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CAD SOLUTION TO DETERMINE POINTS FROM CHIPPING TOOL SOLID MODEL CUTTING EDGES

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Abstract

The Mixed CAD Generating Method, developed by the first author and presented in previous papers, is able to generate gear teeth gaps from a special points cloud. The generation method requires only a few specific points from the cutting edges of the generating tools. These points can be obtained in a first approach through a simple drawing of the cutting edges. The drawings can use either mathematical equations, or simply the construction and design principles of the cutting tools. In the case of multi-edge cutting tools of a higher level of complexity, or in case of the absence of the edge equations, there exists a simpler approach. It consists in building a solid model, or obtaining the solid model of the tools from the tool's designer or manufacturer. In these cases, the generating points are downloaded from the solid model. This paper presents two possibilities of obtaining these points with usual CAD methods.

Keywords*: mixed CAD generating method, generating points, tool edge, solid model.*

1. Introduction

Gear and drive modeling in the virtual environment is widespread nowadays. Computer simulations have become important tools in basic mechanical engineering development and research. Machined parts, such as gears, are first modeled in a computer environment **[1, 2]**. In order to achieve accuracy of results in various gear drive application research it is indispensable that the modeled surfaces of the gears, by each application, must be reconstructible or modifiable quickly, but also with sufficient precision. Despite continuous development, these numerous modeling procedures have severe limitations.

Among the surface-generation methods based on non-mathematical equations, the "Mixed CAD method" **[3, 4]**. developed and published by the first author and his team, is subject to ongoing development. The modeling title seeks to cover the generating method based on the relative movements of the work piece and the tool, associated with the Boolean Solid Subtraction and the subsequent CAD modeling procedures. Since it does not require mathematical models and complicated surface equations (including the gear tooth surfaces), the advantage of this method lies in the almost instantaneous modeling capacity of repeated and numerous modifications. In contrast with the Solid Subtraction Method **[1, 2, 3]**, the modeling time is significantly shortened, moreover, a partial visual control becomes available in a very short time.

The process consists of the simulation of the relative linear and rotational motion sequences of the cutting tool with respect to the workpiece, presented in steps (**Figure 1.**).

The cutting edges are defined using only a limited number of points located on the edges and positioned consequently according to the relative cutting movements. These are recorded by a computer program developed by the authors. Finally, the simulation process results in a point cloud situated in a specific location (the teeth gaps). This is processed by our own point filter algorithm, and finally it yields a set of points situated on the teeth surfaces. Using the filtered points, we build the necessary NURBS surfaces involving CAD techniques. These surfaces allow the build-up of the solid gear body models.

2. Definition of generating points

In papers **[3]** and **[4]** the edges of the worm hob were determined and computed on the basis of design data given in **[5]**, by using a relatively rough approach. Then, these were drawn through using basic AutoCAD commands (**Figure 2.**).

Although the real cutting edges are space curves, here they were approximated to straight segments, lines and circle arches, finally unified in 3D polylines. These polylines, are included in planes occupying various spatial positions, approximating the worm hob geometry. In a next step, they were carefully multiplied, then moved and rotated to a suitable position, calculated ac-cording to the pitch helix of the worm hob.

It is obvious that, due to the inevitable inaccuracy of the above-described modeling process, the whole procedure is affected; any later modification of the tool profile is somewhat easier, but will be less accurate and flexible than what is required of the procedure.

These difficulties, given in case of complex multi-edge cutting tools, were postponed to a later research time. Research priority was given to the generated points cloud filtering algorithms and the CAD techniques involved in the build-up of the tooth surfaces.

This paper proposes a simpler and more ac-curate way to determine the points cloud generating points from the solid cutting tool models.

Solid body models of the cutting tools can be built more simply using parametric modeling programs, based on descriptions and design aids from the current literature **[6, 7, 8]**. Moreover, here tool body models from external sources can be also used e.g. tool designers or even tool manufacturer's internet sites.

Figure 3. shows a solid body model of a worm hob, modeled exactly according to the literature **[7, 8]** and built using simple Autodesk Inventor instructions, with only a few minutes working time demand.

The worm hob solid model was built in Au-to-desk Inventor, and imported into AutoCAD as ACIS .sat file. Our goal was to import the created solid model into a file format compatible with any modeling environment, in order to confirm that the transferring process is universally applicable to any solid modeling system. From here, the goal consists of identifying the cutting edges, to highlight them and then to extract the generating points from it.

First, as stated in the literature **[9]** -], we realized that the cutting edges will appear as a cubic spline

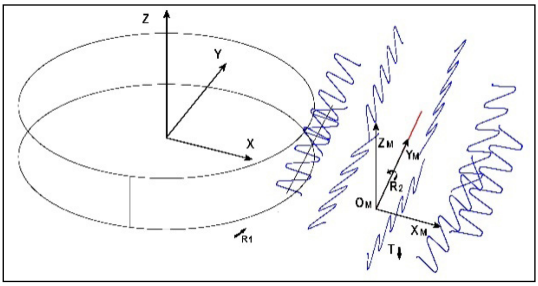

Figure 1. *The generating scheme of a spur gear using the Mixed Cad Modeling Method*

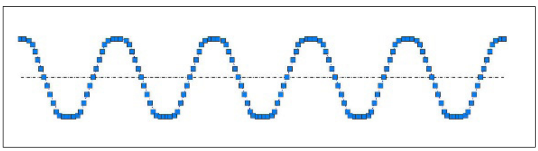

Figure 2. *AutoCAD plane approximation of the edges of a worm hob*

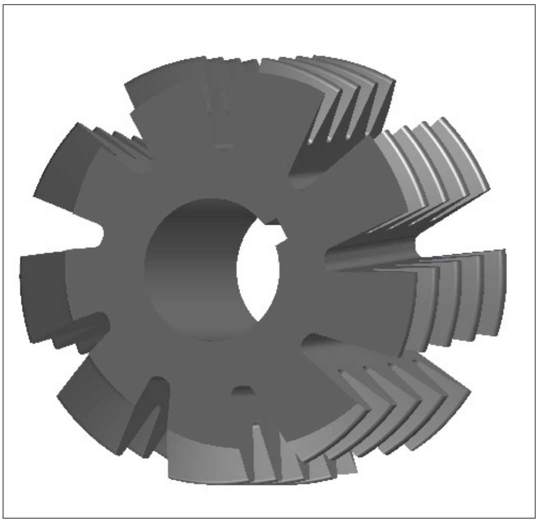

Figure 3. *A worm hob solid model, built with parametrical modeling software*

in the AutoCAD environment, and then went on to search for AutoCAD commands, capable of accomplishing our goals. Although we have nearly 20 years of experience in programming the AutoCAD API, we have tried primarily to always use standard commands to extract edges.

One of these is the Copy Edges command described in **[11]**, which is available in our 2016 AutoCAD version via „Modify → 3D Operations → Extract Edges". This command suit extracts all edges of a body model (**Figure 4.**).

The application of the command described above resulted in 1080 spatial spline curves from which we must select and remove all those that are not cutting edges. It can be stated that, compared to the edges built using the initial drawing method, the accuracy is completely acceptable from a technical point of view: the resulting edges are clearly spatial curves, with the precision of the cubic splines, in a perfect superposition with the original edges picked up from the body model surface.

The first procedure involves the identification and deleting of a large number of splines, a rather complicated and time-consuming task that requires very careful attention in order to avoid deleting useful splines. It is easier to achieve the same edges by firstly converting the body model to NURBS surfaces. They will be much less in number – only 362 in comparison to the 1080 from the procedure presented before. These make the deleting of the unnecessary surfaces and then getting their intersections as edges easier.

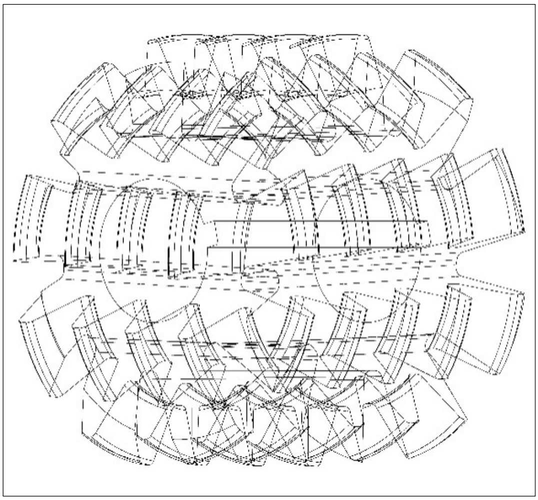

Figure 4. *Che edges of the worm hob solid model, obtained using the Extract Edges AutoCAD command*

The transformation of the solid body model to surfaces was performed using the command suit "Modify → Surface Editing → Convert to NURBS" **[12]**, followed by a near 20 seconds requiring manual selection for work (**Figure 5.**), followed by the extraction of edges and simple manual deletion of excess splines.

The final result is shown in **Figure 6.** In the middle of the figure, there is a highlighted detail of one edge. The position of the generating points on the spline curves can be clearly observed in this detail.

All we need to do is to make a change in the initial generating program: to replace the 3dpolyline

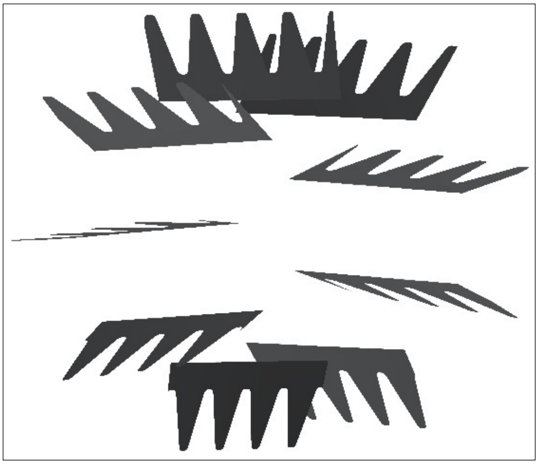

Figure 5. *The cutting edges containing NURBS surfaces*

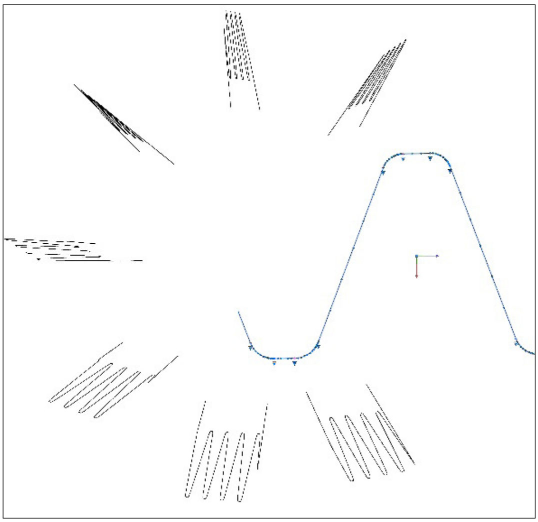

Figure 6. *The spline cutting edges and an enlarged image with the generating points*

type with the spline in entity identification, and read out the coordinates of the points from the DXF group-code, the sequential code groups of 10, after each discrete step.

3. Conclusions

The presented simple CAD method is expected to increase the accuracy of the "Mixed CAD Method" and to simplify the modeling of the most diverse cutting tool types in the applications of the newly developed surface generating method;

As cutting tool constructions in form of solid body model is much faster than assembling drawing elements, the flexibility of the generating method also increases considerably, allowing a quick and very flexible re-modeling procedure of any profile, due to any modification made to the tools, with a considerable shorter computing time demand;

In the meantime we are working to improve the filtering algorithm of the points cloud, in-tending to further improve the accuracy, and to decrease the modeling time;

Works in progress also intend to apply the developed method in order to perform an effi-cient study of newly developed gear types.

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