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REVERSE ENGINEERING FOR AUTOMOTIVE INDUSTRY

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Abstract: Fast development of the product requires obtaining fast digital or real prototypes and sometimes of final parts. This paper proposes to present different methods for obtaining the digital prototype of existing physical models.

1. INTRODUCTION

In mechanical field, reverse engineering has become a viable method to create a 3D virtual model of an existing physical part for use in 3D CAD, CAM, CAE and other software. The reverse engineering process involves measuring an object and then reconstructing it as a 3D model. The physical object can be measured using 3D scanning technologies: mechanical contact 3D scanners, laser scanners, structured light digitizers or computed tomography. The measured data alone, usually represented as a point cloud, lacks topological information and is therefore often processed and modeled into a more usable format such as a triangular faced mesh, a set of NURBS surfaces or a CAD model.

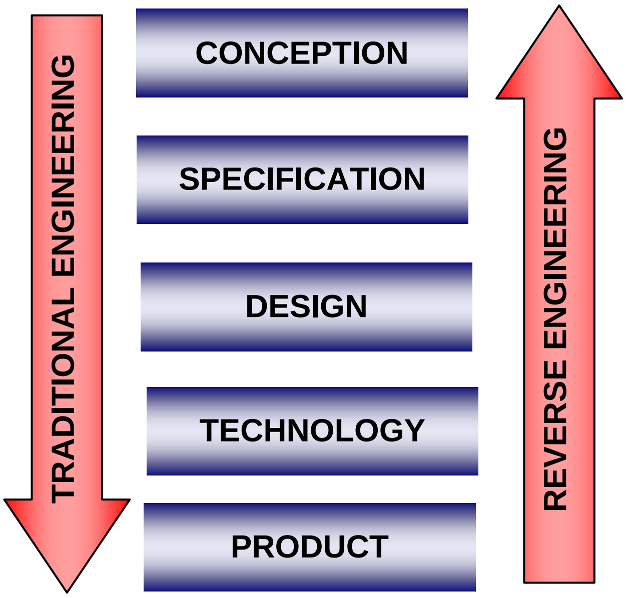

Figure 1. Traditional and reverse engineering

Reverse engineering usually starts from a 3D object considered a prototype, it will be digitalized using whichever method and transposed in a CAD like software. The prototypes used in reverse engineering can be real or virtual. Figure 1 shows the principle of reverse engineering. From this figure we can see that in classical engineering we start from the technical idea and finish with the product, while in reverse engineering it's backwards, we start from the product or an existing prototype and finish by digitalizing the object and assigning the specifications.

Reverse engineering must be used only where it isn't violated the intellectual property rights. The most frequent applications are in the medical field (dentistry, orthopedics), artistic (digitalizing of art objects for reconditioning at high fidelity), product development having a complex design in auto, marine, etc. industry.

By reverse engineering we can realize prototypes using classical methods or rapid prototyping and functional parts, figure 2. The method is advantageous for small series of fabrication.

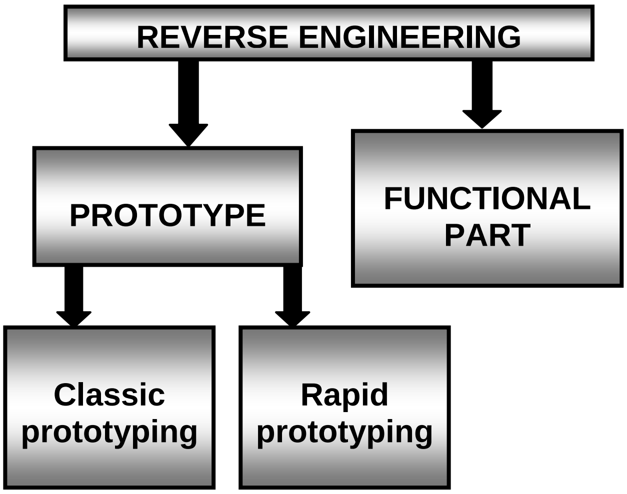

Figure 2. Reverse engineering solutions

2. MANUFACTURING OF SHEET METAL PARTS

2.1. CLASSIC MANUFACTURING

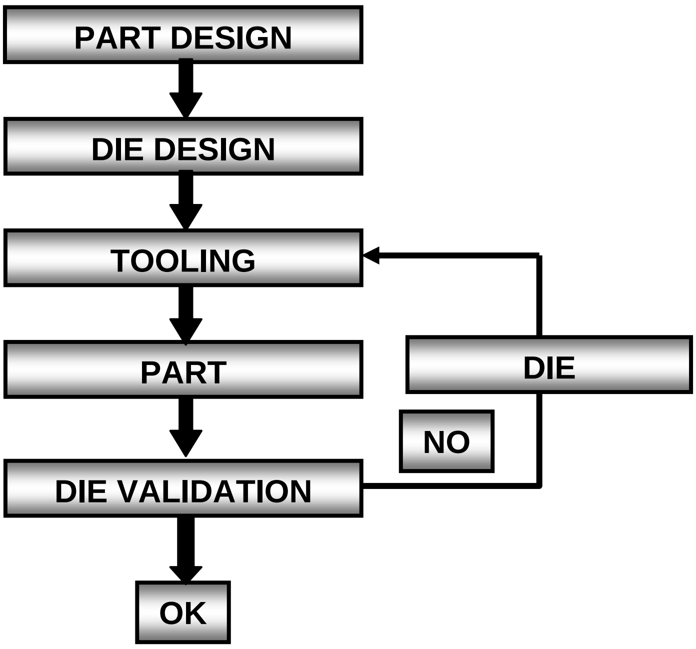

Figure 3. Classic manufacturing of the sheet metal parts

Product design of stamped metal sheets for the automotive industry raises high problems because of the high precision demand and the instability phenomena (elastic recovery, inhomogeneity, etc.). Traditionally, first there is designed the metal part after which the die is designed. The die is built and after that tests are made. Designing the die, it must be taken into account the elastic recovery of the material, part configuration and the material used. These corrections of the die according to the finite part depend a lot on the skills and the experience of the designer. After the die is tested it is observed that most of the times the finite part doesn't fit to the dimensional precision, shape and position imposed. For that, this must be corrected based on the observed difference. This is a very expensive operation (sometimes it can be up to 60% of the initial cost of the die) and requires long time and high skills.

2.2. SHEET METAL PART MANUFACTURING DEVELOPED AT UNIVERSITY OF BACAU

To eliminate the disadvantages that appear during classical manufacturing of the sheet metal parts, it was developed a method based on the simulation of the stamping process using finite element. This method it is shown in figure 4. It starts by designing the sheet metal part using a CAD software (NX CAD, Solid Edge, Solid Works, Catia). After, comes the die design, which can be made using traditional methods or by using specialized software (DieDesign, NX Tooling). During the design of the active elements of the die, corrections are made that take into account the elastic recovery of the material. After the designing process, the die's static and dynamic behavior during stamping process is verified, using the finite element method.

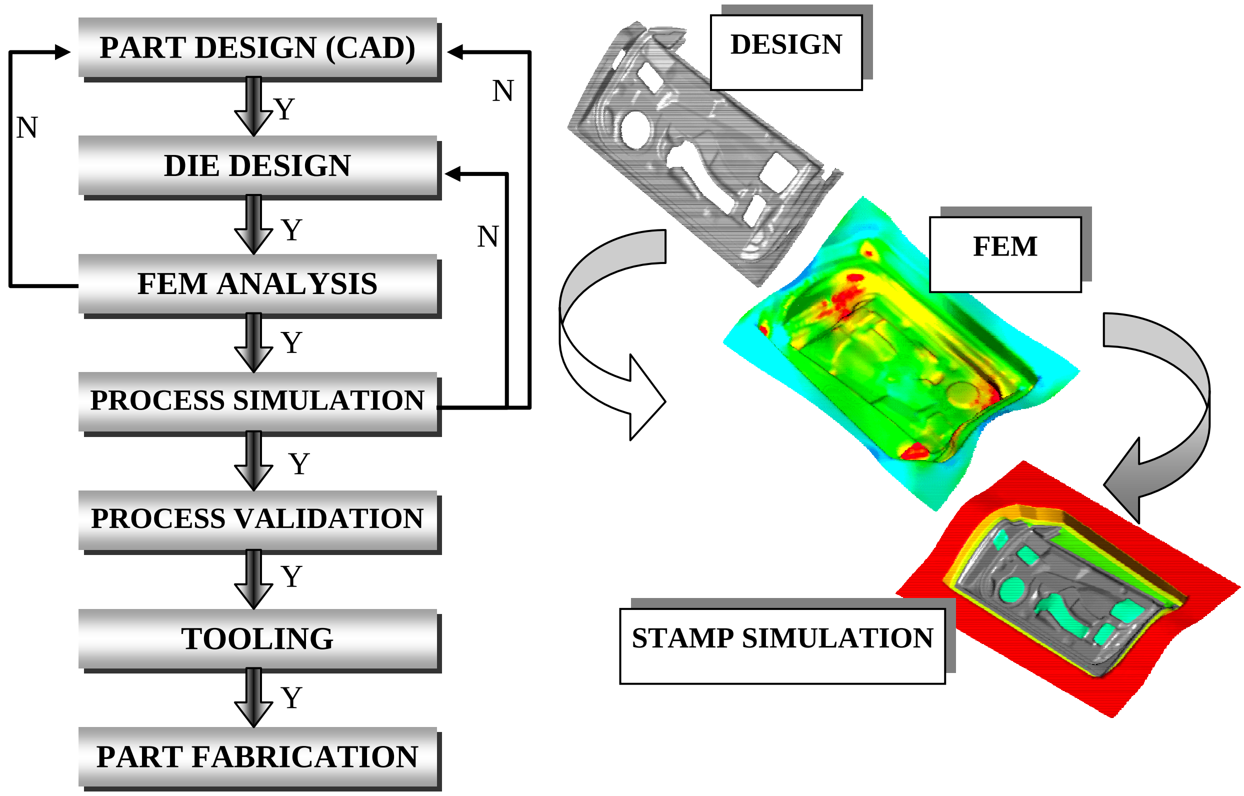

Figure 4. Modern manufacturing of sheet metal parts

If the constructive solution of the die is validated, we can start the simulation of the stamping process and check the part dimensions obtained using a finite element (ABAQUS, MARC and DYNAFORM). The simulation of the stamping process is made by finite element analysis using an orthogonal set of experiences developed by using the Taguchi method. There can be used as optimization parameters the die dimensions, friction force, blank retaining force, stamping force, stamping speed and others. For each optimization parameter used, is pursued the value that confer the smallest deviation between the simulated part and the virtual one. Based on these values and using an optimizing polynomial function it is established the optimum dimension of the die and the recommended parameters of the stamping process.

Based of the obtained data during simulation, optimal values will be used for the final design of the die and a new finite element simulation. During simulation, if the resulted part fits within the technical documentation's limits of error, the next step is making the die. After fabrication, as for the traditional method case, verification and validation of this process is made. If the errors are greater than the ones specified in the technical documentation, corrections of the die will me made again. These corrections, which are very expensive, were not needed for the studied cases at the University of Bacau.

3. APPLICATION OF REVERSE ENGINEERING IN DESIGNING THE SHEET METAL CAR BODY OF AUTOMOBILES

Designing the car body of an automobile can be made by these methods:

a) Using traditional model designs made by specialized draftsman
b) Using modern CAD software witch have included specialized styling modules for varied types of products (auto, naval, electronics, etc.)

Through the process of reverse engineering, the digital shape of any physical object is extracted. That data is used to troubleshoot, reproduce, study, analyze, inspect or used in other downstream applications.

With the digital data generated by this process, CAD models can be easily updated to reflect the changes in the model, object, tool or die. Any part of the tool or die can be duplicated with the help of the surface model created by this process. Physical product designs like clay and other prototypes can be converted into solid models for making the required tooling.

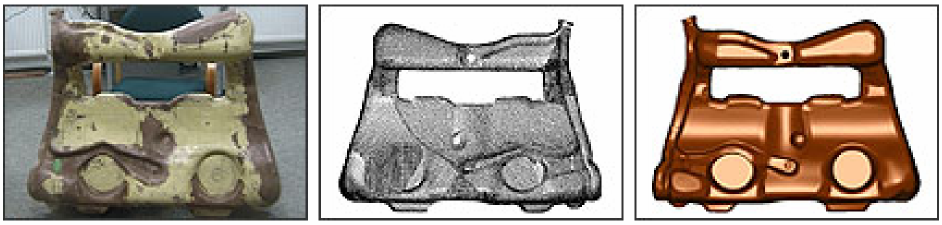

Figure 5. Example of reverse engineering process [10]

c) Using 3D models made from clay by designers using manual methods.

This method needs longer time for the prototype developing, but it has a big advantage because the car body can be obtained with a great aero-dynamical coefficient by changes that can be applied directly during the aero-dynamical tests from the wind tunnel.

This method starts by making the 3D clay model based on the designer's sketches, figure 6. After the 3D clay model is made it is tested in the wind tunnel. In the tunnel the stylists can change the car body until the aerodynamic coefficient is as stipulated in the product's standard. Next is the 3D scanning of the model using a laser based scanner or mechanical contact. The scanning result digitizes the product which can be used in CAD software.

Instead of creating a complex clay model by hand, and then recreating the same form in a time-consuming CAD solid modelling activity, the clay model is directly used to generate the relevant data for a CAD solid model, and which is then also used to create final renderings and animations.

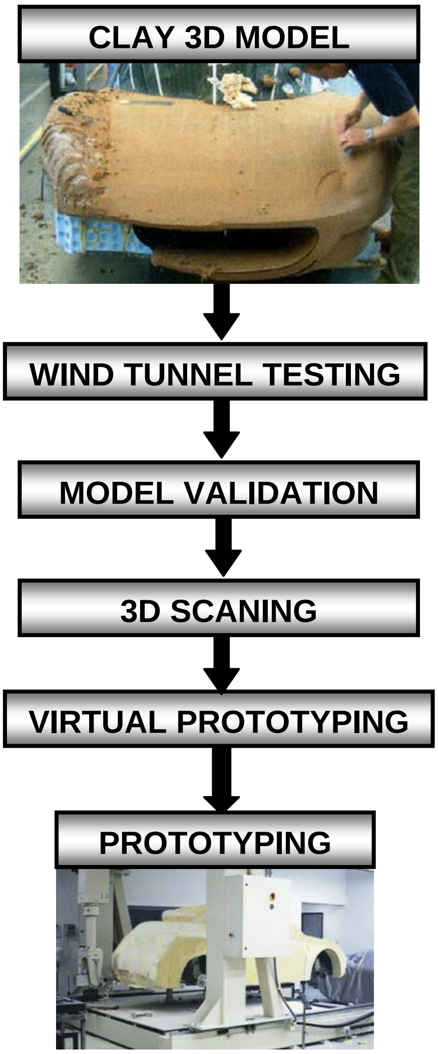

Figure 6. Car body design

Based on the digital model we can make the virtual prototype of the car body which will serve for sheet metal designing and behavior simulation using finite element analysis. Also, using specialized software it is verified the possibility of stamping the sheet metal parts. After all design and technological corrections are finished a new 3D prototype can be made from clay or plastic, using 3D milling machines. This new prototype is tested and if all results are good the series production can start.

4. CONCLUSIONS

Reverse engineering capabilities allow designers to use input from physical components at every stage of the design-to-manufacturing process. This approach not only allows for accurate design representation and rapid comparisons of physical legacy data, but also bridges the physical-to-digital environments. Geometric representation can be created in a fraction of the time of conventional CAD systems.

Specialized software for stamping die design must be a toolkit for the designers and manufacturing engineers, focusing on die process specification, die layout and die analysis. Thus, the more costly and time-consuming processes of the production of stamped sheet metal parts can be automated, which can significantly reduce their typical lead times.

Wasted time, effort and resources must be eliminated, not only between product and die development, but also throughout the die design, optimization and manufacturing process.

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