METHOD FOR THE CONTROL OF THE GEOMETRIC AND CONSTRUCTIVE ELEMENTS OF THE SPIRAL-FACE AND END MILLING CUTTER

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Abstract: In the paper are presented the bases of a methodology for the determination of all the geometric and constructive elements of the cutting tools for the milling machines, starting from the getting of a solid model 3D of the measured tool. There are shown the possibilities to obtain a 3D model and the graphic model of the geometric parameters control.

Keywords: *Control, Cutting Tools, 3D Model, Geometry.*

1. General Introduction

Unprecedented development of material manufacture and technical orientation toward higher accuracy of products required development of the cutting tools' construction, made by using new materials to increase the precision of their execution. Increase bad-dimensional and geometric precision of the tools required technological processes and new machinery and apparatus at the highest level.

The necessity to exactly endeavor the dimensions and cutting tools' geometry, especially complex, assembled or curved cutting edges and ordered development of techniques and different technologies, which would shorten the time needed to control and would permit to obtain endeavor parameters at all cutting edges, to verify if all the geometric parameters are real and included between acceptable limits, more or less close to the optimum.

To control the cutting tools' geometry there are imagined, developed and built a large variety of devices and control instruments, from simple templates, rulers, sublime and reporting workshop microscopes to larger or smaller cars and the coordinated measures [Minciu et al. 1995].

Currently, the explosive expansion of computer's use and devices permitted a new approach of the problems of the cutting tool's control, based on other principles, that we did not find in the autochthon literature or in the strange literature [Strajescu 1989].

The original idea developed further make use one of innumerable programs (software) made by firms specialized in CAD, CAM (3D model-horizon), in order to determine all the geometric and constructive elements of cutting tool using 3D solid model of the studied cutting tool obtained in advance.

2. Obtaining 3D Solid Model Of Cutting Tools

The methodology that we propose is based on the getting of a 3D solid model of the controlled cutting tool [Enache et al. 1988]. As is easily intuited, if the project of the tool is made with a computer using software CATIA, Solid Works, Solid CONCEPT, the 3D model exists, because that model is generated by the software. It is known that at the design of the cutting tool, there are some preconditions which allow the construction of integral tool. Using 3D model made on this route would allow the designer visualize all geometrical elements at all edges of the cutting edge which classical design methodologies not allow. Other two possibilities to obtain 3D model are taken into consideration toward the authors of this article. This 3D model is obtained by scanning the cutting tool (modern scanners will produce geometric precision and high dimensional, maximum deviations hundredth of a millimeter is now toward normal), and by obtaining the 3D model using photography, photos, and treatment with specialized software.

2.1. Obtaining 3D model of the phase of projects hard.

The trend of placing in the cutting tools' current design of the technical computing, imposed and developed by the personal computers requires a complete description of the geometric shape and dimensions of tools.

The assisted design of the cutting tools can be optimized by programs.

For the cutting tools of any type, design subsystems are built in the next order:

1. elaboration of the principles for the development projects;
2. parameters' description of the processed parts;
3. implementation of the model for calculating the geometric and constructive elements of the cutting tools;
4. elaboration of the block scheme of calculation;
5. developing computer programs.

In order to realize an automatic design of the cutting tool with efficiency, it would essentially determine the correct informational structure of the cutting tool. In this respect, it should be clarified the following connections:

a) spatial, which determine place and sequence of placement;

b) function, which determine the parameters' size (e.g. parameters of the constructive elements which determine strength and rigidity);

c) external, upon the interaction's character and conditions with the manufactured piece.

The external connections determine the initial data formation, the external factors being very numerous.

The multiple integration, multidirectional, programs from the computer-assisted sphere, specialized programs on the problems of generating geometry (3D drawing), and simulation and calculation of static and dynamic behavior presents a lot of advantages.

We gate away from the pre-project until to reach the final product.

So, the successive stages are: specification of the project's theme, the preliminary drafts, realization of the pre-project, the model calculation and analysis with logical for cinematic and dynamic simulation, the results' getting, the decision on the accuracy, the finite element analysis, decision on the analysis' results, the realization of the prototype or experimental product, experimental research, simulation and optimization through testing and confirmation of the procedures.

There is currently a tendency to extend the use of the solid model geometry, which is a generalization of the geometry in space.

A solid model provided a complete and consistent definition of the piece geometry. Principles of the edition remain available in three-dimensional space, with the remark that changes affect mass properties of the ensemble (center of gravity, moment of inertia) that can be calculated automatically.

The parametric design of the simple parts or assemblies is actually an effective concept and represents the way to suit for the purpose of this paper. This concept design integrates design and analysis steps.

Using generalized cutting tools on different types of tools are included in the concept of parametric design.

In this case are necessary complex calculations and the project no longer analyses directly the piece geometry. Analysis is made on a generalized or idealized model to be complete in a timely and with an acceptable coast. Switching to an ideal geometry ask for a fundamental change in the information model. Idealized model may be different depending on the type of analysis (e.g. static or dynamic, structural or thermal, linear or nonlinear). A simulated event is equivalent to a single running of an experiment. Therefore it must perform a statistical analysis of a set of experimental results. The accuracy is higher and the confidence in the results is greater when the set of runs is greater. It is possible to run multiple tests under different conditions. The results can be statistically processed.

Following such a process to obtain high accuracy with a 3D solid model of cutting tool that can be cut with all the desired measuring planes, the programs used for this purpose may put up all searched angles, without calculations or other operations.

2.2. Obtaining the 3D model by photography.

An absolute new path in the field, usable to obtain a 3D model can be visualized today by the existence of some computer programs that allow reconstruction 3D model from photos made in fixed positions that encircle the subject of the wanted model. Initially such programs were developed for the architecture, but appear variants with net superior precision that can be applied to the cutting tools. Software developments in this area will bring increased safety with precision and dimensional accuracy. We must say that these programs function today, but the necessities for the obtained images' processing are great time consuming.

The D Sculptor computer program permits to create computer photo-realistic models of a large domain of objects, using common pictures of objects in a relatively easy mode and quite fast. No need for special hardware items, but only a computer and a camera. It is recommended a digital camera, but it is possible to use scanned images.

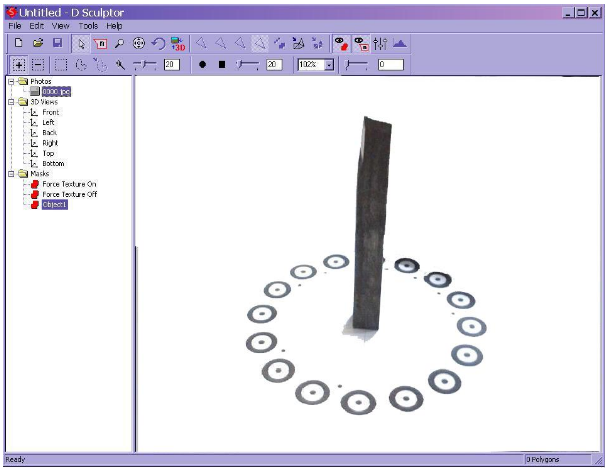

Figure 1: *The main screen of D Sculptor software.*

The basic processes for the composition of the base model are the next:

- it is placed the object for which we need the model on the calibration plane (fig. 1);
- the object is photographed from multiple angles;
- the pictures are imported in the D Sculptor soft;
- D Sculptor automatically detects the model;
- the outside lines of the object in each photography are marked, using the tools for masking from the D Sculptor menu;
- D Sculptor computes the three-dimensional model;
- the three-dimensional model is exported for use with other software (as it is necessary shown).

While D Sculptor 2.0 brought improvements both at the technical level and in terms of interface. You can create models faster than before, and D Sculptor 2.0 Professional last version has a high accuracy.

2.2. Obtaining 3D model by scanning

A convenient way to achieve easier a precise 3D model of a cutting tool is by scanning and reconstruction model. The method is really simple, but its application is limited by the high coast of the scanner device and, some time, by the necessity of an ulterior addition of the model. This last action can be complicate if the scanned object is complex and have many concave surfaces or masked by other parts surfaces.

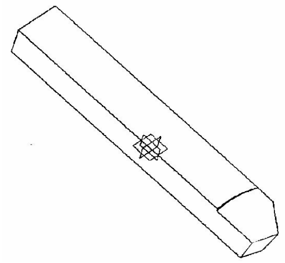

Figure 2: *The solid model for a lathe cutting tool. The main screen of D Sculptor software.*

For the present paper the solid model was obtained using a scanner 3D (Model 2020i Desktop 3D Scanner) that gave very good results.

In conclusion at the chapter 2, it is possible to tell that the use of the 3D model obtained in the project phase permits the integral determination of the geometric and constructive elements in every point of the active surfaces or cutting edges, avoiding for the designer ulterior surprises.

The getting of the model by the two other ways (photographing and scanning) permit the complete and precise determination of the geometric and constructive elements of the studied cutting tools.

3. The Use of the Solid 3D Model for the Control of the Cutting Tools' Geometry

Starting from the solid model obtained in one of the ways described above (Fig. 2) and using a design mean as CATIA or Solid Works, by simple commands consecutive to the points assessment in which the geometry is measured it is possible to draw planes considered as main planes: the orthogonal plane P_O, the tangent plane (actually the plain of the edge projection on P_r) P_T,, the normal P_n (less important for practice, but extremely useful in complex geometric calculations), P_f frontal plane and the posterior plane Pp.

4. Application of the Use of the Solid 3D Model for the Control of the spiral-face and end milling cutter

This kind of tool work simultaneously two perpendicular surfaces, having teeth on the cylindrical and frontal part.

The exterior diameter is established in function of the technological needs and of the tool type, being content generally between 1 and 160 mm.

For the diameters between 1 and 75 mm there are preferred the constructions with a cylindrical or conic tail, and for the bigger ones there are used constructions with circular holes.

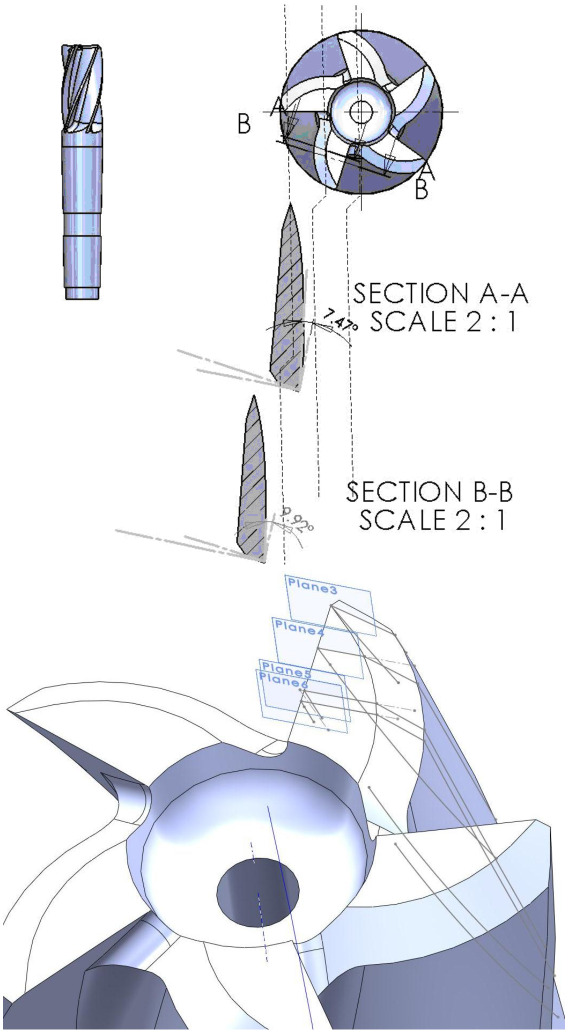

Figure 3: *Intersectii cu plane normale frontale.*

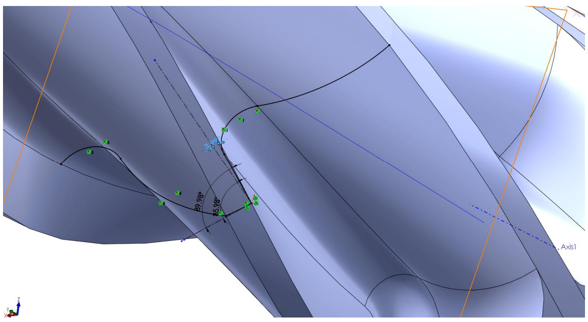

Figure 4: *Intersections with planes perpendicular on the cylindrical helix*

The used plans (perpendicular on the cutting edges, named in ISO Standards orthogonal planes P_O) for the frontal or cylindrical teeth are shown in the fig 3 and 4. Using the program possibilities, the values of the cutting angles α_n and γ_n are precise for different points of the active edge.

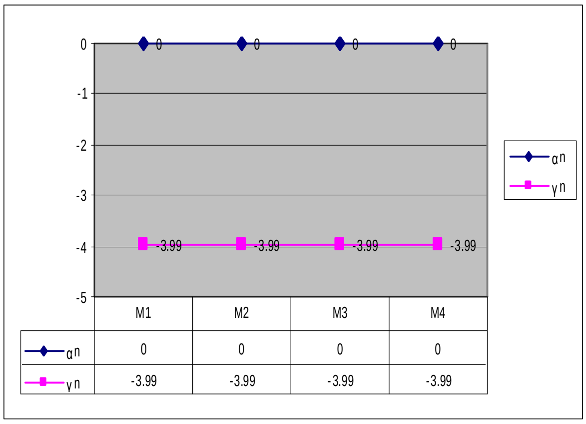

Figure 5: *The graphic representation of the variation of the angles' value for 4 point.*

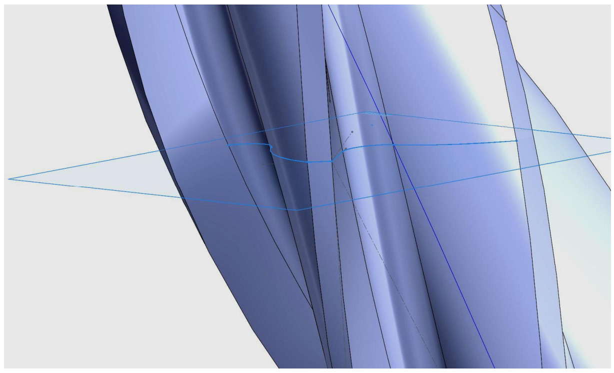

Figure 6: *Intersections with orthogonal planes.*

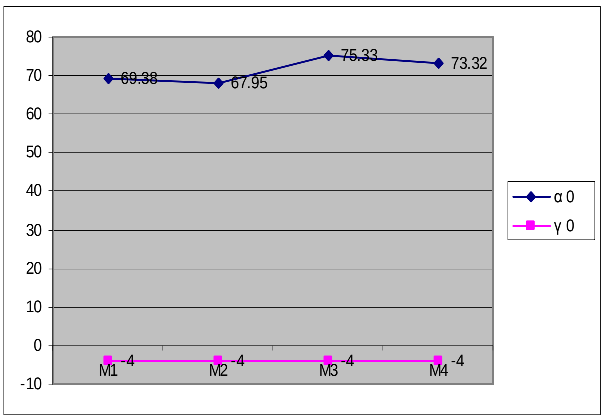

Figure 7: *The representation of the section planes in which are determined the α_O and γ_O angles and the graphic representation of the variation of the two angles' value for 4 points.*

4.1. Intersections with tangential planes

After the intersection of the tangential plane with the reference plane, it was obtained the angle K_r, shown in fig. 8.

The method is especially useful for complex tools, small, with the active surfaces and curved cutting edges, to which access control with current instruments is very slowness or impossible and where the definition of theoretical planes control angles is difficult to apply.

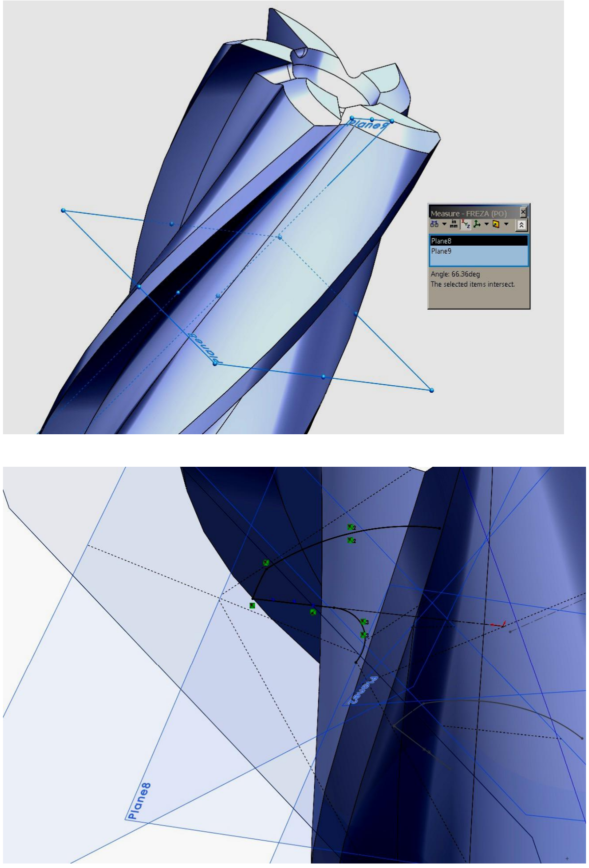

Figure 8: *The tool sectioned with different planes in which is shown the angle κ_r.*

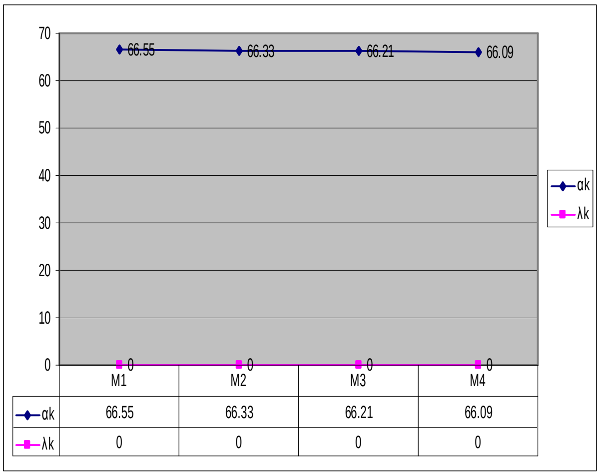

Figure 9: *The Graphic representation of the κ_r angles' variation..*

10. Conclusions

A proposal for a complete control of cutting tools made on the basis on the getting of a 3D solid model is new and brings the first advantage that it is possible to obtain all the angles searched at any point of the cutting edges or active planes. In the same time, the solid model permits at any time to obtain again the lost values. Our research led to the stroke for the control of a milling tool very low, but getting a solid model consumed time and resources, especially to correct the model obtained by scanning, correcting imperfections due to their software interpreting the results of the scan.

The other method of obtaining the 3D model through photography has its limits, given by the precision low shape recovery, but the rate of increase in performance software creates good premises for future use. An important observation concerns the tools with edges and surfaces curvilinear, at which we can determine all the geometric and constructive parameters, achieving with the help of additional software included in the software graphics of the parameter's values of all edge points. Further research will develop methodologies for control of complex tools for very large or very small, with curved surfaces, methodologies able to change the angles of the long edges or surfaces with steps as small, based on programs developed independent and included in the design software used for analyzing 3D model.

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