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INSPECTION OF FREE FORM SURFACES

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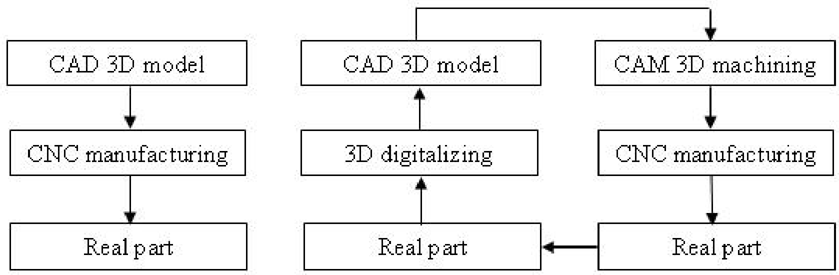
Abstract: *The paper want to present the theoretical bases and practical knowledge of design and manufacturing of shape complicated surfaces (Free Form Surfaces – FFS) by computer aid: RE/CAD/CAM (machining) /CNC.*
Key words: *Reverse Engineering, Free Form Surfaces, Inspection, optical 3D scanning*

1. INTRODUCTION

The computer aided process for acquiring the 3D digital models of real physical object at nowadays called Reverse Engineering (RE). In the machine industry RE means those engineering processes, by which regaining computer CAD geometry of physically existing object, part or workpiece. More simply told: from the given object is need to create – as far as is possible – 3D model, which most exactly represents the real shape and dimensions of the objects. In the Fig. 1 is the comparison of conventional process of part manufacturing in machining with RE process with computer support - in machining.



a) *b)*

Fig.1 *Comparison of conventional process of part manufacturing in machining (a) with RE process with computer support – in machining (b).*

2. CHAIN RE/CAD/CAM (machining) /CNC

The Faculty of Materials Science and Technology with seat in Trnava has established workplace, which in frame of Slovak University of Technology Bratislava is classified into the network of high-tech laboratories with name “Laboratory of design and manufacturing of free form surfaces”. The laboratory is very well equipped with softwares, machines and devices for realizing the chain RE/CAD/CAM (machining) /CNC. One of our 3D scanners is the optical 3D scanner GOM ATOS.

The ATOS (Advanced TOpometric Sensor) is based on the principle of triangulation using a stereo camera setup. This stereo camera setup and a projection unit are integrated in the compact ATOS sensor head.

The sensor projects different fringe patterns onto the object´s surface. These patterns are recorded by the two CCD cameras, forming a phase shift based upon sinusoidal intensity distributions on the CCD chips. The ATOS uses multiple phase shifts in a heterodyne principle to achieve highest sub-pixel accuracy. Based on the optical transformation equations, precise 3D coordinates are automatically calculated for each camera pixel. Depending on the camera resolution, a point cloud of 0,8 million up to 4,0 million surface points results for each measurement.

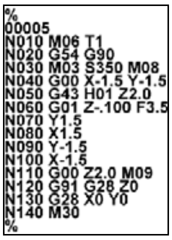
The geometrical configuration of the ATOS sensor and lens distortion parameters are calibrated using photogrammetric methods.

In the “Laboratory of design and manufacturing of free form surfaces” was performed the next interesting project (Fig. 2):

a)

b)

c)



d)

e)

f)

g)

Fig.2 *Example of utilization of RE process in the field of art product manufacturing*

a) original real part (relief – 560x560x55 mm; fibre-glass laminate), b) 3D digitalization with optical 3D scanner, c) digitalized 3D model, d) CAM 3D machining (generating the strategy of machining), e) CNC machining (copy milling) on Eagle VMC 1000,
f) miniature relief (140x140x13 mm; plaster), g) miniature relief (140x140x13 mm; bronze) – vacuum casting

Given was the original relief of General M. R. Štefánik (1880-1919) (Fig. 2.) This real part is made of fibre-glass laminate with bronze surface visual effect and has dimensions 560x560x55 mm. The aim was to manufacture the modificated duplicate (miniature) made of bronze, with dimensions 140x140x13 mm. Forasmuch as the original relief - created by free form surfaces - is a hand-made work of the artist, therefore do not exist the digital documentation of the relief. By this reason, in the process of project realization was used the optical 3D scanner GOM ATOS for capturing the digital 3D model of the relief. This digital model was exported into the 3D CAD software Delcam PowerShape, where the digital model was edited for dimensions 140x140x13 mm. In the software Delcam PowerMill was designed and generated the strategy of machining for copy milling for plaster material, what was realized on CNC milling machine Eagle VMC 1000. Therefore was captured the miniature duplicate of the original relief. Finally, this plaster miniature was used in the vacuum casting process to get the bronze miniature relief, what was performed in a other workplace.

3. COMPUTER AIDED INSPECTION

In the most cases after the manufacturing the part must be measured or compared with required dimensions defined on the mechanical drawing or by digital 3D CAD model. The inspection of correctness and accuracy of manufactured dimensions of FFS requires the use of special measuring methods and devices [1]. By these devices are captured the 3D coordinates of significant point on the measured object´s surface. According to the scanning mode of surface points the measurement methods of FFS are divided into 2 main classes (in the brackets are listed the measurement devices used in todays practice):

- Contact measuring methods (CMM – Coordinate Measuring Machines, measuring arms, tracker with touch probe),
- Non-contact measuring methods (laser 3D scanners, optical 3D scanners, computed tomography).

For the dimension inspection of swage die, i.e. for obtaining 3D coordinates of surface points we used a non-contact measuring device, specifically the optical 3D scanner GOM ATOS.

The GOM ATOS software allows to determine and document deviations of polygon meshes, point clouds or sections to CAD data or primitives. With this comparison principle, the software determines the deviation of the measuring data towards the CAD data. This means that the system calculates the shortest orthogonal distance of each polygon point of the measured data to the surface of the CAD model. The deviations are visualized by means of colored deviation plots, i.e. each polygon point of the measured data is colored according to its deviation to the CAD data. These deviation plots are either displayed as colored surfaces, colored sections or colored needle plots. Surface points provide the possibility to display the deviation values in labels.

The Fig. 3 illustrates the CAD Comparison of the swage die CAD model with scanned 3D model. Simply told, the two digital models are superposed and the colored deviation map represents the surface deviations from the set-surface (in this case from the 3D CAD model) The manufactured swage die is in the value tolerance ± 0,1 mm, the biggest deviations are in the locality of fillet radiuses (± 0,4 mm). The manufacturing process of swage die and the CAD Comparison was realized also in the Laboratory of design and manufacturing of free form surfaces in Trnava.

4. CONCLUSION

This article has been presented an insight into 2 concrete solved works realized in the Laboratory of design and manufacturing of free-form surfaces of Slovak University of Technology. During the problem solving was utilized the most modern computer aided technologies begining with optical 3D scanner through part manufacturing pending the inspection process. In the article listed example contains RE, with the well-known chain CAD-CAM-CNC is extended into the chain RE-CAD-CAM-CNC. In the future we plan to make CAD comparison between the part manufactured by swage die (idle solid) and 3D CAD and also digitalized model of swage die. At inspection of dimensional deviations from required dimensions on mechanical drawing, basically on inspected deviations is possible to modificate for example the manufacturing accuracy, because the manufacturing inaccuracy may caused problems in the process of assembly [2].

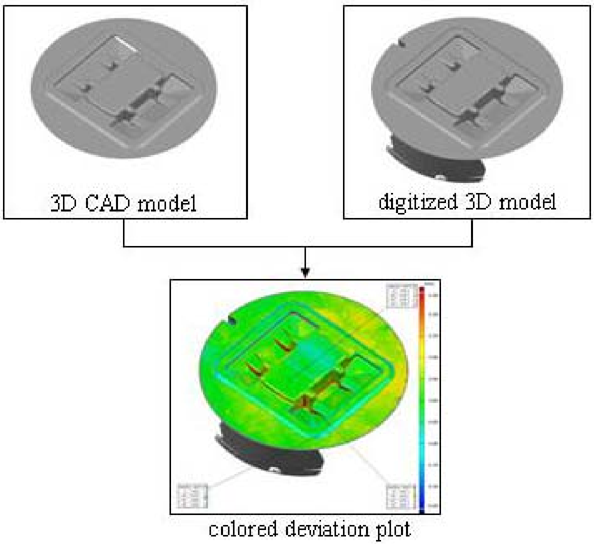


Fig.3 *CAD Comparison*

The article has been worked out by the project VEGA 1/3162/06.

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