POSSIBLE ACHIEVEMENTS IN COMPONENT MANUFACTURING AND THEIR APPLICATIONS IN MOTOR VEHICLES FOR EXPERIMENTAL STANDS BY FDM 3D PRINTING

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ABSTRACT: Nowadays the current trends involve different manufacturing technologies in order to create components with the same properties of classic ones, or even better, while having lower production costs. In this regard, 3D printing is one relatively new approach which involves a method through which successive layers of material are added one on top of another and in this way the component „grows” during the process. In direct connection with the aforementioned technology, the purpose of this paper is to establish the possibilities of manufacturing different functional components for experimental stands used for laboratory applications and created together with students from the Road Vehicles specialization in the Mechanical Engineering Faculty, Politehnica University Timisoara.

KEYWORDS: 3D printing; fabrication parts, PLA material, FDM printing;

1. INTRODUCTION

3D printing represents one of the most actual trends in industry. Basically, it is a technology involved in almost any branch of science.

3-D printing employs an additive manufacturing process whereby products are built on a layer-by layer basis, through a series of cross-sectional slices. While 3-D printers work in a manner similar to traditional laser or inkjet printers, rather than using multi-coloured inks, the 3-D printer uses powder that is slowly built into an image on a layer-by-layer basis. All 3-D printers also use 3-D CAD software that measures thousands of cross-sections of each product to determine exactly how each layer is to be constructed. The 3-D machine dispenses a thin layer of liquid resin and uses a computer-controlled ultraviolet laser to harden each layer in the specified cross-section pattern. At the end of the process, excess soft resin is cleaned away through use of a chemical bath [1].

As it stands, 3-D printing technology has revolutionized the parts-on-demand approach and found applications in tissue engineering [2-5], structural materials design, [6-9], artisan and do-it-yourself 3-D printing, fabrication of micro fluidic devices, [10,11] and soft robots and actuators [12-14].

These applications take advantage of the variety of additive manufacturing techniques such as fused deposition, stereo lithography, laser sintering, and melting [15].

A broad application of 3-D printing in manufacturing would require a new level of control over the quality and speed of the printing process.

A recent development of the 3-D printers has made them readily available to the public at low costs.

While earlier models of 3-D printers could cost as much as $10,000, [16] [17] most small-scale low-cost desktop 3-D printers were priced well under $500 in 2016.

Most of the low-cost printers fabricate objects primarily from acrylonitrile butadiene styrene (ABS) or polylactic acid (PLA) [18]. There are also low-cost printers that employ stereo-lithography technology (SLA), which uses a laser to polymerize photosensitive resin, producing higher-resolution printed objects of more complex geometry. In order to make 3-D printed parts to be more useful for engineering applications the mechanical properties of printed parts must be known [19, 20].

Also, while from an engineering point of view, the 3D printers have evolved in the past years, there are still issues relative to their impact on human health in terms of fumes produced during the manufacturing process. Several studies [21-25], examined the ultrafine particle emissions from earlier models of 3-D printer and found nanoparticles (<100 nm) with an estimated emission factor of 108 to 1011 #/min or #/gram filament consumption. However, there are still gaps on the aerosol emissions from filaments other than ABS and PLA. More studies are needed to exam other filaments and the other emissions that may pose health risks from 3-D printing [26].

Also, another restrictive factor is represented by the 3-D printer size. The produced components have to be smaller than the printer casing. In this context, even if there exist 3-D printers, the general approach of a large component manufacturing involves the production of segments which are afterwards put together in order to produce the final component; this aspect is both resources and time consuming, having the potential to represent an important issue in terms of good quality manufacturing.

In terms of educational applications, using 3-D-printed prototypes, researchers and educators can benefit from lower expenditures, easier equipment maintenance and repair, better availability of spare parts, higher relevance and flexibility of adaptation to research needs and education curriculum [27] [28]. The present paper presents different components manufactured using 3-D printing and their applications on different test rigs located at the Mechanical Engineering Faculty, Engines Laboratory, Politehnica University Timisoara. Conclusions will be traced relative to the components utility in terms of their respective application.

2. CASE SCENARIOS FOR PRINTED COMPONENTS

In the next paragraph there are going to be presented different components created using 3-D printing and their respective role and applications for different test rigs.

2.1 Development of a water valve for the Junkers hydraulic brake to regulate the torque necessary for the brake axle to rotate.

The water valve was necessary to replace the existing valve which was manually controlled by a person (Figure 1). The fact that the valve was operated near the engine and the hydraulic brake, the person responsible for the valve adjustment was at high risk.

The new valve is created by components which allow regulating the load generated by the hydraulic brake, using an electric motor connected to the valve. In this way there is no need for somebody to be in close range of the engine or the brake because the controls of the new valve are located on a console at a safe distance.

Depending on the water column inside the brake, the engine will have to generate a specific toque to rotate the brake axle.

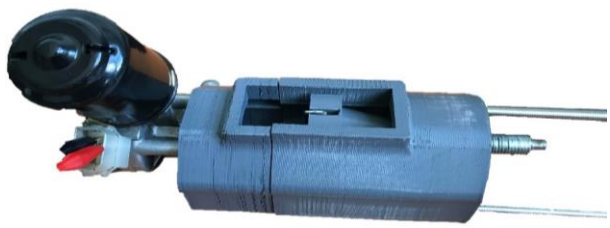

Figure 1. Assemble printed 3D valve

The principle of the valve is using a cone which will make a translation movement entering or exiting the pipe where the water exits the hydraulic brake. The cone is attached to the electric motor which will engage the cone movement regulating the water.

The principle part of the valve is using a cone (Figure 2) which will make a translation movement entering or exiting the pipe where the water exits the hydraulic brake. The cone is attached to the electric motor which will engage the cone movement regulating the water.

Figure 2. Cone valve 3D printed

The cone has a hole for the screw which is connected to the electrical motor, on its back it is a nut which immobilises the cone to remain on the desired position. The cone is equipped with a splash guard for the cases when the cone starts to close the water circuit and the water pressure raises. The guide prevents the cone from rotating while it is actioned by the electrical motor. The connector for the potentiometer will help determine the position of the cone.

The main advantage in this case is that 3-D printing allowed to create the desired design at a relatively low price. Another advantage is that being made of plastic the risk of corrosion does not exist.

2.2 Creation of a „scale”, for the produced engine torque.

The overall thinking was to create a system that used force sensors and the produced signal can be transmitted to an engine command unit. In this scenario there is no need for access to the scale to determine the indicated mass and calculated moment, this being showed directly on the digital screen of the software that controls the engine.

The 3D printing was not the first choice because of the large forces involved during the testing part, but after some initial testing of the load distribution it was determined that using PLA material it is sufficiently resistant to be used for the proposed solution (Figure 3). This fact relates to the main distribution of the force on a perpendicularly axis to the ensemble.

The components were provided with O-ring channels for centring purposes and in this way the loading force acts directly on them.

Figure 3. Threaded component

One of the components was provided afterwards with a threaded area and in this way, it became a nut through the way of a threaded rod which makes the connection with the hydraulic brake (Figure 4).

Figure 4. Open ensemble 3D printed

The thread was made in the same way as for a metallic component with an M16 thread. In this context a 14 mm hole was made and an M16 tarp. The piece has a solid thread and was tested at strengths of about 400 N, resisting without problems (Figure 5).

Figure 5. Overall view of ensemble

2.3 Intake engine gallery.

The intake gallery (Figure 6) was created for a test rig using a moto generator developed for testing different fuels – liquid or gaseous. The component was designed using different materials.

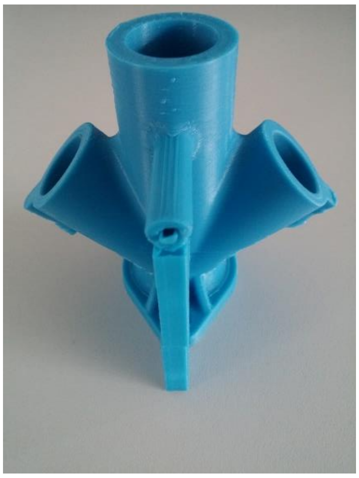

Figure 6. Intake gallery - PLA material 3D printed

The component presented above is made from PLA (Figure 6) which has good mechanical resistance, with a fill in ratio of 100%. It has good breaking resistance but is breakable.

Figure 7. Intake gallery - VisiJet

This material is a resin and the printing technology used in this case is different from the ones presented so far. The material is in liquid state and is solidified after depositing it layer by layer with the help of a UV lamp. This technology offers a superior quality for the material surface and a high degree of precision (Figure 7).

2.4 Electronic board housing.

3-D printing was considered for creating the housing because of the low manufacturing cost which depends only on the used plastic material quantity and the printing time was about 10 hours (Figure 8).

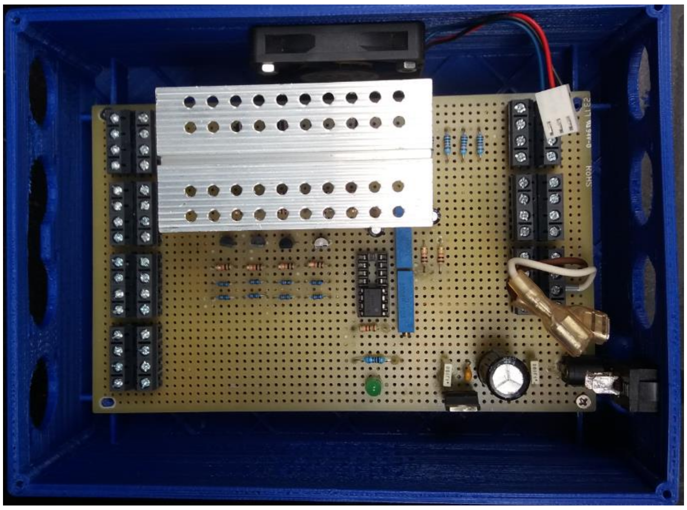

Figure 8. Electronic board housing with components

Relative to other used technologies this aspect can be considered a negative factor but is compensated by the aspect of no material loss and the low manufacturing cost. The overall purpose of using this technology was the hardware and software availability, as well as the know-how relative to developing a cost-effective device for laboratory purposes.

3. CONCLUSIONS RELATIVE TO USING 3D PRINTING TECHNOLOGY

The main advantages to using 3-D printing are the following:

- It helps students to better understand the problems which can appear during assembly operations. Because of the possibilities to create the components from a physical stand, the students can better understand the need for a tolerance calculus.
- It has no requirements for advanced knowledge on component design, as for example in the case of a CNC machine. Once the 3D model is created in special software a „cloud" of elements is generated which is saved with the STL extension (figure1). After this initial step, the created extension is imported in the program that splits the component in layers for it to be reproduced by the 3D printer.
- The acquisition cost for a 3-D printer is relatively low by comparison with other equipments, being variable according to the used printing technology. The adding material has, in its turn a relatively low cost.
- The materials used for the designed components come in different solutions. 3-D printers can use polymer-based material with different properties, according to the experimental demands (i.e. PLA, ABS, PETG, Polijet, etc.)
- The components made using this method do not need any supervising from an operator during the manufacturing process. Because the continuous evolution of technology, the 3-D printers have less and less errors during manufacturing, which in its turn brings a positive input over the defective parts but can also be put into operation after the end of the program, thus saving time.
- Students can produce components that could have not been produced using other technologies.
- Using 3-D printing technology there can be made products which can incorporate electronic components, thus helping the students to better understand teamwork and coordination with other colleagues in charge of programming and electronic parts.
- Some materials used for 3-D printing can be reused through grinding, extrusion into the filament which is necessary for 3-D printing, thus reducing environmental pollution.
- When creation of supports is needed, those can be easily removed, according to the printer design. The supports can even be dissolved in warm water, thus reducing further processing of the component
- Due to the rapid manufacturing time on a 3-D printer, the designing time is significantly reduced, and the changes can be tested as soon as they are implemented, thus obtaining a faster validation for the product.
- Applications are not restraint to a certain field of interest, the technology being used for a very large field of applications (medical with applications in prosthetics, or to help students to better understand organs or bones).

The main disadvantages using 3-D printing are the following:

- The printer might get an error at the middle of the job and all the work is ruined, because you must start over. Once a part is damaged in any way, it cannot be repaired.

- The mechanical strength of the part is reduced. For the same volume of material, a component made from steel alloy is much stronger.
- The printed parts cannot withstand high temperature, although there are some materials with relatively high melting point, it is incomparably lower than the melting temperature of steel.
- Because the plastic is heated to print the parts, the final product is smaller than in CAD.

4. ACKNOWLEDGEMENTS

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