Achievements in Mechanical and Materials Engineering

COMMENT Worldwide Congress on Materials and Manufacturing Engineering and Technology

16th - 19th May 2005 Gliwice-Wisla, Poland

COMMITTEE OF MATERIALS SCIENCE OF THE POLISH ACADEMY OF SCIENCES, KATOWICE, POLAND
INSTITUTE OF ENGINEERING MATERIALS AND BIOMATERIALS OF THE SILESIAN UNIVERSITY OF TECHNOLOGY, GLIWICE, POLAND
ASSOCIATION OF THE ALUMNI OF THE SILESIAN UNIVERSITY OF TECHNOLOGY, MATERIALS ENGINEERING CIRCLE, GLIWICE, POLAND

13th INTERNATIONAL SCIENTIFIC CONFERENCE ON ACHIEVEMENTS IN MECHANICAL AND MATERIALS ENGINEERING

Use of 3D-scanning and reverse engineering by manufacturing of complex shapes

M. Sokovic, M. Cedilnik and J. Kopac

University of Ljubljana, Faculty of Mechanical Engineering, Askerceva 6, SI-1000 Ljubljana, Slovenia

Abstract: Applications of Reverse Engineering to speeding up a product realization process have gained momentum in recent years. The aim of this paper is to firstly provide a brief overview of Reverse Engineering technology and the reasons for its development. Furthermore is presented Renishaw Cyclone 2 scanning device with a probe head, which was used for digitizing a real model of a face. Digitized model with assistance of CAD/CAM-technique had been applied for making a real copy of the face in another material. On the basis of the special computer software the whole procedure from a digitized model to the real copy of the face was verified in the last section.

Keywords: Reverse Engineering, Scanning (digitizing), Deviation error

1. INTRODUCTION

The engineering design supported by CAD/CAE techniques allows optimizing the product concept before manufacturing with assistance of CAM, in management for rapid product development and rapid set-up production in advance. For some product development processes RE (Reverse Engineering) allows to generate surface models by 3D-scanning technique, and consequently this methodology permits to manufacture different parts and tools in a short development period [1]. On the other hand global market requires aesthetic and ergonomic product led up by more and more complex shapes. To fulfil constantly shortening time for development alongside complex shapes of a new product, RE-technology offers a solution. The RE is now an accepted part of the product design and manufacturing process [2], especially when relating to complex surfaces, which are often very difficult to create on conventional route in modern CAD-software. Skilled model-maker can normally apply aesthetic design changes more efficiently, in many cases, during the tight design/product review loop than a CAD- technician who must apply the changes to the mathematical representation [3]. Another factor not to be underestimated is that a very complex models are usually made in real scale in wood, clay or plastic, because stylists often rely more on evaluating real 3D-objects than on viewing projections of objects on high resolution 2D screens at reduced scale.

After a statuary art, various 3D-scanning devices into numerical one can transform a real-scale model. The existence of a computer model provides enormous gains in improving the quality and efficiency of design, manufacture and analysis. Furthermore a numerical surface or model can be deduced in order to exploit the advantages of CAD/CAM technologies [4].

In addition to above mentioned reasons for RE development, it can be found also several other application areas of RE:

- It is often necessary to produce a copy of a part, when no original drawings or manufacturing documentation are available.
- In other cases we may want to re-engineer an existing past, when analysis and modification are required to construct a new improved product [4].
- In some cases it is necessary only to extract 2D-profile data from the model as the complete part may be efficiently modelled using these profiles and a surface CAD/CAM system [2].
- Potential application area can be found in the injection moulding industry (rapid tooling, recovery broken moulds or duplicating a mould), and other fields such as medical and chemical industry, film industry, and toy industry [2]. In those fields a broader interpretation of RE term may involve also understanding of design intents and mechanisms of working.
- Very fast growing area is also unique production of prosthesis and implants for handicapped persons, which can be directly linked with unique production of eyewear glasses, helmets, clothing, bullet-proof jackets, shoes, boots, etc. everything what makes and personifies modern human being.

All the above-cited cases have very differing RE-requirements; from recovering mechanical design information to design based modifications. In case of extracting mechanical design information we will be interested in absolute tolerance contrary to the case of design based extraction where the precedent will be that of extracting design intent.

According to all mentioned context, RE-methodologies and techniques are absolutely necessary because allows capturing and digitizing the object surface geometry to be utilized in various CAD/CAE/CAM systems [2].

2. THE REVERSE ENGINEERING PROCESS

The whole Reverse Engineering process can be divided into four steps:

1. Scanning – Digitizing
2. Processing captured data
3. Surface creation (*.stl or CAD-surface)
4. CAM or technician documentation

2.1 Scanning – Digitizing

The first objective of RE-methodology is to generate a conceptual model from a physical model. In this sense the 3D-scanning techniques aided by specialized software's for model reconstruction are necessary. 3D-scanning is the process of gathering data from an undefined 3- dimensional surface. During the scanning process, an analogue-scanning probe (contact or non-contact) is commanded to move back and forth across the unknown surface. During this process the system records information about the surface in the form of numerical data – generates a point's cloud matrix (3D-coordinates) [2].

<u>Renishaw Cyclone 2 scanning device</u>

Scanning device Renishaw Cyclone 2 (Fig. 1) is independent unit for very precise 3D-scanning and measuring tasks outside the production lines. The heart of Cyclone 2 scanning device is the Tracecut software, which combines data capturing system with supervisor function over the whole working device. Tracecut program also enables you to manipulate data and then create NC-code or create different IGES, ASCII or even STL-surfaces files from the captured data [5]. At the beginning of our work the physical model of a face (Fig. 2) was scanned by touch probe head on the Cyclone 2 scanning device.

Fig. 1: Renishaw Cyclone 2 scanning device

Fig. 2: Physical model of a face

2.2 Processing captured data and surface creation

Very important phase of RE is post-processing of captured data. In most cases captured data (point cloud) needs more or less correction such as reducing number of scanned points, improving particular part of scanned sections, joining different scanned models, wiping parts of the model, etc. in order to get a replica or geometric variant from the scanned data, Fig. 3 [5]. Modified data are then imported to the model reconstruction system software to be transformed in a conceptual model supported by a triangular surface geometry or by a CAD-surface data. In our case we took advantage of the Tracesurf (module for surface generation, which working under the Tracecut) software to create the triangular surface from a captured data (Fig. 4).

Figure 3. Captured data ("point cloud") from the physical model of the face

Figure 4. Numerical triangulated model of the face

Fig. 5: A replica of model of the face

2.3 Machining (CAM)

Using numerical triangulated model of the face we generate NC-code and machined a replica of the face (Fig. 5) in plastic material (UHMW – PE 1000 PE) on MORI SEIKI FRONTIER - M CNC-machine placed in Faculty of Mechanical Engineering, University of Ljubljana.

3. VERIFYING THE PROCES OF RE

In the last section of our work we try to verify the whole process of RE. The replica of the face was scanned again on the Cyclone 2 scanning device and the gathered "point cloud" were compared with numerical triangulated surface in special software Raindrop GEOMAGIC.

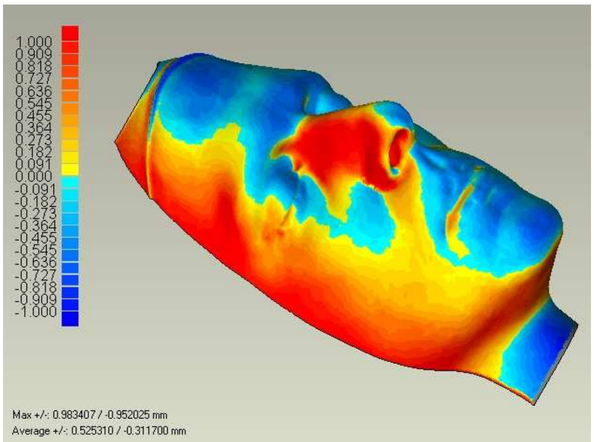

Figure 6. Comparison between numerical models

On Fig. 6 it can be seen a deviation error between captured data from the replica and triangulated surface generated from "point cloud" of an original face model. Blue colour indicates that point cloud from replica is above numerical triangulated surface (max. 1 mm) in contrast to red colour segments mean vice versa.

The primary reason for that deviation can be found in concavity of the replica model. Due to smallness of an original piece of plastic, the model got concavity form after the machining had been carried out.

4. CONCLUSIONS

The main goal of our work was firstly to get familiar with the Renishaw Cyclone 2 scanning device and the reverse engineering technology. Besides that we try to found out the capabilities of the scanning device together with Tracecut software and limitations of using touch probe head. At that point it is fair to say that hardware evolution and particularly software improvement consequently make a huge boost to all RE applications and technology itself. According to that better software consequently signify better result. At the end we can say that during handling with Renishaw Cyclone 2 scanning device we acquire knowledge of RE technology and practical experiences, which undoubtedly will be turned to advantage in future projects.

REFERENCES

1. Sokovic, M., Kopac, J.: RE (Reverse Engineering) as necessary phase by rapid product development, 12th Int. Conf. of Achievements in Mechanical & Materials Engineering, AMME 2003, 7-10 December 2003, Zakopane Poland, pp. 825-830
2. Sokovic M.: 3D-scanning as main phase by Reverse Engineering, Proceedings of the Workshops on Monitoring of Cutting Equipment and Processes Using Acoustic Signals, MONACO, Department of Manufacturing Engineering, Budapest 2004, pp. 51-57.
3. Varady, T., Martin, R.R., Cox, J.: Reverse Engineering of of Geometric Models - An Introduction, Computer Aided Design, Vol.29, No.4, April 1997, pp.255–268.
4. Herbertson, T.: Reverse Engineering, CAD/CAM studio, Italy, ICIT 2003, pp. 419-422
5. Cedilnik, M., Sokovic, M., Kopac, J.: Use 3D-scanning and Reverse Engineering by Manufacturing Complex Shapes, Diploma thesis, Faculty of Mechanical Engineering, University of Ljubljana, 2004.