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THE PRODUCTION EFFICIENCY INCREASING OF THE TEMPLATE FOR ROTOR WINDING

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Abstract: *The contribution deals with the suggestion of new production mode of the template for rotor winding. The handmade part with variable radius fillet is concerned. To obtain the dimensions of such real part with undefined radius fillet is often very difficult, especially, if the accuracy requirement is great. The solution of this problem can greatly affect the efficiency of the part manufacturing and so considerably decrease the economic cost for its manufacturing.*

Key words: *unknown radius fillet, reverse engineering, digitizing, CAD/CAM system, CNC machining.*

1. INTRODUCTION

The part modelling in CAD/CAM software is standard today. It is mostly done on the base of drawing documentation, where the model dimensions are defined. The problem originates if the real part exists, for example as the hand-made prototype, it is complex-shaped and its geometrical characteristics are unknown. The produce of other parts (exactly same) is problematical in this case, mainly, if the production is batch.

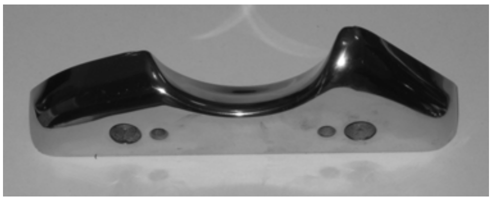
One of the methods how to produce this complex part is the preparation of case mould and by means of it to make new product as a copy of original. This manufacturing manner on the other hand isn´t suitable for every materials, for example, if the part has to be made from tool steel.

Other method, by means of which it is possible to obtain the data that describe the shape and the topology of the real part, is the digitizing of original subject by means of scanners. The scanners are equipments, which enable the conversion of real 3-dimensional objects into digital versions and they enclose the loop between real & virtual world. [1] The principles of the most of them is based on the object shape scanning in the discrete points, what means that the digitizing object is represented in the space as the so called “points cloud”. The scanners can be divided in contact and non-contact according to the used technology of the scanning. The most common scanners are optical, mechanical or magnetically-resonant. The choosing of the scanner type is depended on the precision requests between real and digitized model. The precision at the machining part is request rather high. Other important factors that affect the scanner choosing are the time of scanning and the size of the scanned object. The most quick are the laser scanners. [2] Apart from hardware devices a substantial role at digitization of 3D objects is played by software equipment. Individual scanning equipments use own software for processing of the scanned data, however these need to be transformed several times and eventually transferred into a neutral format (IGES, STEP,…) which CAD/CAM systems can operate with.

2. THE PROBLEM DEFINITION AND SOLUTION

The example of problems, which originate at the modelling of part with unknown variable radius fillet, can be shown on the template for the coiling of rotor winding (Fig. 1) that existed in the firm as real steel part but the radius fillet and dimensions were unknown. It is a real component, which used to be produced abroad in a way that its finite shape underwent a hand grinding into an anti-template but the drawing documentation of the resultant topography was not available. The average delivery time was longer than 3 month.

It was needed to create 3D model of this part in CAD/CAM system Pro/Engineer according to sponsor requests to obtain the CL data for the NC program generating. The part is a component that has to exactly fit into assembly.



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b

Fig. 1. The component and the whole assembly of the template for rotor winding.

2.1. The advantages of NC/CNC manufacturing in relationship with CAD/CAM software

What makes CNC so flexible and productive is the ability to run different and difficult workpiece programs. With the right program, machining is a pushbutton affair. Provided that the proper cutting tools and set up fixtures are available, all a CNC machine needs to begin automatically machining a new and different program. [4]

How to create those new and difficult programs has taken various approaches. Many CNC machines can be programmed on the shop floor, with the operator entering data at the control panel. This method has been very popular, especially for simpler workpieces. Programs can also be prepared "off-line," away from the machine tool, using computer-aided manufacturing (CAM) software. This method is most often used for more complex workpieces. The latest CAM software for the PC (personal computer) provides many automated features that make NC programming largely a push-button affair, regardless of how simple or complex the workpiece might be.

When the applications became more complicated and especially when new programs were required on a regular basis, the writing of programs manually became much more difficult. To simplify the programming process, a computer aided manufacturing (CAM) system can be used. CAM system is a software program that runs on a computer (commonly a PC) that helps the CNC programmer/machinist/manufacturing engineer to program from the drawings and with the whole programming process. The making of drawings, and programming parts from drawings, was (and still is) time consuming and subject to a lot of human error. Someone got the bright idea to eliminate this to-and-from drawing step, and integrated CAD/CAM was born. Integrating computer-aided design with computer-aided manufacturing (CAD/CAM) system produces quicker and more efficient manufacturing processes. This compatibility of CAD/CAM systems eliminates the need for redefining the work piece configuration to the CAM system.

Most computer numerical control (CNC) machines are programmed in the ISO 6983 “G and M code” language. Programs are typically generated by computer-aided manufacturing (CAM) systems that use computer aided design (CAD) information. However, ISO 6983 limits program portability for three reasons:

- First, the language focuses on programming the tool centre path with respect to machine axes, rather than the machining process with respect to the part.
- Second, the standard defines the syntax of program statements, but in most cases leaves the semantics ambiguous.
- Third, vendors usually supplement the language with extensions that are not covered in the limited scope of ISO 6983.

Fig. 2 shows how design data is communicated to manufacturing in current practice. Design creates the specification for a product as a 3D model. Detailing decides the manufacturing requirements for the product by making a drawing. Path planning generates tools paths. Manufacturing controls production. The job of design is performed using a CAD (Computer Aided Design) system, the job of detailing is performed using a drawing CADD (Computer Aided Design Drafting) system, the job of path planning is performed using a CAM (Computer Aided Manufacturing) system, and job of manufacturing is controlled using a CNC system. In many cases the CAD, CADD and CAM functions are combined into a single integrated CAD/CAM system but in all cases the CNC function is performed by a separate system [4].

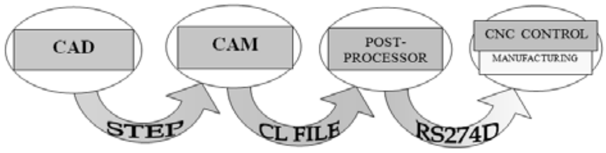

Fig. 2. Data flow from CAD to manufacturing.

Data flow in mechanical engineering:

- First the information about a product is imported into the CAM system. Usually 3D CAD model is imported.
- In mechanical engineering CAM is used to calculate toolpath to cut material. The CNC programmer just specifies the machining operations and the CAM system creates the toolpath, usually written in CL data (Cutter Location data) file.
- Calculated toolpath is imported to the postprocessor which converts the CL data to the NC program - the specific machine codes that are required to operate numerically controlled machine tools. Machine codes vary by machine tool. The output from a postprocessor should be usable in the controller without further modification.
- NC program written in a notation called G-code is exported to the NC machine and the manufacturing process can begin.

One of the most important links in the CNC machining process is postprocessor. The company can have best programming system, the best DNC system, and the most accurate machines, but without dependable postprocessors the code getting to its machine could cause problems. Most machines require some tweaking to the postprocessor to make it to produce code to user's likings and programming habits. Most CAM software comes with built in postprocessor; however there are many stands alone postprocessor. It is the last software link between an ideal CAD model and a “real” machined part.

Some problems on the postprocessor subject are:

- Absence in a CAD/CAM system of the ready postprocessor for specific "machine tool /machine control" combination and also far too high cost of new postprocessor development.
- As a rule, it is very difficult and often impossible, to modify the postprocessor available in the CAD/CAM system to the specific "machine tool / machine control" combination. In general, the technologist is forced to permanently correct wrong NC program file with the text processor.
- Usually generalized postprocessors of majority of the CAD/CAM systems are very difficult to adapt to NC/CNC equipment, made in 70 – 80 years.
- Each new CAD/CAM system requires an individual postprocessor for the same NC equipment, so the company has to pay twice for the same stuff.

- Creating a custom postprocessor for each unique machine is often difficult and costly.

On the basis of listed above it is visible that for the manufacturing of complex shaped parts by means of CNC machines is useful to create 3D model serving for CL data generation.

2.2. Process of 3D model creation

One of the modes how to acquire the dimensions and in the conditions of Faculty of Manufacturing Technologies of the Technical University in Kosice, with the seat in Presov, was the using of 3D laser scanner with the Dr.PICZA3 software.

This scanner that integrates hardware/software system is an ideal 3D capture solution for all popular CAD/CAM and animation applications. It allows designers to capture complex data for hand-held consumer products, blister package design, hand-sculpted characters for feature animation, and face models for anaplastologists. [3] It makes it incredibly fast and easy to generate precise 3D models, it will save designers hours of manual reverse engineering work. It uses an advanced non-contact laser sensor to quickly generate precise models. The combination of precision laser optics and motion control within a rigid enclosure lets the LPX250 produce high quality scans with minimal surface noise.

The unknown geometrical characteristic obtaining at the complex shaped parts is time consuming process. It consists of several steps:

1. Real steel part preparation.
2. Scanning.
3. Data processing and transferring.
4. 3D model creation.
5. CL data generation.

1. The problems those are sometimes necessary to solve at the process of scanning are for example:

- The reflex and shiny face of real part causes that laser beam reflects back and the surface can´t be scanned. In this case it is needed to tarnish the part for example by spraying, not however by black colour, because that laser beam absorbs.
- The material, from which the physical model is made, should not be from transparent material (such as for example glass).
- The combination of concave and convex surfaces on one part caused that laser beam is not able to recover the shape as one whole entity. The solution of this problem is repeated scan of the object in various positions and with various settings. The combination of planar and rotating scan modes provides the possibility to scan already objects with difficult shapes. [5]
- The size respectively the weight of scanned object in respect to technical parameters of scanner.

2. Considering the surface of the original component was too reflexive for the laser beam (as it was polished), it was necessary to decrease its gloss values, e.g. by spray-painting it with a gray undercoat colour. At the same time, it was essential to evenly apply the sprayed layer as this factor may also affects the approximation rate of a created model toward its original and a finite accuracy of the component created on the basis of a virtual 3D model. On the Fig. 3 are shown the scanned part in solid presentation.

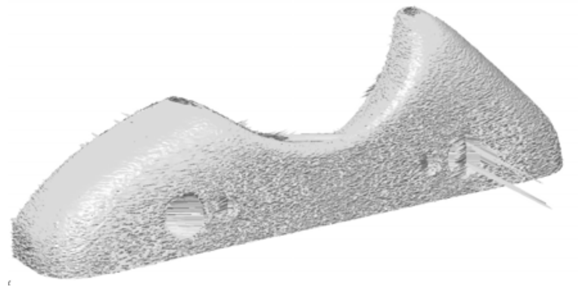

Fig. 3. The scanned part in solid presentation.

3. For next processing it was necessary to export the acquired data from the software Dr. Picza3 and subsequently import them into PIXFORM software. This software allows:

- to translate one complex shaped surface through a cloud (a grid) of scanned points, whilst the accuracy of coverage depended on the number of selected checkpoints,
- to modify the polygonal meshes by means of editing control points, polygon edges and surfaces (removing, moving or adding new surfaces),
- a reduction of a polygonal meshes, i.e. a reduction of the number of polygons in the meshes, however, at the expense of the quality and display fidelity,
- to fill the cracks which arose at the scanning in polygonal meshes on the basis of the NURBS surface definition, and repair a partially insufficient representation of the scanned data,
- to partially polish the obtained model, however, not with a sufficient accuracy.

The polygonized surfaces with 300 check points are shown on Fig. 4.

However, after the scanning, the virtual radius surfaces and the transition curves were not smooth. Geometric data describing the established surface were neither applicable for various types of analyses, nor for a CL data generation. As a result, it was necessary to export them again in IGES, STEP or STL format and import them to a selected CAD/CAM system, in order to further process them.

4. Pro/Engineer system was selected as CAD/CAM system based on the authors experience and in connection with the software availability. It is advantageous to utilise the surface operations in this system for work with complex shaped design. For this purpose, sections were created on an imported model and the interpolating or approximating curves, defining the profile of "top surface" in the section plane, were translated through a point set via a mathematical

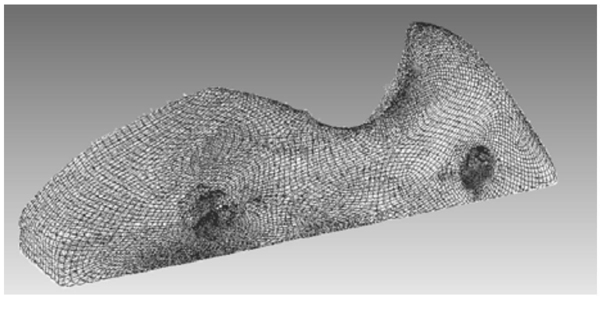

Fig. 4. Polygonized surfaces.

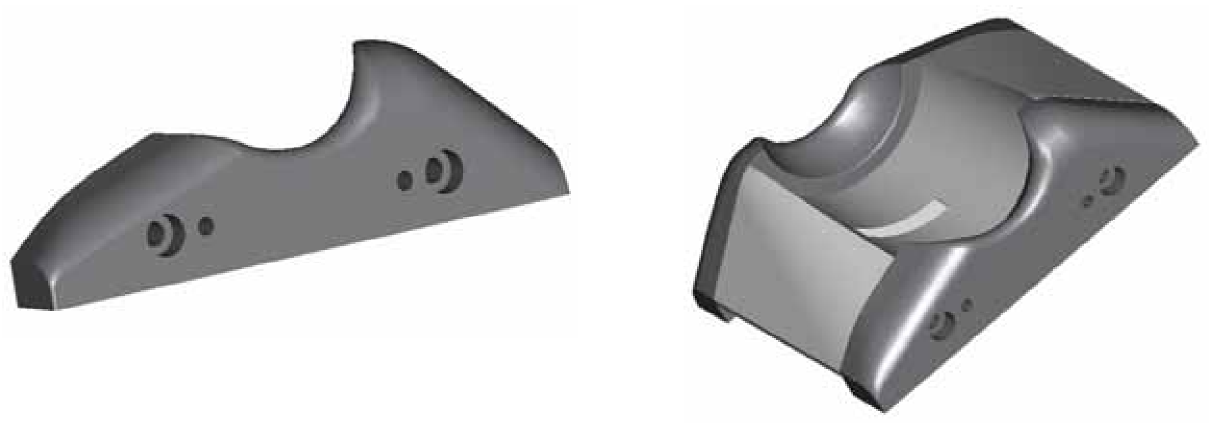

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Fig. 5. The definite 3D model of the part and the assembly modelled in CAD/CAM system Pro/Engineer.

apparatus. The curves were smoothed by means of software Matlab. Approximating curves of Bezier and Spline types were used most often at work as they best represented the imported template shape in the parallel planes.

The curves were covered with a coat surface which was created as a Pro/Engineering system's own element so the geometrical data describing this surface were readable also for CAM system area. In the process of 3D model finalising, various techniques and tools were used, which selected CAD/CAM system Pro/Engineer offers to user. Model had to correspond to original part inside required tolerances ±0.1 mm. The final version of 3D model with unknown radius fillet created without geometric and drawing definition is on the Fig. 5.

5. Prepared virtual model serves for the generating of CL data to make new parts on CNC machine.

3. CONCLUSIONS

The automation of the manufacturing is one of the main goals in present days, what is enabled by the quickly development of information technology and by the sequential application of computer aid into all areas of the production. Within the automation the NC program creation and the complex manufacturing with the utilization of CNC machines are needful for the every plant that wants to be a success with its products on the market today. The generating of CL data as the output of CAM module in the scope of CAD/CAM software enables to create NC program for selected control system very simply by postprocessor. The manufacturing of new part by means of CNC machine is so very quickly and simple today. Assembly prepared according to the manner listed above is used in real production today. In this case, after the creating of 3D model and after the generating of NC program, the terms of delivery were shortened about 98 % (from 180 days on 2–5 days), the number of stored templates decrease about 50 % and the price of the parts made in Slovakia derogated about 60 % compared with original foreign supplier.

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