IMPLEMENTATION OF SYSTEMS FOR REVERSE ENGINEERING IN PRODUCT DEVELOPMENT

IMPLEMENTACIJA SISTEMA ZA REVERZIBILNI INŽENJERING U RAZVOJU PROIZVODA

TOPCIC, Alan; CERJAKOVIC, Edin; BABOVIC, Zijad & TRAKIC, Elvedin

Abstract: *Development of new or redesign of existing products is costly and long lasting process by which products get new values or their existing values are improved. Application of Reverse Engineering systems along with Rapid Prototyping systems in all phases of products development/redesign assure significant saving of time and money, with possibilities for control of new generated products by CAD inspection.*

Key words: *Reverse Engineering, Rapid Prototyping, CAD inspection*

Sažetak: *Razvoj novih ili redizajn postojećih proizvoda predstavlja skup i dugotrajan proces kojim proizvod dobiva novu vrijednost ili mu se postojeća unaprjeđuje. Aplikacijom sistema za reverzibilni inženjering uz primjenu tehnologije brze izrade prototipa u svim fazama razvoja/redizajna proizvoda osiguravaju se značajne uštede u vremenu i novcu, uz mogućnost kontrole novo stvorenog proizvoda primjenom CAD inspekcije.*

Ključne riječi: *reverzibilni inženjering, brza izrada prototipa, CAD inspekcija*

Authors´ data: Alan **Topčić**, PhD, University of Tuzla, Faculty of Mechanical Engineering Tuzla, Tuzla, alan.topcic@untz.ba; Edin **Cerjaković**, dipl.ing., Faculty of Mechanical Engineering Tuzla; Zijad **Babović**, PhD, Faculty of Mechanical Engineering Tuzla; Elvedin **Trakić**, dipl.ing., Faculty of Mechanical Engineering

1. Introduction

With the aim to achieve and maintain competitive abilities on the global market, modern production companies are forced to introduce new products continuously in the shortest possible time on market (time-to-market) with minimal costs, whereat products need to satisfy rigorous market conditions such as: functionality, quality, reliability, ergonomics, aesthetic, ecology, etc.(Ognjanović, 2007). To fulfill aforementioned requirements producers continuously seek new ways for product development, and implementation of Reverse Engineering and Rapid Prototyping systems allows them exactly that. By application of the mentioned systems fast generation of three dimensional products models in digital form, their remodelling and exporting in some of Rapid Prototyping, Rapid Tooling or Rapid Manufacturing systems was allowed. In such way product development cycle is reduced to the shortest possible at this moment, with significantly lower costs in comparison with conventional methods of product development.

2. Basic principles of Reverse Engineering system usage

In general, concept of Reverse Engineering can be viewed as a systematic approach to analysis of some existing devices or systems, and can be used either for analysis of design processes or the first step in redesign process with the goal of observation and approach to mechanisms of devices' operation. In the narrow sense Reverse Engineering can be defined as a duplication process of some existing components, assemblies or products without support of drawings, technical documentation or computer models (Plančak, 2004).

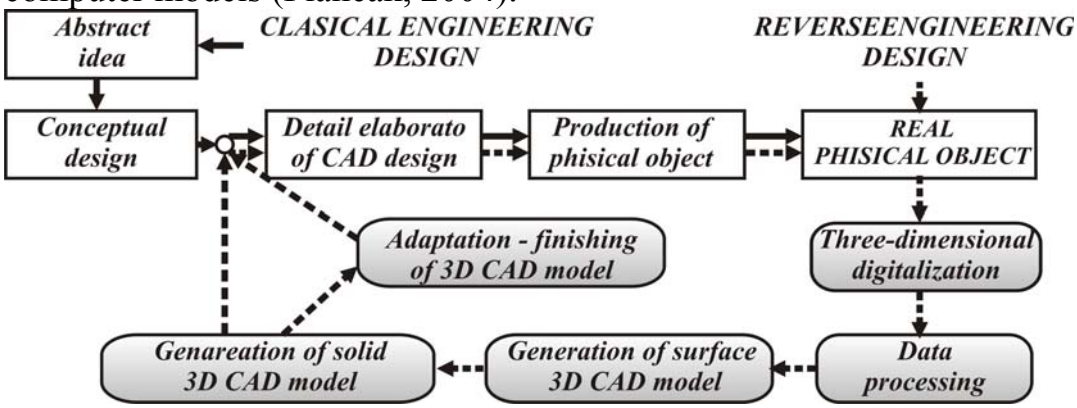


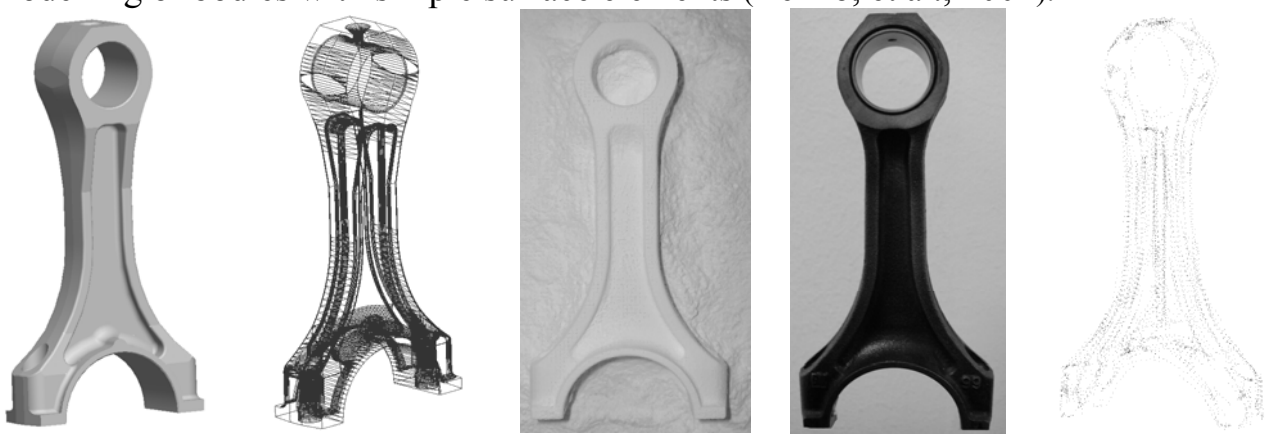
Figure 1. Schematic collate review of „classical" and reverse engineering approach in development of new products

According to the above mentioned and the schematic collate review presented on figure 1, it is possible to draw a conclusion that, unlike "classical" engineering design which starts with abstract idea, thru its elaboration via conceptual design, up to a detailed CAD design, Reverse Engineering designing process starts from a real physical object which is transformed to a three-dimensional CAD model thru series of steps, with adjusting consistent to specific requirements if needed, and final production by using one of the available technologies (Computer Numeric Control machines, Rapid Prototyping, etc.). In this way painstaking and strenuous modelling

work of specially complex geometrical surfaces, which require many efforts, time and exceptional knowledge of CAD software, become much easier, simpler and shorter because use of Reverse Engineering systems neutralise influence of complex shapes and surfaces of modelling parts.

3. Usage of three dimensional digitalisation systems in product development

Concept of three-dimensional digitalisation implies acquisition process of geometrical information about unknown three-dimensional surface through collection of series of points which describe particular surface and their recording in a digital form. Lately, for this process a term of scanning has also been used. In general, three-dimensional digitalisation methods can be classified to active and passive (contact and contact less methods) (Zaimović, 2003). Passive methods are characterised by absence of interaction with an object of digitalisation, while in the active methods interaction exists i.e. contact with object of digitalisation (contact methods – there is a direct physical contact with the object of digitalisation and sensors, contact less methods– there is some kind of energy projection in the form of recording, reflecting or transmission). Result of accomplished digitalisation is "cloud" of points which represents geometry of an observed object and is used as the basis for generating three-dimensional CAD model (figure 2a). Transformation process of "cloud" of points in three-dimensional CAD model can be done in one of the two following ways: by geometrical modelling of free surface form or by complex topological modelling of bodies with simple surface elements (Benko, et al., 2001).



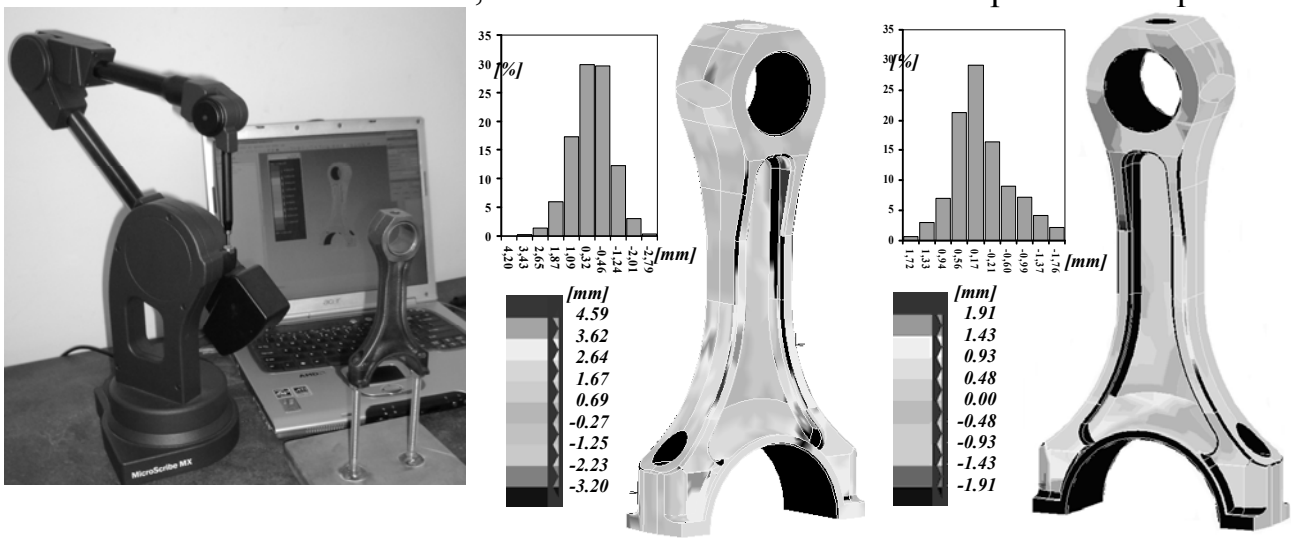
a) *b)* *c)* *d)* *e)*

Figure 2. a) review of 3D CAD model, b) review of *.stl model, c) 3DP prototype of connecting rod in working chamber of 3DP machine, d) real connecting rod, e) digitalised cloud of points (52.000 points) of 3DP connecting rod prototype

3.1. Concept of CAD inspection

Significant number of products incorporates complex geometrical forms in their shape which can't be described by standard geometrical characteristics and as such they disable usage of measuring instrument and procedures, especially in the cases of complex measurement tasks performance (shape and placement tolerance). Such surfaces can not be described by standard geometrical characteristics. For their description, complex mathematical equations and sets (clouds) of points are used

which are results of certain three-dimensional digitalisation techniques. Consistent to abovementioned, inspection of such surfaces can be done in the following ways: by usage of CAD data or by modern methods of CAD inspection. Concept of CAD inspection implies usage of virtual CAD model of products with the aim of checking geometrical and dimensional deviation of the finished product from its CAD model. In the beginning concept of CAD inspection was based on work with two-dimensional data, but today this term is mostly used for inspection of the three-dimensional solid CAD models, which is also known as the concept "CAD-to-part".



a) *b)* *c)*

Figure 3. a) process of three-dimensional digitalisation, results of CAD inspection of real object (b), and produced prototype by three-dimensional printing process (c)

4. Integration of CAD/RP/RE systems on concrete practical example

With the aim of reducing product development time, integration of Reverse Engineering and Rapid Prototyping technologies assure consolidation of design and production processes through computerized generation of models on the basis of existing physical model by Reverse Engineering usage and direct production of real physical model by Rapid Prototyping technologies. According to that, generation of initial three-dimensional CAD model by Pro/Engineer software (figure 2a), its pre-processing by triangular approximation technique in appropriate form for application on three-dimensional printing - 3DP process (figure 2b) was done. Process of three-dimensional printing is one of Rapid Prototyping technologies which found its place in many applications thanks to available building materials, quality of production and relatively low production costs. Basically, three-dimensional printing process is based on "printing" - chemical binding by adhesive liquid medium successively deposited cross sections of building material (on plaster, ceramics and starch basis) layers with appropriate thickness (function of wanted accuracy) converted directly from three-dimensional CAD models (Topčić, et al, 2002). By this process, physical objects are created. After finished initial three-dimensional modelling process and production of three-dimensional printing connecting rod prototype (figure 2c), acquisition of needful data for CAD inspection was done. Data acquisition was made by three-dimensional pantographic digitizer (IMMERSION®, MicroScribe MX, USA) which

represents a device that consists from a series of rigid sticks connected by spherical and cylindrical joints with measurement sensor at the end of the last stick, figure 3a. For performance of CAD inspection, a "cloud" with 52.000 points was formed by data acquisition, figure 2e. The process of CAD inspection itself was carried out in the software module Pro/ENGINEER - Pro/VERIFY, where after the "cloud" of points loading, its orientation and overlapping with three-dimensional CAD model, an overview of deviations of digitalized model from three-dimensional CAD model for a real object (figure 3b) and for produced prototype (figure 3c) was generated.

5. Conclusion

Development of information technologies in the field of digitalisation data and its implementation in CAD systems, systems for Reverse Engineering and Rapid Prototyping, development time of new products or reengineering of existing products, is reduced significantly. Moreover, afore-mentioned solutions give opportunities of accurate and fast control of produced parts with a detailed visual display of achieved results. Companies which implement the mentioned systems in activities of new products development create real assumptions for an increase of own competitive abilities and faster response to the market impulse with minimal investments.

6. Literature

Benko, P.; Martin R.R. & Varady T. (2001). *Algorithms for Reverse Engineering Boundary Representation Models*, Computer and Automation Research Institure, Budapest, University of Wales, Cardiff

Ognjanović, M. (2007). *Razvoj i dizajn mašina*, University of Beograd, Faculty of Mechanical Engineering Beograd, Beograd, ISBN 978-86-7083-603-7

Plančak, M. (2004). *Brza izrada prototipova, modela i alata – Rapid Prototyping and Rapid Tooling*, University of Novi Sad, Faculty of Technical Science Novi Sad, Novi Sad, ISBN 86-80249-96-3

Topčić, A.; Tufekčić, Dž.; Fajić, A. & Cerjaković, E. (2008). Implementation of three-dimensional printing – *3DP process in casting*, *Proceeding of 5th international conference Construction, shaping and design - KOD2008*, Kuzmanović S. (Ed.), page 71÷78, Novi Sad, Faculty of Technical Science Novi Sad, ISBN 3-901509-32-1

Zaimović-Uzunović, N. (2003). *Mjeriteljska infrastruktura*, University of Sarajevo, Faculty of Mechanical Engineering Zenica, Zenica