

USING PLM METHODS IN REENGINEERING AUTOMOTIVE PARTS

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ABSTRACT

The goal to design, manufacture and sell a product with the highest efficiency possible is the common target of all companies. Time shortages regarding the product's development can be obtained by starting from an existing model, and changing its characteristics to match future trends. Product reengineering fulfils all these major tasks in order to build fast, precise and at a lower cost as a conventional approach. Product reengineering is linked with modern tools like: Rapid Prototyping, 3D Scanning and state of the art CAD software, in order to obtain conclusive results. In this research we present a complete flow of a product design makeover, from existing model to a new one and also manufacturing aspects.

KEYWORDS: reengineering, 3d scan, CAD, rapid prototyping, design.

1. INTRODUCTION

The reengineering term was first launched by Hammer, one of the co-authors of the book "Reengineering the enterprise"- considered to be the "bible" of reengineering, into one article of the Harvard Business Review named „Reengineering Work: Don't Automate, Obliterate”.

Business reengineering is defined as a fundamental rethinking and radical redesign of the business processes, in order to obtain spectacular improvements of indicators, considered today to be critical in evaluating the performances, like costs, quality, service and speed [1].

Product reengineering is defined as the study, capture, and modification of the internal mechanisms or functionality of an existing system or product in order to reconstitute it in a new form with new features, often to take advantage of newly emerged technologies without major change to the inherent functionality and purpose of the system.

Reengineering uses as a fundamental catalyst the information technology (IT), without it the process could not be subjected to the reengineering process.

In order to capture the existing product and reconstitute it into a new form, a certain path has to be followed. In our case we have started from a scale model which we scanned with a 3D scanner. The virtual model from the scan has been imported into CAD software, namely CATIA V5 R 17. Here the shape of the body was modified after functional and aesthetical criteria. To validate if the design changes

are appropriate a 3D model was printed and analyzed. Next a car body component has been extracted and its manufacturing processes designed.

2. CAR DESIGN REENGINEERING

The first step towards reengineering or redesigning a model is to choose an existing one. We focused our attention on the Porsche 959. The input for the design came from a scale model (1:17).

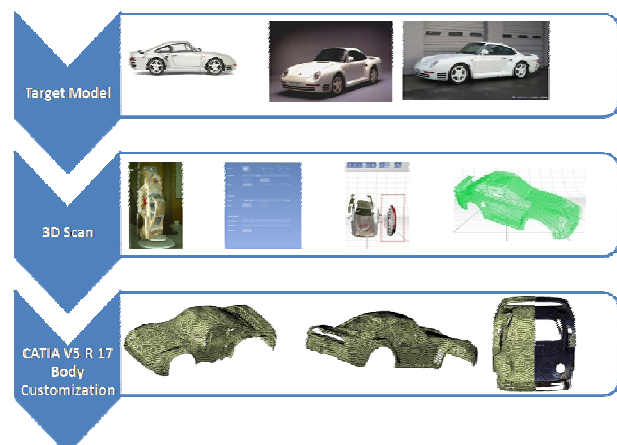


Fig.1. Reengineering flow

The Porsche 959 is a sports car designed by Porsche by 1986 to 1989, first as a group B rally car and then as a legal production car, to satisfy FIA homologation regulations requiring a minimum number of 200 street legal units to be built. During its

production run, it was hailed as being the most technologically advanced road-going sports car ever built [4].

The goal of this work is to design an updated body shape of the model that is new and at the same time keeps a strong bound with its predecessor.

3D Scan

The second step of the reengineering flow is the 3D scan. Before starting the actual scale model scan, some preparations have to be made regarding the target surface and alignment points.



Fig.2. Next Engine Scanner and Support

The surface that is being scanned must not reflect the scanner laser beams. Therefore the model was covered with a thin layer of powder.

This enabled to receive a better quality of the scan.

Alignment points were also drawn on the model to later assemble the scan sequences. The 3D scan software (ScanStudio Pro) also has an auto alignment option, but there is no guarantee that the software can always compute the alignment. Finally the prepared model is fixed in the scanning support of the 3D scanner (NextEngine).

After the model preparation, the scanning parameters are being chosen: precision, number of sequences, surface finishing.

The scanning time depends on the number of the scan sequences and precision.

Our model was at first scanned 360° in 12 scanning sequences.

The alignment of the scanned sequences follows (this basically forms the 3D model). Here the alignment points drawn earlier come in handy if the auto alignment does not work. Alignment pins are placed on the common points of the scanned sequences.

The software needs to have at least three common pins placed on two different scanned sequences to build the complete virtual model.

But the model is still incomplete further single scans from the rear and front of the model are made. In the end the 360° scan is assembled with the single scans from the rear and front using common alignment points on each scan that could be recognized.

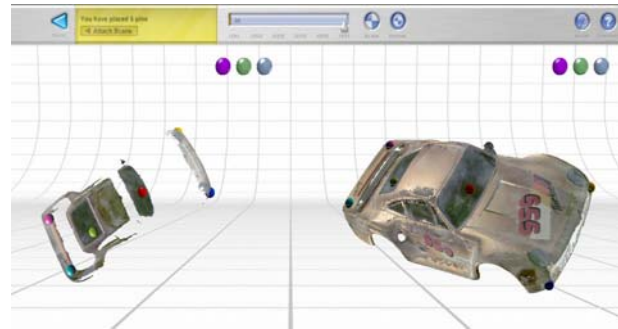


Fig.3. Placement of alignment pins

Also important is that all scanned sequences were “cleaned” by trimming the unwanted scanned elements (the support appears in the scan). This can be performed trimming each scanned sequence or at last when the whole model is assembled.

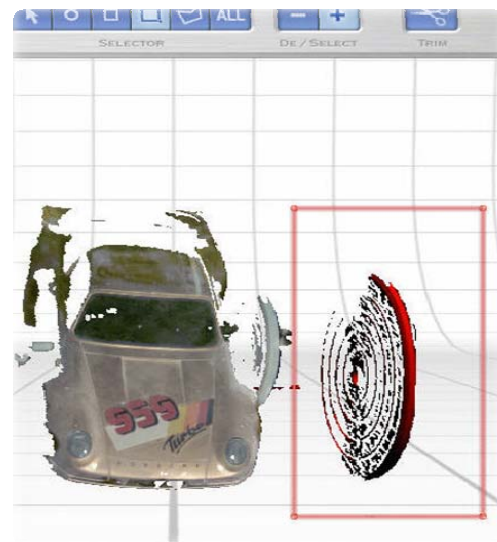


Fig.4. Trimming unwanted elements

Because the goal is to export the scanned model into CAD software, we have to improve the surface quality. Creating a waterproof surface (using the FUSE command) fulfills that, allowing to approximate later the model by a certain number of surfaces or to extract splines that cut the model at a specific increment (defined by user). These last elements (surfaces/splines) could be saved as *.iges file.

Usually for relatively big models before using the Fuse command it is recommended to optimize the assembled model. Without this optimization in some cases the system cannot calculate the waterproof surface (often a message that warns about low RAM is shown).

Model Redesign

We started by importing the *.iges file into Catia V5 R17 environment. As already mentioned before, the goal is to improve the car shape by the aesthetical

and functional criteria. For this purpose we used the Generative Shape Design Workbench (GSD).



Fig.5. The main functions in GSD

Building the existing model

The model imported from the 3D scan usually is not at the best quality. In order to improve the existing design, first a good quality input model is needed.

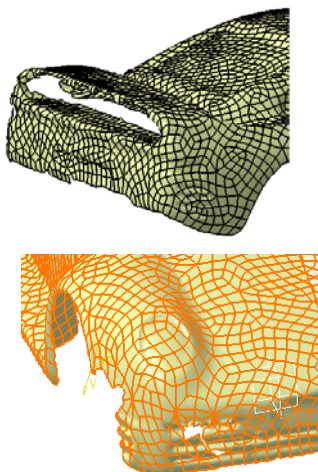


Fig.6. Example of missing elements

The first steps were to rebuild the missing elements. We focused to have a complete half.

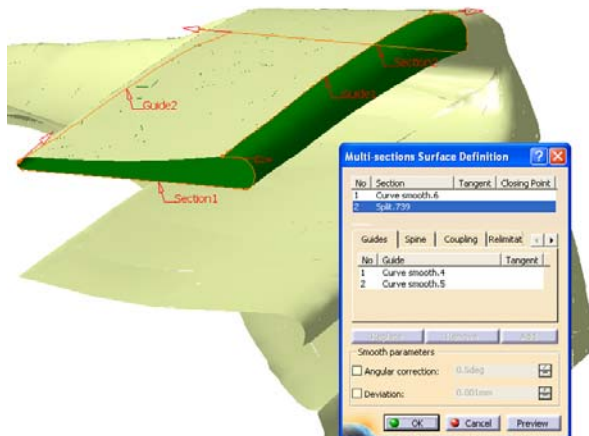


Fig.7. Spoiler reconstruction

For example the spoiler was partially missing but using guidelines and reference sections on the existing elements of the spoiler we managed to reconstruct it [6].

Improvement of the design

Now having as a complete reference the old model, the new shape is ready to be built.

Following improvements were done on the existing model:

- Improved front air intake.
- Front bumper improvement.
- New fender air outtake.
- Lowered center of gravity.
- Reduced air friction coefficient.
- Rear bumper improvement.

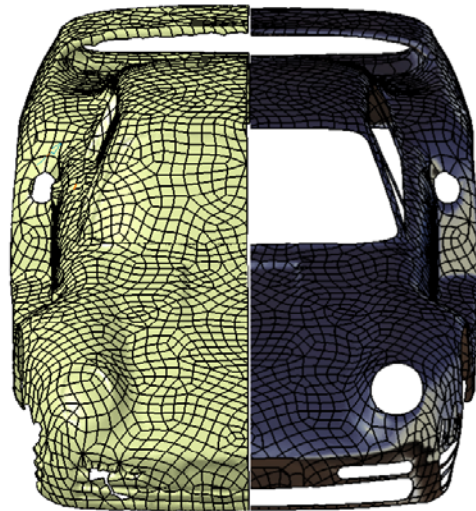


Fig.8. Old shape vs. new shape

Before deciding upon the final shape, the model was printed on a 3D printer (**Zcorp ZPrinter 310**) to see if the design looks good also in reality.



Fig.9. Zcorp Zprinter 310

After using this rapid prototyping tool we decided that the design does not need further changes.

3. VIRTUAL MANUFACTURING FLOW

Fabrication of one of the outer shape components was another goal of our research.

The bonnet (the exterior metal sheet) was the element that we set out to fabricate.

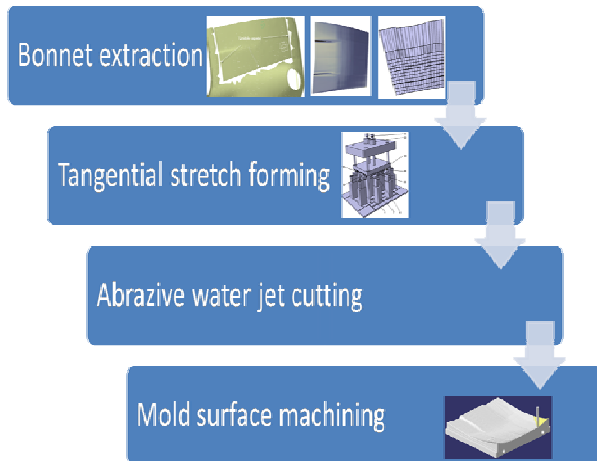


Fig.10. Manufacturing flow

The first step was to extract the shape of the bonnet from the virtual 3D model and the scale was modified to be at the real dimensions.

The shape was optimized to have the best quality possible [3].

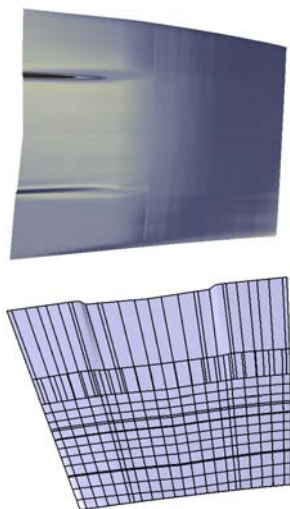


Fig.11. Bonnet shape

The second step was to find the best production solution for our part.

Taking into account that the shape is relatively complex, we decided that the tangential stretch forming method is most suited.

The whole process is conducted in five process steps:

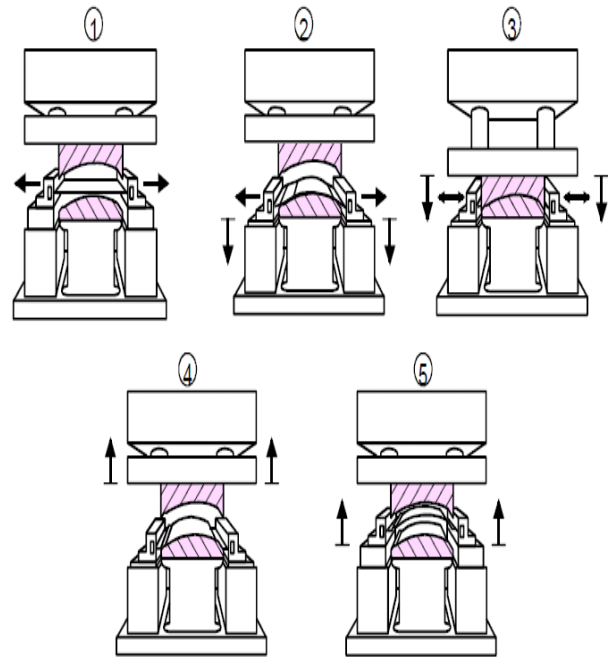


Fig.12. Stretch forming steps

- The sheet blank is clamped between two gripping jaws located opposite to each. The grips are moved away from each other stressing the blank,
- Without reducing this applied stress, the gripping jaws are moved downwards so
- The ramming punch is now moved downwards to produce the counter pressure
- The punch is moved back to its original starting position.
- The gripping jaws are opened and also moved to their original starting position, enabling the shaped part to be removed

A stretch forming system was designed that can grab and stretch the sheet metal in tangential directions to meet the bonnet shape specifications.

The bonnet material is an aluminum alloy that allows the car to keep a reduced mass (6016_T4) with the following characteristics:

$$A_6 = 0,22$$

$$R_m = 226 \text{ daN/mm}^2$$

$$\sigma_0 = 117 \text{ N/mm}^2$$

$$\varepsilon_0 = 0,816\%$$

Poisson coef. = 0,3 ;

Young coef= 7×10^4 Gpa;

Specific weight = $2,7 \times 10^{-5}$ N/m³;

To cut the final shape after the stretch forming we selected a water jet cutting solution (with abrasive particles) as the fourth step.

The resulting dimensions are 1170x1178x882.

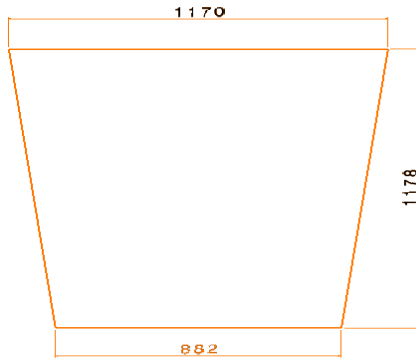


Fig.13. Metal sheet shape after water jet cutting

The final step is the fabrication (surface machining) of the mold on which the sheet blank is stretched. The mold is made out of cast iron (globular) GGG40 DIN EN 1563.

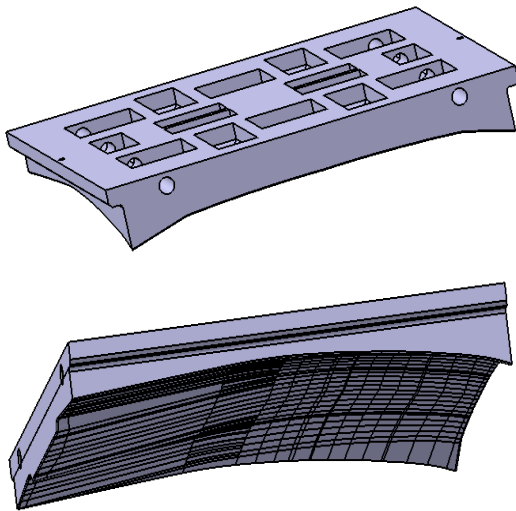


Fig.14. Tangential stretch forming mold

The following operations were made to machine the raw cast iron stock part:

- Drilling and reaming
- Tool -FRAISA Unicut 45332, $\Phi 20$, Z=3
- Tool-FRAISA Unicut 45362, $\Phi 20$, Z=6
- Roughing
- Tool-Franken Time -S cut, IC= 12,5 mm, $\Phi 80 \times 45,5 \times 21$, R=1,5 mm, Z=6 with HPC inserts covered by TiAlN T13 (code 9589A)
- Sweeping
- Tool- Franken Time -S cut, IC=8mm, $\Phi 25 \times 44 \times 23$, R=1,5 mm, Z=3 with HPC inserts covered by TiAlN T13 (code 9589A)
- Finishing sweep
- Tool-Ball End Franken $\Phi 32$, R=16 mm, Z=2 with KP1 inserts covered by TiAlN T13 (code 9589A)
- Biax finishing

The estimated effective machining time for the cast iron mold is approximately 16 hours.

The program we used for the mold machining is Catia v5 r17 with its Surface Machining Workbench. This environment offers a user friendly interface and a very powerful tool for extremely complex shapes.

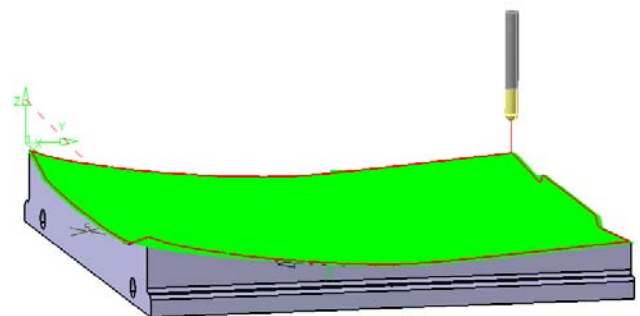
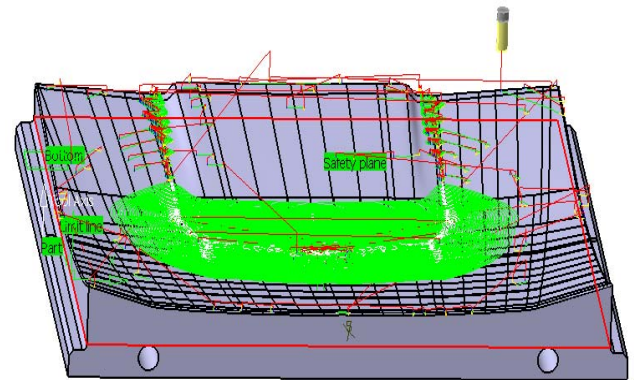
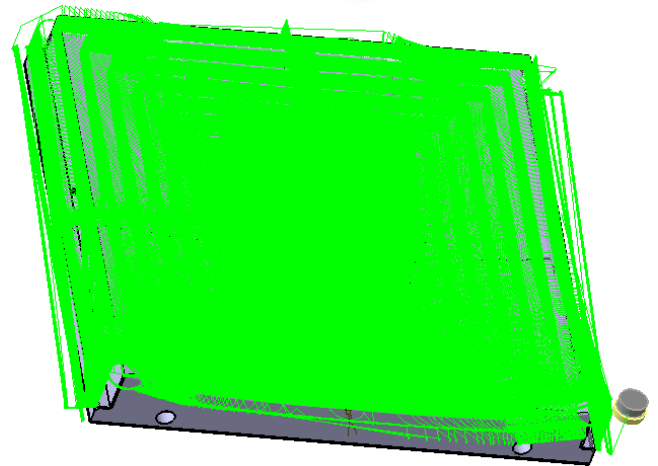
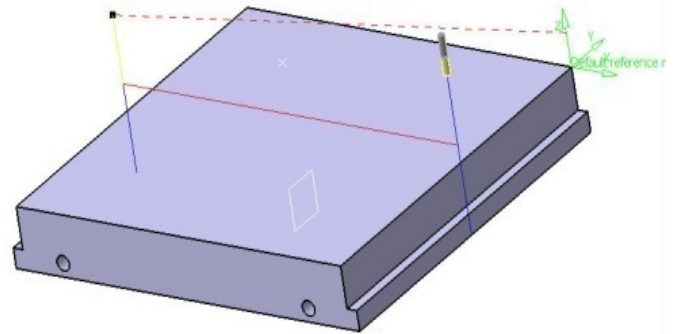


Fig.15. Drilling, roughing, sweeping and finishing sweep

To obtain the desired result from the sheet metal that is being deformed sessions of testing are established and carried out. Usually always some changes have to be made so that the mold reaches desired performance.

4. CONCLUSIONS

In this paper we presented a reengineering process, in which an auto shape was redesigned regarding aesthetical and functional criteria. Also the fabrication flow of one component found its place in our paper as a natural step in presenting a complete loop from design until production of a product.

The completion of this cycle was not easy, at every step problems mainly concerning the computing power that imposed always optimization.

This approach in comparison with the traditional one has the following advantages:

- Reduction of product developing period
- Reduction of fabrication period
- Reduction of production costs
- Better error avoidance

As future intentions we would like to go further with the car design, to approach aspects related to the design interior ergonomics, different components placement for a better assembly (DMU Fitting) or to further change the exterior design to a more aggressive line.

The companies should make out of the newest technologies usage one of their main competencies if they want to succeed into an every changing environment.

The ones who are capable to recognize and understand the potential of the newest technologies will have a continuous and ever growing advantage over the competition.

Reengineering has also its critics that are linking it with massive reduction of employees or that are stating that reengineering has nothing new, that also Henry Ford did reengineering when he designed and implemented the production line in 1908.

Worth mentioning is the fact that everything that was needed to complete this paper was located in the "Hermann Oberth" Engineering Faculty and thus the whole cycle can be completed by students with other products. It could serve as didactical guidance.

Using the PLM concept it was possible to realize stamping and moulding tools, under the circumstances of high quality and low costs.

The design and manufacturing teams, the technological and quality engineers worked linked at the Internet overlapping the activities and so reducing the preparing time of the manufacturing and the delivery terms. All of these led to on increases of the company profit.

Product Lifecycle Management - PLM is a strategic business approach that applies a consistent set of business solutions to manage product definition data for a product throughout its lifecycle.

Through PLM, automotive industries can: improve the product, support the customer, reduce the cost, minimize the downtime, beat the competition, increase the profit, etc. and know how and when to pull the plug of a product.

In our research we focused on the following activities:

Planning - configuring, scheduling;

Design - conceptualizing, detailing, analyzing, prototyping, testing, solid modeling, simulation;

Manufacturing - process planning, part producing, CNC machining, virtual NC.

Using the PLM concept it was possible to realize stamping and moulding tools, under the circumstances of high quality and low costs.

The design and manufacturing teams, the technological and quality engineers worked linked at the Internet overlapping the activities and so reducing the preparing time of the manufacturing and the delivery terms.

All of these led to on increases of the company profit.

Product Lifecycle Management is a strategic business approach that applies a consistent set of business solutions in support of the collaborative creation, management, dissemination and use of product definition information across the extended enterprise from concept to end of life: integrating people, processes, business systems and information.

All the undertakers wish to satisfy their customers as good as they can. The working analysis is an effectual way of defining the products that answer customers' expectations.

So, it has to consent to the definition of "the good product", the one expected by the final customer, but it has to integrate the intermediary users that will interfere in order to give life to the product as well-starting with the conception. Organizing a company (factory) depends essentially on its importance and on the types of the manufactured products. It is believed that the resources of a factory are organized on a structure determined by its functions.

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