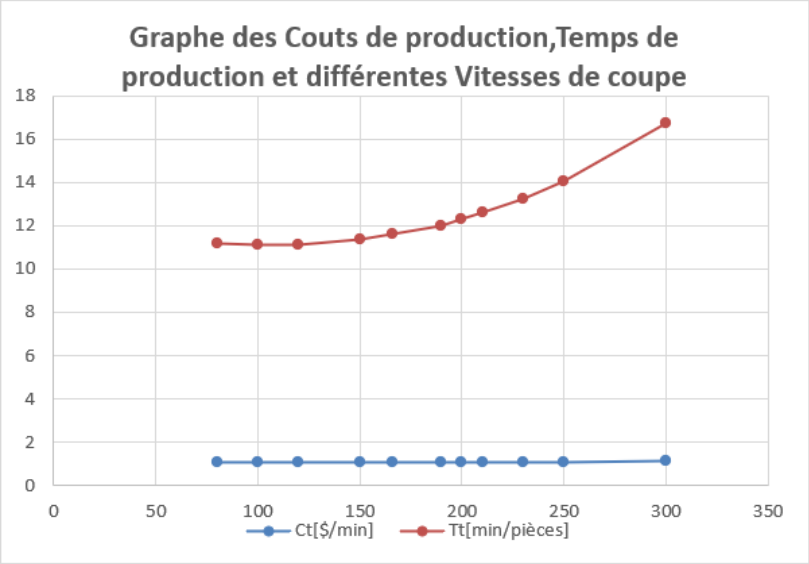


Fig. 3.5: graph of the production costs, production time and cutting speed.

The trend of changes in the cost of production compared to the regimes cup of figure 3.6, we can obtain the graph sections, chip, speed chip with different cutting speeds.

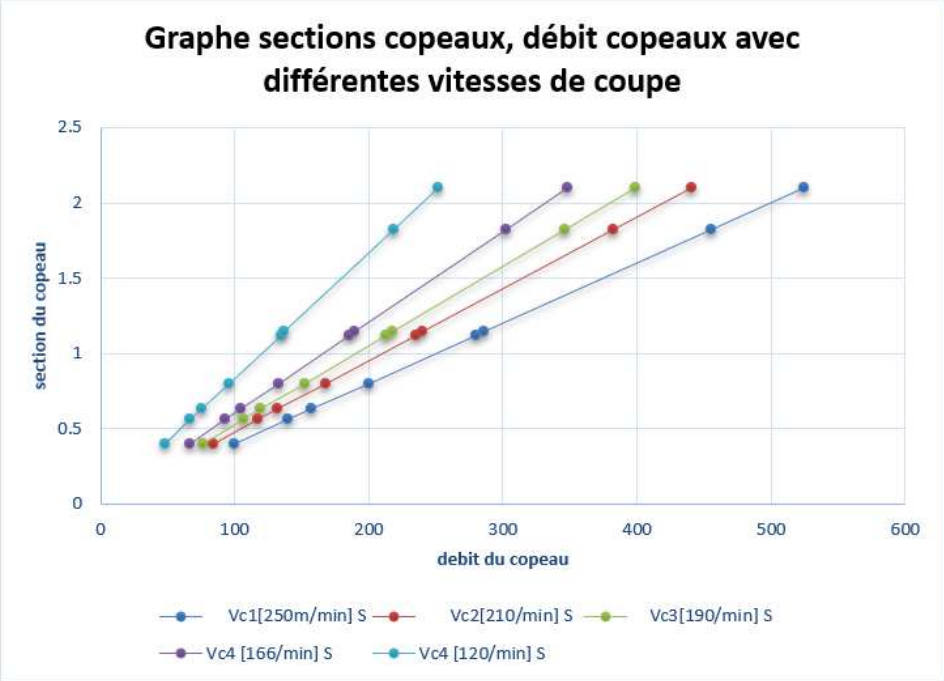


Fig. 3.6: the graph sections, chip, speed chip with different cutting speeds.

4. CONCLUSION

The projected goal in this article is based on the understanding of one of the current concerns of the problem of the formatting of the material by removal of material; it is the cost optimization of machining in dry turning of a steel material S400N by the experimental approach of GILBERT, for an operation of turning.

We have taken into account the phenomena of degradation of the tool (wear and tear) which significantly affect the productivity by reducing the quality or precision of the workpiece, or by increasing machining costs.

We also take into account the nature of the cutting tool (carbide brazed grade P20.The rational selection of cutting conditions has contributed largely to our goal in operator expressions of the models in (3.7) and (3.9).

Therefore, it is necessary to respect the plans of cutting in order to prevent damage to the quick of the tool, reducing the quality of the workpiece to finally avoid the increase in the cost of machining

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