SELECTION SYSTEM FOR CUTTING TOOLS MACHINING BY MEANS OF GEOMETRIC ANALISYS APPLIED TO SYSTEM PLANNING PROCESS MACHINING

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***Abstract**. The use and damage of the cutting tool resulting from an inappropriate choice may lead to increased costs and decreased quality of the finished piece. Depending on the complexity of the profile that makes up part of the insert and the choice of support makes it a challenge for any computer system to be developed. A methodology was developed for selection of cutting tools based on the profile of the parts dimensions, where the dimensions of the workpiece sections could be represented by points in Cartesian coordinates. These points can be constructed by means of mathematical functions and compared by the values defined by mathematical expressions, also generated the tool geometry that can be regarded as interference. These functions obey almost completely the information passed by the user to register the tool and workpiece. Consequently it was necessary to construct databases of information code according to ISO 513 (2004) and the number of tools, such as material, mechanical properties and dimensions. This database belongs to a system in development planning process called SAPPU (automatic planning machining process), which aims attributes related to the sectors of manufacturing and materials. Thus this system has acquired as main feature the integration of several subsystems with their unique methodologies including the selection tool that will be the focus of this work.*

***Keywords**: Selection of cutting tool, machining, parameter of cut.*

1. INTRODUCTION

Choosing the right tool for a particular operation and the correct determination of machining conditions plays an important role in working with metals and a factor in determining the evolution of machine tools and cutting tools. This fact is accentuated in serial production, where differences in the choice of cutting speed and tool can cause remarkable variations in manufacturing costs, Ferraresi (1989).

Currently they are looking at developments in computer-aided systems for the automation of process planning. The efficiency and level of automation of machining processes depend significantly on the existence of detailed cutting data, updated and easily accessible and fast. The automatic selection of cutting tools and an automated production plan depends on this context, ie, databases efficient.

A major difficulty in the choice of cutting tools according to Jensen et al. (2002), is related to the part profile. Interference relevant regions of a given profile may limit the quality or performance of the tool during its cutting path. These interferences which determine the choice of tool interference are the local and global. They occur when the curvature of cut is as small as before the versatility of the tool at the time of cut and there may be clashes between the tool body with the profile of the part.

2. SELECTION TOOLS

The machining of metals is a complex process, composed by a variety of operations and materials involved. In most cases, the machining is done on machine tools, numerically controlled, with multiple tools consisting of pads, brackets and fixings. According to Zhou and Wysk (1992), the decisions for the selection of tools, determination of machining parameters and tool chang times are made by process planners, programmers and machine operators at different stages of manufacturing. Due to this sharing of responsibilities and lack of interaction with the process can become very difficult to achieve good decisions tooling.

There are many tools available which affect the performance of the operation, it is not surprising that the tool selected by the operator is not optimal. Usually, the tools are at hand and are known, are capable of performing a particular operation, and are used for convenience despite its drawbacks. The tool chosen may be far from optimal and this fact, together with the increased use of integrated manufacturing systems, results in the need of methods for automatic selection of tools (Chen et al. 1989).

3. METHODOLOGY DEVELOPED

The methodology for a system of selection of tools was developed with a unique vision for a comprehensive system for planning machining process called computer-assisted system SAPPU. The system was developed in a program called Delfhi ® 6.0.

For a given geometric shape of the part of the tools are selected under the conditions of interference between tool and part geometry. The selector tool works with the geometric boundaries of the piece. The versatility of the whole insert and support, along with the tool features are part of the procedure adopted.

It was then proposed this methodology based on the profiles of the pieces, where the drawings of these profiles can be represented in Cartesian coordinates of points (Fig. 1). This representation was made possible by mathematical functions and compared by the values defined by mathematical expressions and was also considered the interference of the geometry of cutting tools (Fig. 2). Through the discussion ahead can have a vision of how it handles this mathematical method.

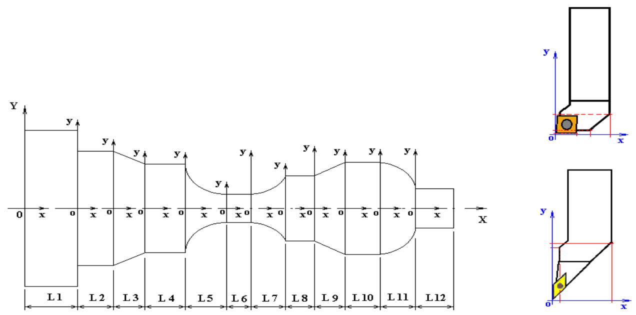


Figure 1. Complex piece staggered sections of simple geometry

The definitions of critical points of the assembly/insert are important points for comparison tests. Based on studies of catalogs of manufacturers of cutting tools was noted a difficulty in defining these points with the code according to ISO 513 (2004). This is due to the fact of the geometric complexity and its variety of tools needed. It was them defined the sections by comparative analysis and obtained values for the mathematical functions that represent the critical points of the set, among them the tool length and dimension I_1 f_1. In Figure 2 can be seen almost every possible dimension.

Values like: Engagement I_3 length, size of "interference" Coupling f_2 are specific cases where the operator needs to consult the catalog or measure if not defined. Some supporters may have other dimensions that can be considered interference, these values however, may not need to be consulted measured in catalogs, and its representative symbol is the f_{1s}.

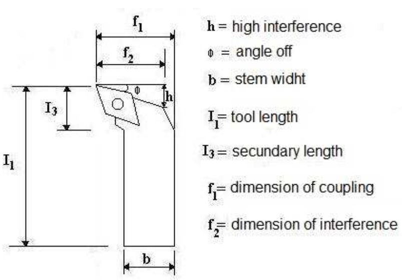


Figure 2. Dimensions needed for the development of interference relations

The dimension symbolized by the letter "h" shown in fig. 2 can also be regarded as an interference value of this type of support and can be determined by eq. (1), which values are obtained from the geometry of the tool itself, however, as already mentioned, some supporters will have to be measured by an instrument in hand. If the value of the interference of support "h " is equal to the ordered part of the profile of this support it will not be selected.

$$h = tg\phi . f_2 \tag{1}$$

$$\phi = 180 - (\kappa_r + \alpha) \tag{2}$$

Where κ_r corresponds to the position angle, α corresponds to the tip angle or nose radius r_e, f_2 valley dimension as interference in the tool and ϕ the clearance angle.

As mentioned, the method of assessing the interference consists of comparing two functions one of which is defined by the geometry of the coupling of the tool and the other is defined by the geometry of the part, ie, the profile of the part. A complex profile can be considered for analysis, ie a part that can display more than one different type of profile, known as the three profiles (cylindrical, conical and consistent). Figure 1 above gives the possible divisions of the complex profiles of the number of profiles for sections simpler. This can facilitate obtaining the mathematical expression that represents each profile.

The present terms in the equations of profiles represented in the drawings of fig. 3 are from the dimensions of the piece, unless the terms x and x_0. These two terms represent the motion of the tool toward the z-axis machine tool.

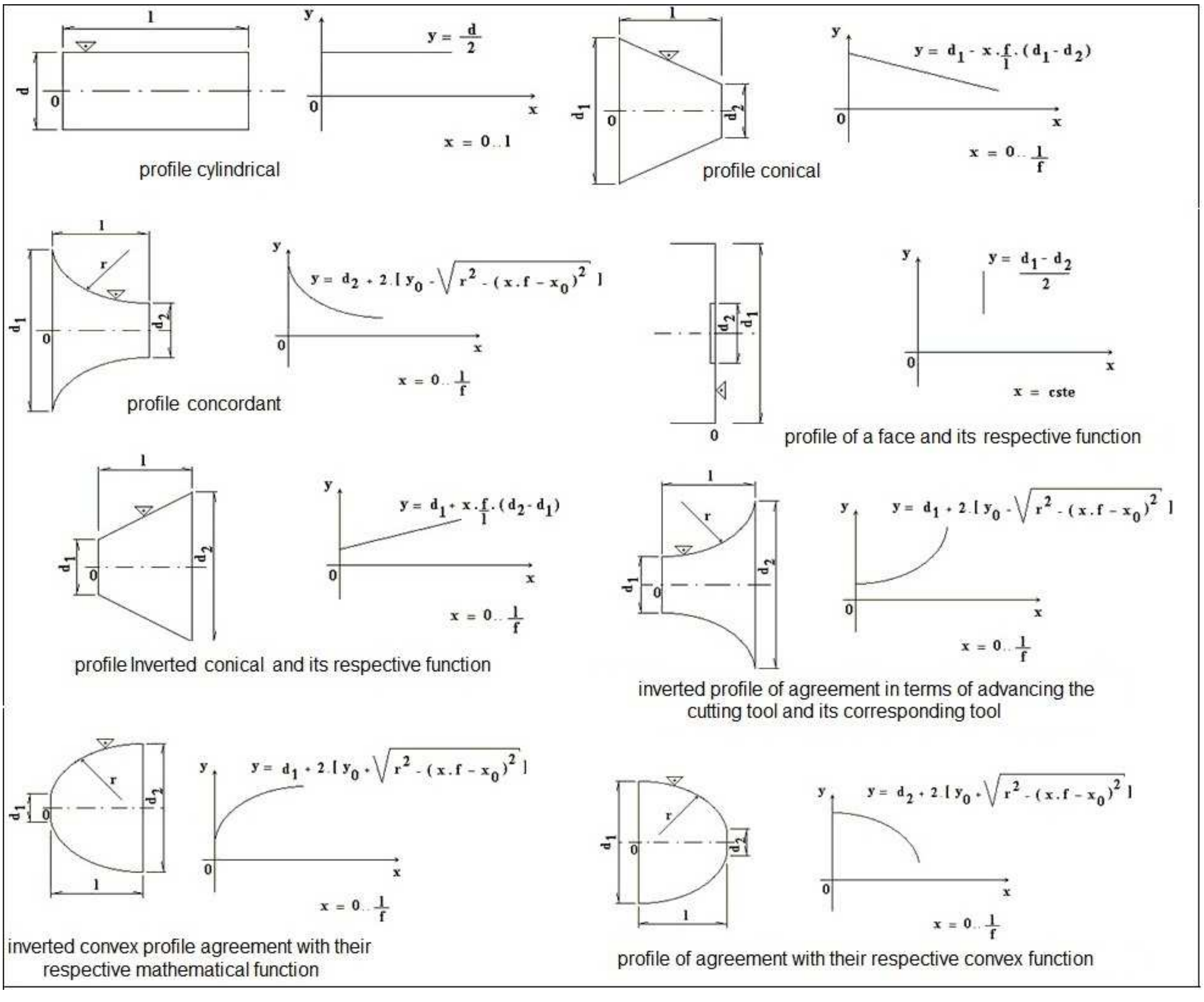
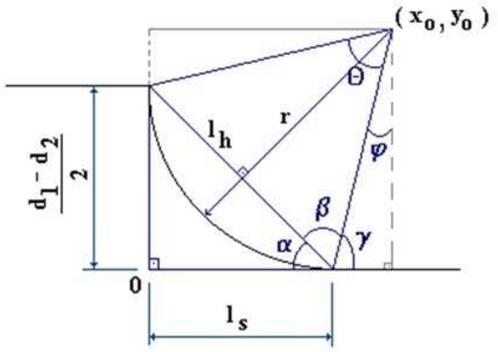


Figure 3. Representation from all parts of the turning profiles and their expression

Where:

- y = function of the profile section of the piece;
- f = forward;
- d = d_1 and d_2 = are the dimensions of the diameter of the section of the piece;
- r = radius of the profile of the agreement;
- x is the incremental position that allows the analysis of possible interference between the critical points of engagement tool/support and profile of the piece;
- x_0 and y_0 are the respective points of origin of the radius of curvature (z_0, x_0) in the machine tool.

The points x_0 and y_0 are calculated from the data section of the piece and the radius of the agreement, fig. 4. Through this figure we can have a view of the geometry of the concave arc of agreement and to obtain such source is used the equations shown in this figure.



Geometry for determining the points x_0 e y_0

$$l_h = \sqrt{l_s^2 + \left(\frac{d_1 - d_2}{2}\right)^2}$$

$$\alpha = arctg\left(\frac{d_1 - d_2}{2.l_s}\right)$$

$$\beta = \arccos\left(\frac{l_h}{2.r}\right)$$

$$\gamma = 180 - (\alpha + \beta)$$

$$\varphi = 90 - \gamma$$

$$x_o = l_s + r.\text{sen}\varphi$$
$$y_o = r.\cos\varphi$$

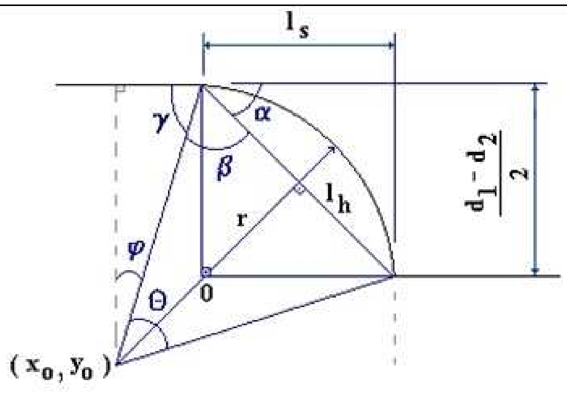
ou

$$x_0 = l_s + r.\text{sen}\left[arctg\left(\frac{d_1 - d_2}{2.l_s}\right) + \arccos\left(\frac{l_h}{2.r}\right) - 90\right]$$

$$y_0 = r.\cos\left[arctg\left(\frac{d_1 - d_2}{2.l_s}\right) + \arccos\left(\frac{l_h}{2.r}\right) - 90\right]$$

Figure 4. Determination of the values from the source to a concave profile consistent

By looking at profiles of agreement, points may be interference in the regions of "descent" or "climb" to the direction of tool advance. As the tool continues then your profile will be designed depending on the size and geometry of the workpiece and the tool may be ill-chosen, damaging thus machined surface or may even lead to further damage. With respect to obtaining the coordinate (x_0, y_0) for convex agreement can repeat the same procedure in the calculations. Thus, by Fig. 5, we also have a vision of geometry developed to obtain the necessary formulas for the calculation of coordinates. These equations are also shown in this next figure.



Convex profile of agreement for the calculation of the coordinates (x_0, y_0)

$$l_h = \sqrt{l_s^2 + \left(\frac{d_1 - d_2}{2}\right)^2}$$

$$\alpha = arctg\left(\frac{d_1 - d_2}{2.l_r}\right)$$

$$\theta = \text{arcsen}\left(\frac{l_h}{2.r}\right)$$

$$\beta = 90 - \theta$$

$$\gamma = 180 - (\alpha + \beta)$$

$$\varphi = 90 - \gamma$$

$$x_o = -r.\text{sen}\,\varphi$$

$$y_o = \frac{d_1 - d_2}{2} - r.\cos\varphi$$

Figura 5. Determinação dos valores da origem para perfil concordante convexo

One of the more complex surfaces in turning operation is the agreement (arc). The limits of their operation are also possible areas of interference. Depending on the fillet radius, the media may be collide, or even produce an undesirable finish. In this case, some tools have to be more versatile than others, aiming for a good finish. The concave and convex shape is shown in fig.6 respectively.

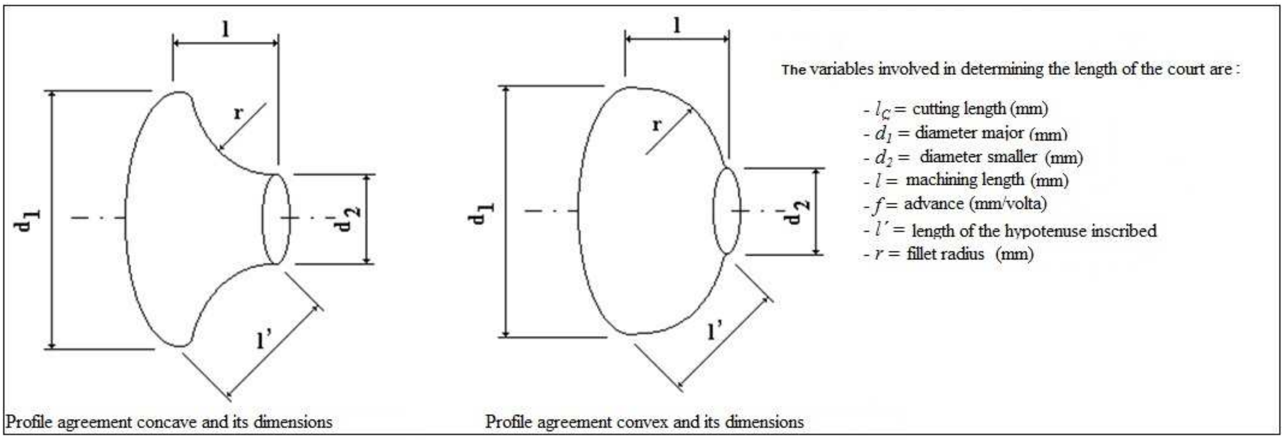


Figure 6. Representation of profile concave and convex

To analyze and detect the existence of interference was also developed other expressions that need to determine them from expressions (1) and (2) previously demonstrated that calculate the angle ϕ to determine the height h. This value is analyzed together with the function of the variable y and, remembering that the function y is a function of the profile of the part and is the advance (increment).

The value of "h" is regarded as a maximum value of interference, because as the tool moves in the depth of cut depending on the support can be chosen contacts before reaching the maximum height off the surface of the tool. This can be seen through the schematic drawing of fig. 7 which depicts the region of interference coupling tool/support and the resulting equations developed. The advance to *a* division comprises the length f_2. This division provides the location coordinates of the critical regions of interference. It is estimated then the height increment h', which can be seen in this figure.

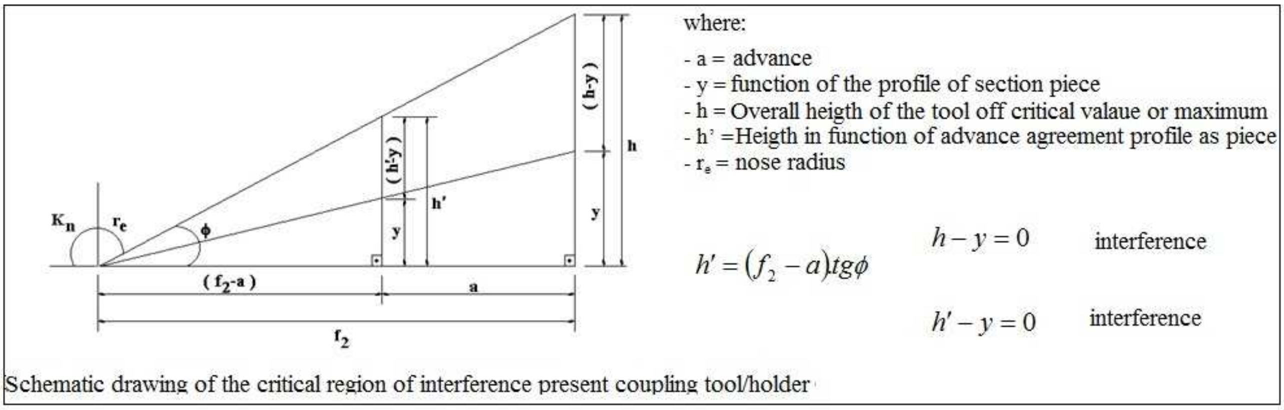


Figure 7. Schematic drawing to obtain the support of the regions of interference

With this, the analysis and location of the interference between the support assembly with the tool and the profile of the part are simpler to run, it can also predict whether interference will occur in the previous and posterior sections of the section which is located in the cutting edge of the tool in question. As already mentioned if there is a coincidence between the mathematical expressions, then there is interference. This represents the physical contact between any part of the overall tool/piece surface and the support of complex profile (Fig. 8).

Each profile consists simply that the piece can be registered in the system as a section, part of the piece to be machined. The nomenclature *L1* to *L12* of the example below represents the position of the section in relation to the mounting plate of the lathe (machine tool), where *L1* is located next to the card or the nuts and *L12* located next to the counter point (Fig. 8). Each section can have a mathematical expression. The algorithm of the system has increments and loops in order to assess whether the difference between the functions *h*, h' and *y* is nonzero.

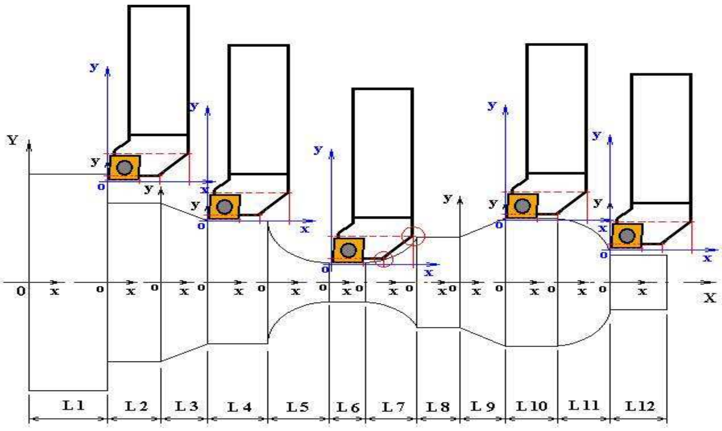


Figure 8. Example of how an interference occurs between a tool set/support and the part surface of complex profile

On the other hand, for the finishing operation, is demonstrated by fig. 9, the support assembly/insert for this operation is compatible with the complex profile of the piece in question.

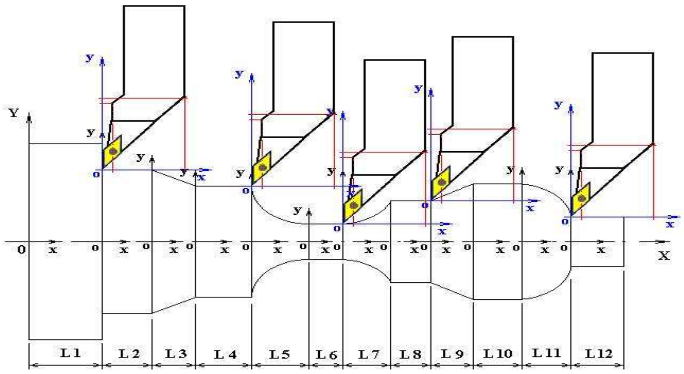


Figure 9. Position Test of a finishing tool

For the choice of a cutting tool, first make sure all records needed to manufacture the part. The moment that defines the machining operation, the system prompts the identification number already registered and all information regarding this piece chosen will determine the selection of the tool. Then we can have an idea of the algorithm of the proposed system.

1 - With information on the workpiece material chosen, the system will assemble a list of compatible chips from wafer table listings. If there is no chip compatible system will report on this deficiency. The system may require upgrading the stock.
2 - With the list of pads mounted, defines the machining operation. This operation will delete the list pads unsuitable for operation.
3 - After screening in block 2, the system will mount a second list (table) containing the supports for the tablets from the list built in block 2.
4 - The system retrieves information about the piece chosen for manufacturing.
5 - Set up the total length of the route where the tool will perform. This value can be obtained by the sum of the lengths of each section or part of the total length of the rod part.
6 - This block is intended to enumerate and count the chips on the list and highlight, one by one, and test all the media chosen valid in block 3.
7 - For each wafer selected counter block 6, block 7 highlight, one by one, each bracket.
8 - With the support of time, the system retrieves all information about the geometry and critical points.
9 - This block is a counter step performed every millimeter, the tool in question. It is the displacement of the tool on the Z axis parallel to the main axis of the lathe.
10 - The tip of the tool in position counter while it is the contact test. This test consists of determining the critical points of contact support with the local sections, previous and posterior. It just exists a coincidence considering the

value equation section profile with the critical value of the support. These tests are conducted across all media selected for each chip.
11 - The results of screening tests will be recorded in a database relating to existing contacts.
12 - With the new list of contact information of the selected tools, is emitted reports on the working conditions of each tool selected

It is shown, therefore, by means of fig. (10) a portion of the algorithm that the system uses to determine whether there is interference, a contact between the critical region of interference located on support assembly/tool and the workpiece surface to be fabricated. The profile of face milling is also an important profile, given that some tools are not accessible to this type of profile. In this case, the value of "*h*" can be calculated when the surfacing is in regions within the design of the piece.

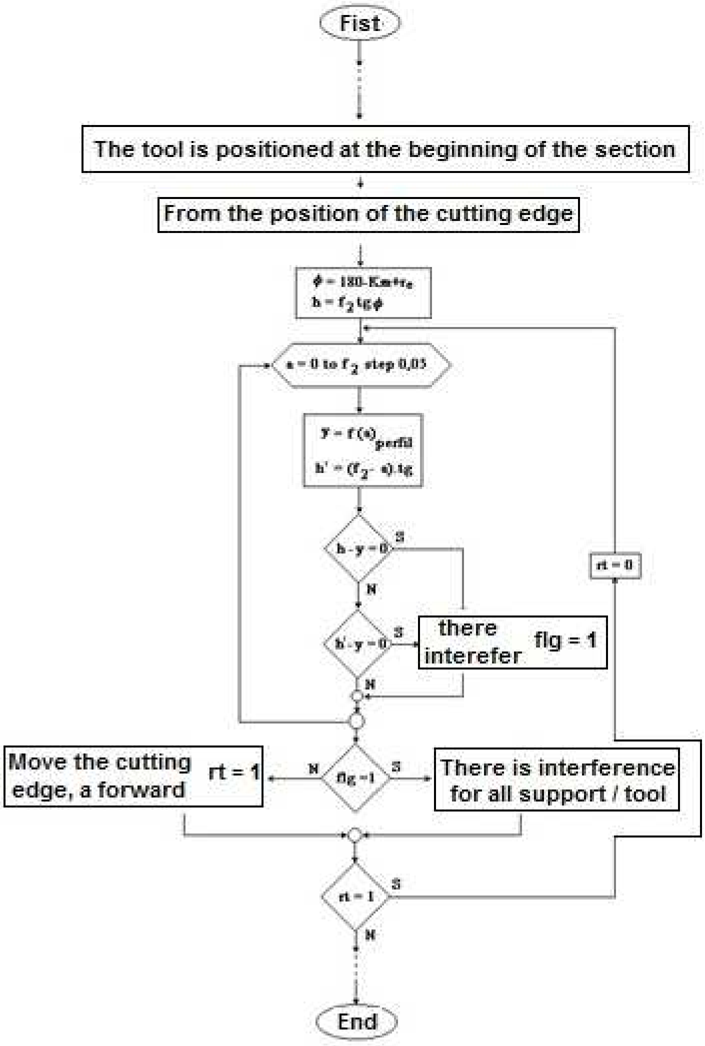


Figure 10. Excerpt from the algorithm that uses the system to check for interference

4. RESULTS AND DISCUSSION

The system was modeled before the concerns of Jensen et al. (2002), and Oral and Cakir (2003), in which the piece is a profile of the issues that must also be considered.

As discussed in the methodology, information from the tool and workpiece must all be passed to the system SAPPU fig. 11 and fig. 12. The registered data throughout the system is used to doing the calculations in a very original and proposed system. In addition, information is logged by the database and other subsystems may be used by that program and that it is not here to be discussed.

Besides the characteristics of mechanical cutting tools, the database calls in their fields, geometrical information of the profile of the tools, highlighting that some tools have regions of interference is necessary so that the user measures these values for calculations.

These requirements may seem a complex form of register, but can lead to a more effective tools and how they behave in relation to the cutting. The information registered mostly follow the ISO code. This was one of the modeling features of the display of registration information of the cutting tools.

Besides the information of the characteristics of the tool linked to the subsystem selection of cutting tools, the screen of fig. 13 shows fields that can be used for statistical analysis for management tools. Inventory control the amount of tools, among other values and can be of great importance for any planning system process. The subsystem's response selection of cutting tools, is automatically defined by the values registered at this screen.

Although this presentation, when selected the item complete tool, insert the fields and support are released, as shown in Fig.13.

Figure 11. Opening screen of the system SAPPU

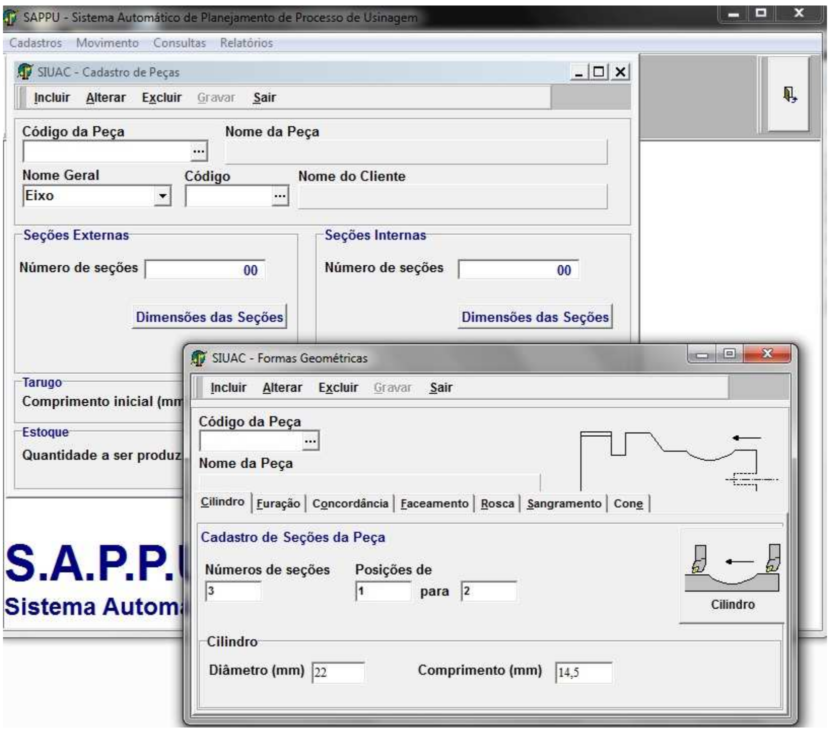


Figure 12. Screen registration number of the profile of piece

As the user goes registering tools, code and input register is constructed, the information through the code of the tools can be linked to other files to register.

The code generated for the register follows an order of digits, as shown by fig. 13. The order comes as the choice, for example, code 01 from left to right represents excellent vibration chosen by the user, then the 01 digit refers to the hard metal and so on.

The cutting tool has other components called accessories, so if the user wants to register this information also, through the screen registration tool can be fired this screen. The result of the register can be viewed through the screen of fig. 14 below.

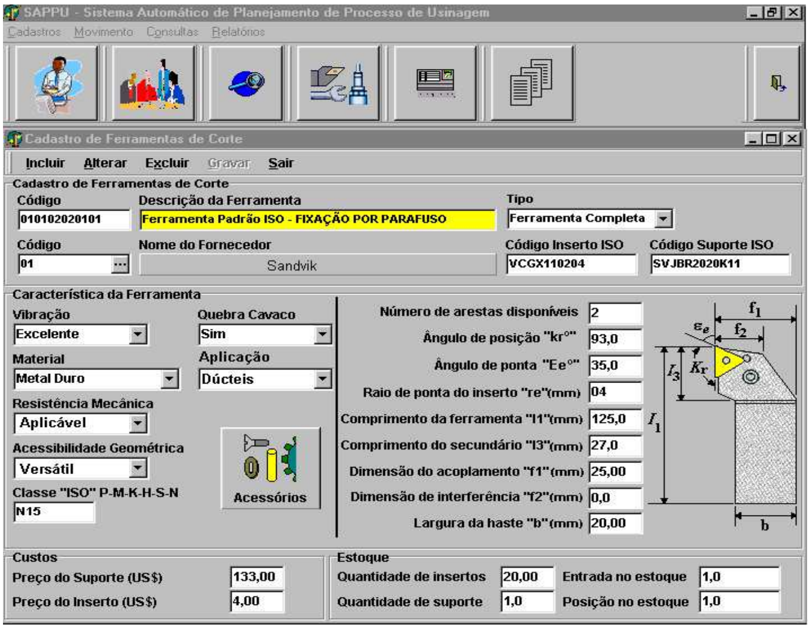


Figure 13. Screen record of cutting tools for turning the system SAPPU

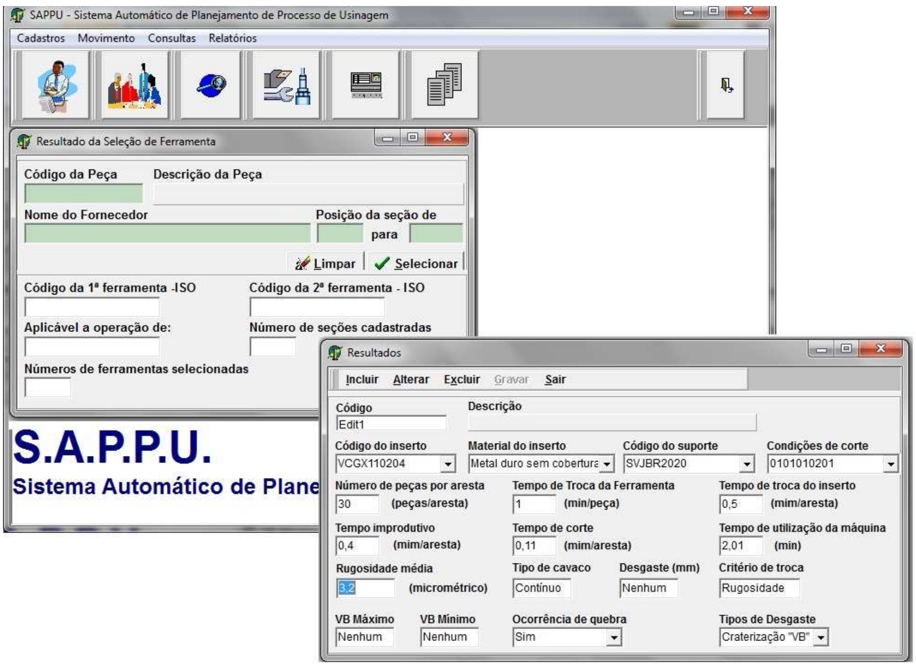


Figure 14. Screens violations result of registration for the selection of tools

5. CONCLUSION

The methodology proposed and developed is somewhat unique, since it is not found in review an idea of transformation profiles in mathematical analysis.

This system offers a low difficulty compared to the user when it comes to data storage, since it the concern was of an illustrative and informative system, and a warning of attention to the importance of data as part of the profile.

The program also brings the relationship with other subsystems such as inventory control, management, both related to the database of the proposed system.

In other work there will be shown to the assembly and the relationship with other subsystems SAPPU, which is still under construction.

The information registration is still under way since this methodology depends on the application subsystem overall system SAPPU.

6. ACKNOWLEDGEMENTS

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