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Optimization of Cutting Parameters under the Constraint of Design Office Requirements

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Abstract — *The allocated time to choose the cutting parameters plays a very important role on the machining time, part price and delivery time. The purpose of this paper is to develop a tool to help in the selection and calculation of cutting conditions in a short time, under the constraint of the life of the cutting tools, the surface condition of the machined parts, the manufacturing tolerances and productivity.*

Keywords — *Cutting parameters, Manufacturing tolerances, Workpiece quality,*

I. INTRODUCTION

Around the 80s, the competition was known and limited, the lifespan of industrialized products was long, deadlines were set by the company, this allowed an unconstrained industrialization phase. The customer had little choice, so quality was not a production criterion. Currently, the reduction in orders, the reduction in the lifespan of products, competition and the need for quality, have imposed a transformation of the industrial tool. It took place through the improvement of processes (numerically controlled machines, three-dimensional measuring machines, automation, CAD/CAM, etc.) which enabled an increase in productivity. Performance optimization was achieved through a vertical approach without interconnections between functions. The goal in this paper is to develop a new strategy to optimize and automate the calculation of cutting parameters.

II. CUTTING PARAMETERS

In any machining problem, it is necessary for technological and economic reasons to determine the values of the cutting parameters best suited to the work to be carried out.
These values have been determined experimentally by laboratories specialized in cutting tests such as CETIM, L.C.A., RNUR, etc.

A. *Cutting speed*

The workpiece is driven on the lathe at a certain speed ω, this angular speed being communicated by the spindle of the machine via the workpiece holder (figure 1)
The relative speed of the part at this point with respect to the tool is given by the following formula (1) [7] :

$$Vc = \frac{D}{2} \times \omega \tag{1}$$

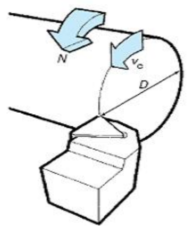

Fig 1. Cutting Speed

The spindle speed is given by the following expression (2) [7].

$$N(tr/\min) = \frac{1000 \times Vc \ \ (m/\min)}{\pi.D(mm)} \tag{2}$$

The cutting speed, table 1, depends on the type of operation.

Table 1. Influence of operation on cutting speed [1],[3]

Operations	Cutting speed
Turning or facing	Vc
Simultaneous turning and facing	0.8Vc
Cutting	0.5Vc
Thread	0.3Vc
Drilling or reaming	0.7Vc
Knurling	0.25Vc

It should be noted that the cutting speed is constant only if the spindle speed and the diameter of the workpiece remain unchanged. In facing, for example where the tool moves towards the center, the cutting speed varies continuously if the rotation of the part is carried out at a constant spindle speed. However, for maximum productivity and better quality of the surfaces obtained, it is desirable to keep the cutting speed constant. On many modern lathes, the spindle speed increases as the tool approaches the axis, thereby compensating for the decrease in diameter. But in the case of very small diameters, this compensation is impossible due to the limited speed range allowed by the machines. Similarly, when a part, as is often the case, has different diameters or is conical or curved in shape, the rotational frequency must be corrected according to the diameter, to maintain the cutting speed constant (figure 2)

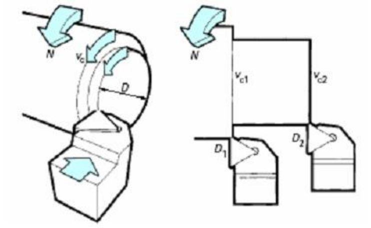

Fig 2. Definition of the three variables (cutting speed Vc, diameter D, rotational speed N)

B. Feed rate Vf

The feed rate Vf (mm/min), Figure 4, is the speed at which the machine moves the tool relative to the frame. The feed per revolution f (mm/Tr) is the value of the tool displacement, when the part has made one revolution. This is key data for the quality of the machined surface. The feed affects not only the thickness of the chips, but also the way in which they break. The federate Vf is given by the following formula (3) [7].

$$Vf = f \cdot N \tag{3}$$

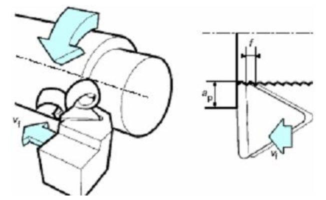

Fig 3. Feed rate Vf

C. Depth of cut (Ap)

In turning, the depth of cut ap (see figure 4) is the difference in radius between the unmachined surface and the machined surface (i.e. half the difference between the unmachined diameter and the machined diameter) . The depth of cut is always measured perpendicular to the direction of the feed and not along the edge of the tool.

D. Chip width and thickness

The chip thickness h is measured perpendicular to the cutting edge. The width bD of this chip is measured parallel to this edge. For a feed per revolution f and a depth of pass p data, the chip thickness and width vary with the edge orientation angle k.(figure 4). In addition, for strong cuts (negligible tool nose radius compared to the other parameters), the chip section is given by the following expression (4) [7] :

$$A_D = f.\ a_p = h.\ b_D \tag{4}$$

For a section of chip removed, we therefore have the choice, by playing on kr , between obtaining a long and thin chip or a shorter and thicker one (figure 5).

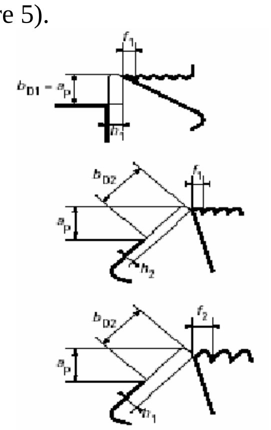

Fig 4. Influence of k on the advance f [8]

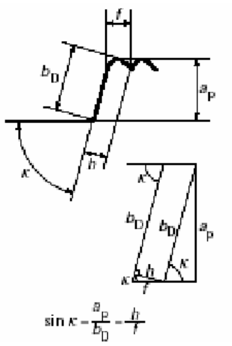

Fig 5. Variation of chip thickness and width with edge orientation angle k [8]

A thin chip distributes the cutting force over a larger part of the edge and therefore reduces the stresses (mechanical and thermal) imposed. On the other hand, a chip that is too thin (less than the "minimum chip") prevents a real cutting of the material, generates high stresses and wears out.

Prematurely the tool: we must then compensate by increasing the feed.

Table 2 illustrates the different angles of attack affect:

- The feed given the same chip thickness;
- The chip thickness given the same feed;
- The effective length of the edge taking into account the same depth of cut;

Table 2. Influence of entering angle on feed, edge length and chip thickness [2],[5]

%	**1**	**2**	**3**
Ko	*f /h*	*h/ f*	*bD/ ap*
90	100	100	100
80	102	99	102
75	103	97	103
60	110	87	110
45	141	71	141

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Volume: 05 Issue: 03 May to June 2022 www.ijlesjournal.org

E. factors influence the cutting parameters

The factors that directly influence the optimization of the cutting parameters [6] are:
- Type of machine
- The geometry and material of the cutting tool
- Tool life
- The material of the part
- room size
- Tolerances and surface condition
- Type of machining (interior or exterior)
- Type of operation (roughing or finishing)
- With or without lubrication

III. PROGRAM ORGANIZATION CHART

The general flowchart of the program developed is given in figure 6.

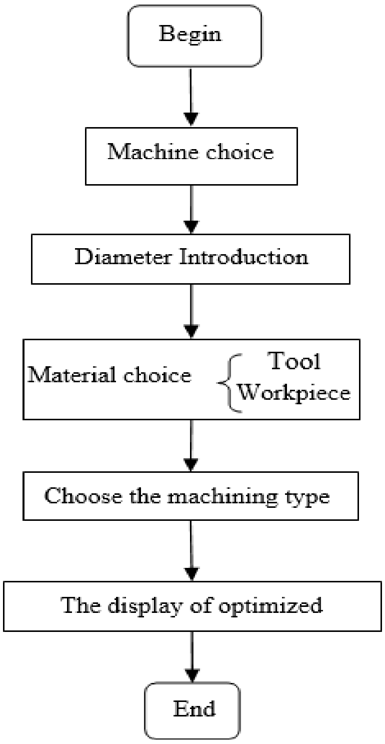

Fig 6. General program flowchart

IV. TOOL PRESENTATION

The first window illustrates the layout of the Expand tool, as Figure 7 shows. To enter the module, just click on ENTER and to exit, click on QUIT

Fig7. Develop tool overview

This tool performs several functions:
- Calculation of rotation speed;
- Calculation of feed per revolution and per tooth;
- Calculation of the forward speed;
- Calculation of the radius of the tool nose (case of turning);
- Calculation of roughness;
- Calculation of machining time;

The screen in figure 8 illustrate the choice of machine.

Fig 8. Machine choice

A. *Calculation of cutting parameters during turning*

The screens in figures 9, 10, 11 and 12 illustrate the calculation of cutting speeds, roughnesses, tool nose radius in different turning operations.

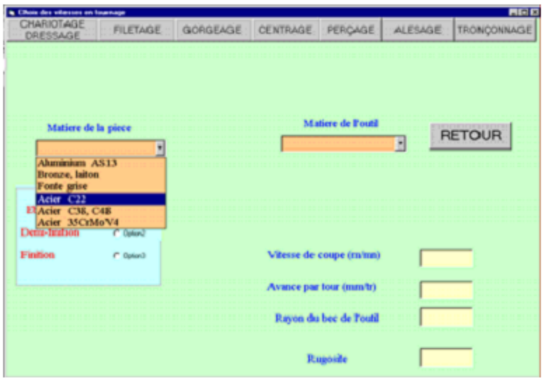

Fig 9. Choice of part material

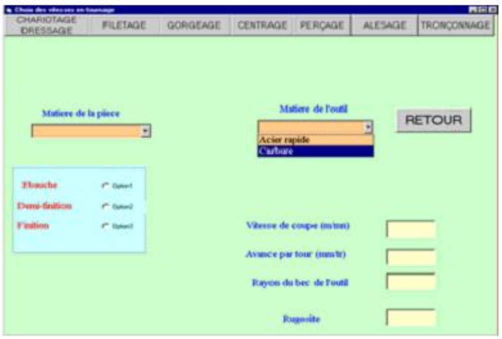

Fig 10. Choice of tool material

Fig 11. Help in choosing cutting parameters in the case of TROLLING/DRESSING

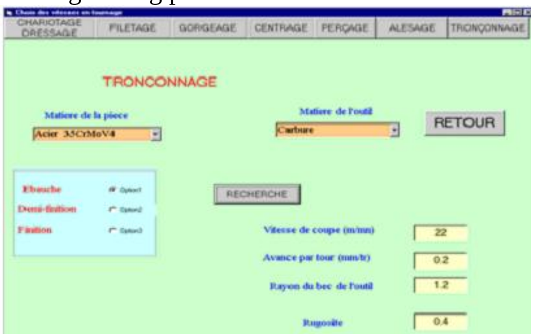

Fig 12. Help in choosing cutting parameters in the case of CUTTING

The screen in figure 13 presents the rotation speed calculation as well as the machining time

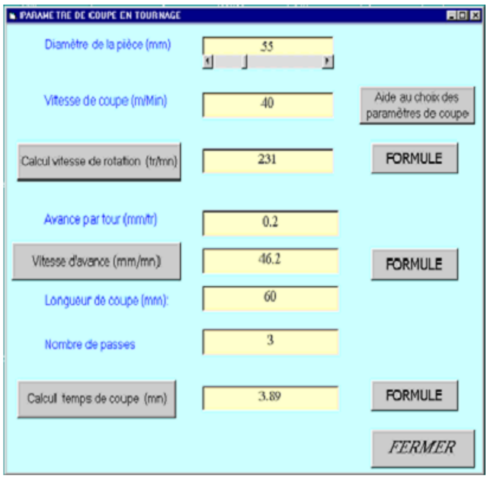

Fig 13. Values of cutting parameters in turning

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B. Calculation Of Cutting Parameters In Milling

The screens in figures 14 and 15 illustrate the calculation of cutting speeds, roughnesses, and tool radius in different milling operations

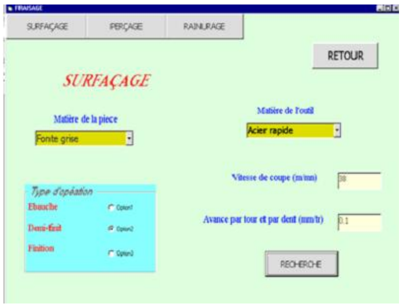

Fig 14. Help in choosing cutting parameters in the case of SARFAÇAGE

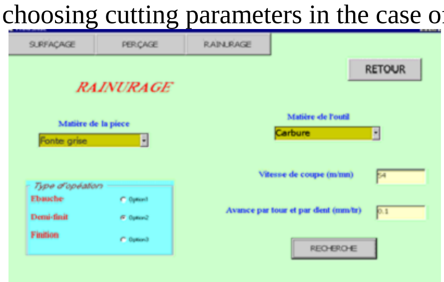

Fig 15. Help in choosing cutting parameters in the case of GROOVE

Figure 16 presents the values of the parameters of milling cut

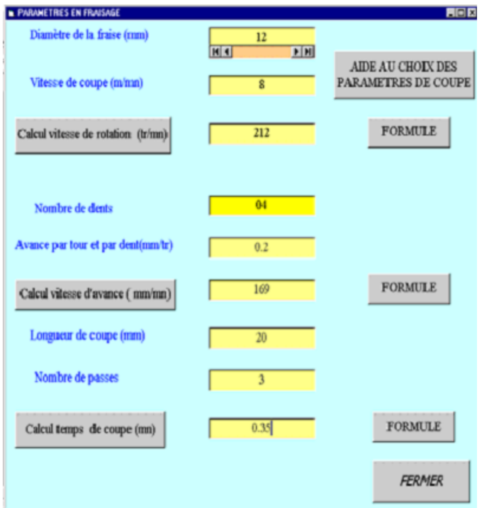

Fig 16. Values of cutting parameters in Milling

V. CONCLUSION

Today, many competitors have arrived at the same level of quality and price. Price competition corresponded massively, quality and innovation took precedence during the globalization of markets, but the increasingly rapid obsolescence of products led to competition in speed term. This work was oriented in order to automate the calculation of cutting parameters. Two parts have been developed. In the first part, we approached to define relations which make it possible to calculate the parameters of cut. The second part deals with the automation of the calculation of the different cutting parameters. This module allowed us to choose and calculate the cutting parameters in a short time.

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