Reverse Engineering in the Automotive Industry

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Abstract: *Reverse engineering is a method that is used in order to make an improvement of an old component or assembly by taking the old component and measure it, redesign it and then re-execute it with the new modifications. The reverse engineering evolution in the automotive industry in the past years had a major change in the way that the development of new products is done. By using the new technology of 3D scanning, the work of improving or creating a new prototype is more easy, faster and achievable. 3D scanning is the fastest way to make a 3D high precision model of the existing parts and you can modify and simulate them with a dedicated software. After the scanning and modifying is done, you can easily print the new model with a 3D printer. By using a 3D printer, you can choose the material that you want to use for the prototype, materials such like plastic, powders, resins, metal, carbon fiber and so on. The development of the product in the initial phases is easier to be done because you are able to choose any kind of material. By selecting any material and printing it with the 3D printer, it gives the development a great flexibility in the process of improving the product. Using this technology helps all developers to reduce the time of development and also to reduce the costs of the prototype. Using this technology helps the developers to develop faster, cost efficient and more reliable products.*

Keywords: *3D printer, 3D Scanner, 3D modeling, material, reverse engineering, automotive*

1. INTRODUCTION

Reverse engineering is a method that is used in order to make an improvement of an old component or assembly by taking the old component and measuring it, redesign it and then re-execute it with the new modifications.

Reverse engineering sped up in the last years because of the possibility to reduce the cost and time of production of the prototype.

This method of reverse engineering can be used in different kind of fields like automotive, medicine, mechanics and so on.

The implementation of the new technology in this case will be implemented in a laboratory that is equipped with a 3D Scanner and a 3D printer.

3D Scanning is the process that is analyzing a real object in order to get real data about its form, shape and dimensions.

There are different types of 3D scanners methods like [8]:

1. Laser triangulation 3D scanning technology - this technology has the advantage that is low cost, easy to use and portable;
2. Structural light 3D scanning technology – this technology has the advantages that it has a very fast scanning time, large scanning area and high resolution;
3. Photogrammetry – this technology has the advantage that it provides high level accuracy and high speed data acquisition;
4. Contact- based 3D scanning technology – this technology has the advantage of beeing able to scan transparent and reflective surfaces;
5. Laser pulse based 3D scanning technology.

3D Printer is a device that is doing the 3D printing of a component or any physical part based on a three dimensional digital model. There are a variety of 3D printers that can be used depending on the application like [9]:

1. Stereolithography (SLA);
2. Selective Laser Sintering (SLS);
3. Fused Deposition Modeling (FDM);
4. Digital Light Process (DLP);
5. Multi Jet Fusion (MJF);
6. PolyJet;
7. Direct Metal Laser Sintering (DMLS);
8. Electron Beam Melting (EBM).

The printer can use different kind of materials based on the necessary requirements of the application. These materials are [8]:

1. ABS – low cost material useful for building durable parts;

2. TPE or TPU – elastic material that is used in aplication where the parts need to easily bend or stretch;

3. PLA – the moust common material because of its easy to use property, low cost and greate accuracy;

4. PETG or PET – easy to print with it, water resistance;

5. Nylon – ideal for printing durable parts because its abrasive resistance and because it is semi flexible;

6. Carbon fiber – this kind of fillament contains fibers infused in the PLA or ABS base material in order to increase strenght and stiffness;

7. ASA – is high UV resistance, temperature resistance and impact resisteance. It is a great alternative for ABS;

8. Polycarbonate – high heat and impact resistance

9. Polypropylene – suitable for low strength aplications.

This method of reverse engineering can be used in different kind of fields like automotive, medicine, mechanics and so on.

2. APLICATION IN AUTOMOTIVE INFDUSTRY

We will analyze the fuel filter housing that is part of the fueling system and also part of the cooling system. The antifreeze travels through this support in order to heat the fuel filter. Below, in Figure 1 [13] you can see the components that are in connections with this part.

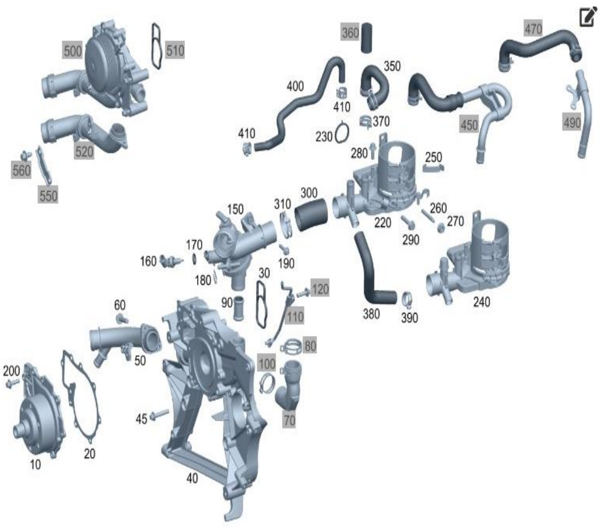

Fig. 1 Position of the support [13]

Because of the high temperature in the engine compartment, the fuel filter support is deforming in time and because of that cracks are appearing and the filter is no longer fixed in its position. Because of that we need to redesign the fuel filter support so that the temperature fluctuation will no longer be able to deform or crack the support. In figure 2 you can see the real part and how it looks.

Fig. 2 Fuel Filter support

In figure 3 [13] is a 3D model of the fuel filter support that will be modified.

Fig. 3 Model 3D of the support [13]

Another application is for the intake gallery because it is deforming in the actuator area and for this reason the engine is malfunctioning. In order to solve this problem, we need to improve the fixing of that area. Also we need to improve the way the rod is moving inside the bearing case. In figure 4 [13] you can see the position of the intake gallery

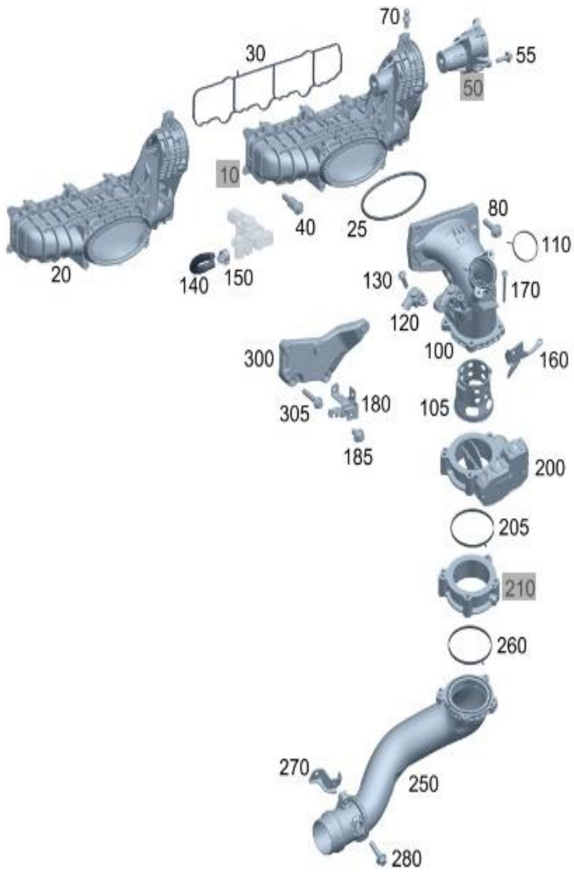

Fig. 4 Exploded assembly [13]

In figure 5 you can see the real part and how it looks:

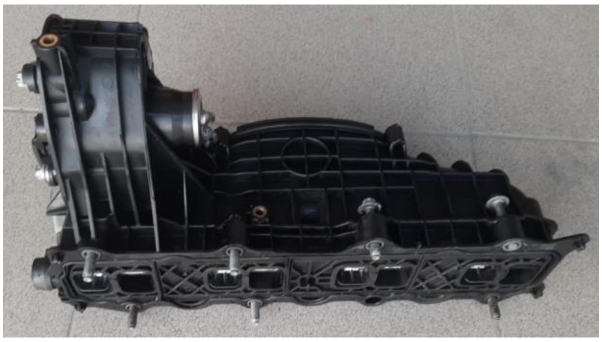

Fig. 5 Intake Gallery

In figure 6 [13] is the 3D model of the intake gallery that will be modify and improved.

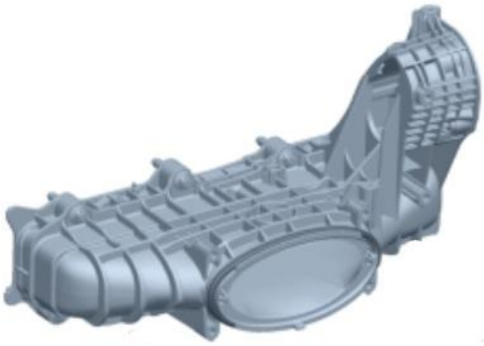

Fig.6 3D Model of the intake gallery [13]

In order to develop these 2 parts, we need to follow the process diagram that is illustrated in figure 7.

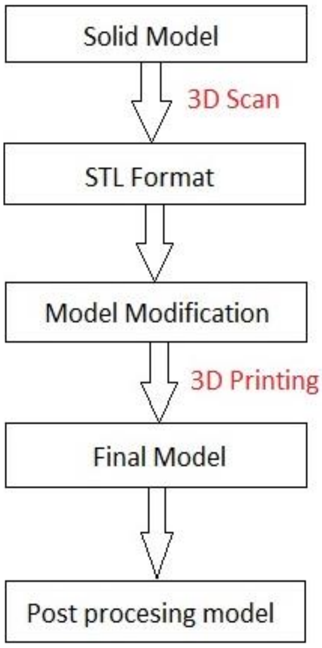

Fig. 7 Process diagram

Using a 3D scanner Figure 8 [10] with the characteristics that are represented in figure 9 [10] we will scan the solid model and make the STL file

Fig. 8 Scanner 3D [10]

Model	EinScan-Pro+			
Scan Mode	Handheld HD Scan	Handheld Rapid Scan	Automatic Scan	Free Scan
Scan Accuracy	0.1mm (0.0039in)	0.3mm (0.01181in)	0.05mm(0.0019in) Single scan	0.05mm(0.0019in) Single scan
Scan Speed	550,000 Points /second	450,000 Points /second	Single scan: <2s	Single scan: <2s
Point Distance	0.2mm-3mm (0.0078-0.118in)	0.5mm-3mm (0.0196-0.118in)	0.24mm (0.0094in)	0.24mm (0.0094in)
Recommended size of scanned object	0.1-4m (3.94in-13ft)	0.15-4m (0.0059in-13ft)	0.05-0.15m (0.0019-5.9in)	0.05-0.15m (0.0019-5.9in)
Align Mode	Reference point, Feature align	Reference point, Feature align	Turntable align	Turntable align
Texture Scan(Add-on Module)	No	Yes (with purchase of texture module)	Yes (with purchase of texture module)	Yes (with purchase of texture module)
Outdoor Operation	No (Affected by strong light)			
Special Scan Object	For a transparent, reflective or dark object, please powder spray prior to scanning.			
Single Scan Range	300×170 mm(11.8×6.69in)			
Light Source	White light LED			
Printable Data Output	Yes			
Data Format	OBJ, STL, ASC, PLY			
Scan Head Weight	0.8kg (1.76lbs)			
OS System Support	Windows 7, 8 or 10, 64bit			
Sharing to Sketchfab	Yes			
Display Card	NVIDIA GTX660, or higher, Display memory : >2G, Processor: I5 or higher, Memory Storage: 8G or more.			

Fig. 9 Scanner 3D characteristics [10]

After the model is created virtually it is necessary to modify the model in order to make the correct adjustments so that the new pat will be better than the old one. We now need to print the new model with our 3D printer presented in figure 10 [11].

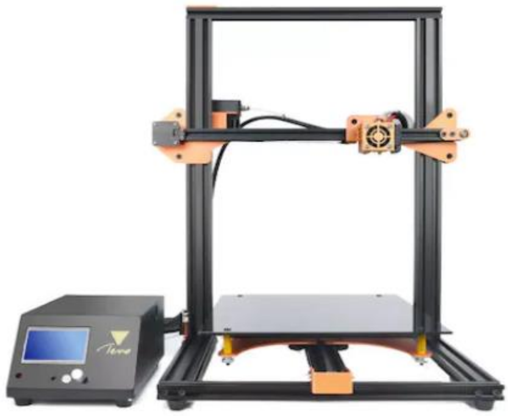

Figure 10 Printer 3D [11]

This kind of printer has the following characteristics figure 11 [11].

Build volume	300 x 300 x 400 mm | 11.8 x 11.8 x 15.75 inch
Layer resolution	0.1mm – 0.35mm
Build speed	60mm/s – 150mm/s
Travel speed	250mm/s
Print surface	Glass-ceramic
Heat bed type	AC heat bed
Number of extruders	1
Filament diameter	1.75mm
Supported materials	PLA, ABS, Flexible PLA, Wood, PVA, HIPS
Special features	N/A
Advanced sensors	2 thermistors, 3 inductive sensors, Antclabs BLTouch (upgradable)
Calibration	Manual / Auto (w / Antclabs BLTouch, upgradable)
Print technology	FFF (Fused Filament Fabrication)
Feeder type	Tevo Titan Bowden type
XYZ resolution	0.05mm, 0.05mm, 0.1mm
Nozzle type	MK8
Nozzle diameter	0.4mm
Nozzle temperature	180°C – 240°C
Nozzle heat up time	< 3 minutes
Build plate heat up time	80°C in less than 2 minutes
Power consumption	100 – 240V 600W max (w / heated bed turned on)
Control board	MKS Gen L (Stepper driver swappable)

Fig.11 Printer 3D characteristics[11]

In the post processing phase we are making fine adjustmants to the model like cleaning excess material, adjusting holes and giving the final finish to the part.
After all of this is done we will anlyse and test the new models in order to see that they are suitable for our needs.

3. VERIFICATION METHODS

In order to be sure that the part is printed acording to the desing we need to make a dimensional check. For this process it is neccesary to use a different kind of messuring tools (mechanical), but to be more acurate it is neccesary to use a 3D messuring device figure 12 [13].

Fig.12 Measuring 3D device [12]

4. CONCLUSIONS

Using this reverse engineering method, all the parts can be more faster produced because all the information is directly imported in the computer so is not neccesary to measure all the part and waste a lot of time.
Improving the existing part is easier and it can be simulated on the computer to see if it passes virtual tests or not. A maintenance and verification plan for the new desing cand be developed, in order to achieve a solid, long-lasting part.
By using this method engineering development is becoming more faster and more precise. Also the cost of manufacturing is considerable reduced because by printing 3D you don’t need so many tools and processes to make the part.

Acknowledgements
All the reserch and documentation was done in the laboratories of the Technical University of Cluj-Napoca.

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