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Impact of 3D Printing on Automotive Parts

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Abstract: *The impact of 3D Printing on automotive parts is investigated. 3D printing is an additive manufacturing technology to rapidly create prototypes by laying down a broad range of material onto successive layers of surfaces. In the automotive parts generally metal or alloy materials are used in the manufacturing. In this research we tested effect of 3D Printing on different automotive components. For the testing purpose we used Front Hub, Rear Hub, Knuckle, Calliper, CAM (engine part) and Steering pedal. After manufacturing in FDM printer using PLA material, the different properties were checked, and compare the result of existing manufactured components with the 3D printed one. The results showed that the 3D printed components having lesser weight up-to 35% to 40% with better geometric finishing. It also allows the complex geometric in the manufacturing process.*

Keywords:*3D Printing, Advance Manufacturing, Automotive component, PLA, Weight Reduction*

I. Introduction

3D Printing

3D printing is a rapid manufacturing technique where a variety of materials can be printed using an additive process, where successive layers of materials are laid down in different shapes. A wide range of 3D printers are available commercially, such as stereo lithography, fused deposition modelling (FDM) and laser type 3D printer. In fused deposition modelling generally 0.25mm, 0.4 mm, 0.6 mm, and 0.8mm nozzles are available as standard. In rapid prototyping, materials are available in the form of solid rods of different diameters (generally 0.75mm and 3mm diameters are used). Materials are melted at higher temperatures according to their properties in the range of 210 °C to 260 °C and laid down in layers according to the size of the nozzle in different shapes, as per the CAD design and dimensions.

The basic process of 3D printing constitutes the following steps [1]:

1. Creating the 3D CAD model of the design.
2. Converting the 3D model to STL or OBJ format.
3. Slicing the OBJ or STL file into a step file. The step file is also known as G-code file.
4. Prototyping the object using a 3D printer.
5. Removing and finishing the object.

Automotive Components

Automobile has a large number of components that helps the long-term functioning in the efficient manner of the car. Automobile parts are being manufactured all over the globe with precision and advance technological method. Engine, Gear box part, Wheel Assembly, steering, suspension and brakes part are some of the most important automobile components. [4]

The main material using for the manufacturing of automobile components are steel, aluminium, copper, plastic, magnesium and carbon fibres. Steel is the most widely used material in the auto manufacturing. Around 80% of car weight consist a steel. Steel is used to construct a car body, chassis, roof. Beams between doors and door panels. Aluminium is also used in the automotive component manufacturing such as knuckle, wheel assembly etc.

II. Reasons for Using 3D Printing In The Automotive Manufacturing

1. It can create any complex geometry in any form of shape and structure.
2. It reduces the weight of components by using wide range of material according to the use of the model in real face.
3. It reduces the cost of manufacturing in the real time production. Specially there were a huge difference in the modelling and 3d printing at the quality testing.
4. Less use of material by changing settings. If a model is not for use in real life cycle (only used for checking dimensions or an assembly design), printing on lower density gives saving of material and cost.
5. All the components in assembly are fabricated simultaneously, layer-by-layer. A support material is used to fill-up the cavities

III. Method Of Manufacturing In 3D Printer

The system at the IGNITE – Incubator & Co-Working space utilises. A program known as 'Cura 2.3.1' to convert the design into a step file know as G-code. Cura 2.3.1 [2] is designed for three-dimensional (3D) printing, but it is open source, meaning it can easily be adapted from 3D to dispenser printing. The software offers the infill pattern algorithmsby calculating a 'Rectangle box' fine pixels to clearly indicate the print route. [3]
Automotive components were printed by using the Ultimaker 2 Extended Plus 3D printer, which is a part of the maker lab at the IGNITE – Incubator & Co-working Space. Total 6 number of parts were printed such as Front Hub, Rear Hub, Knuckle, CAM (engine part), Steering pedal and Calliper. These parts were printed using a 0.6 mm nozzle with 100% infill densities. Infill patterns used for making components were grid with the parameters as shown in Table 1.

Table 1

Parameters	**Units**	**Value**
Material	Poly Lactic Acid	100% density
Bed Temperature	℃	60
Nozzle Temperature	℃	210
Layer Thickness	Mm	0.15
Solid top layers	Mm	2
Solid bottom layers	Mm	2
Wall Thickness	Mm	1.2

The following figure shows the 3D printed automobile components with the configuration as mentioned in the above table.

Figure 1: 3D Printed Rear Hub (Top View)

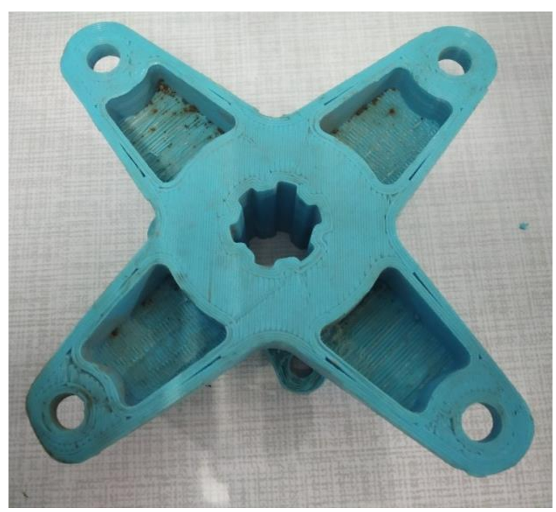

Figure 2: 3D Printed Rear Hub (Bottom View)

Figure 1 and 2 shows the 3D printed Hub which is the component of wheel assembly in the automotive. This type of component is used in the real assembly due to axle construction, so it named as Rear Hub. Rear hub is printed from Poly Lactic Acid (PLA) material in the FDM printer. Figure 1 shows the top view and figure 2 shows the bottom view of the component.

Figure 3 and 4 shows the 3D printed Hub which is the component of wheel assembly in the automotive. This type of component is used in the front assembly due to sleeve construction, so it named as Front Hub. Front hub is printed from Poly Lactic Acid (PLA) material in the FDM printer. Figure 3 shows the top view and figure 4 shows the bottom view of the component.

Figure 5 and 6 shows the 3D printed CAM which is the component of engine parts in the automotive. CAM is a part of CVT driven pulley which is connected to the side of moving sheave. Torsion spring connects the moving sheave to this CAM. CAM is basically used to change the radius of CVT. CAM is printed from Acrylonitrile Butadiene Styrene (ABS) material in the FDM printer to give the higher frictional strength. Figure 5 and figure 6 shows the different angle view of the CAM.

Figure 3: 3D Printed Front Hub (Top View)

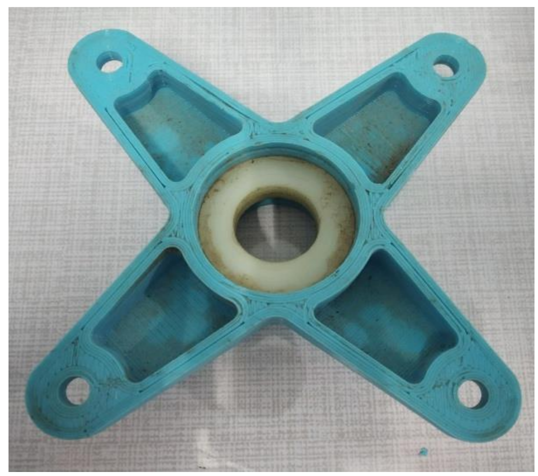

Figure 4: 3D Printed Front Hub (Bottom View)

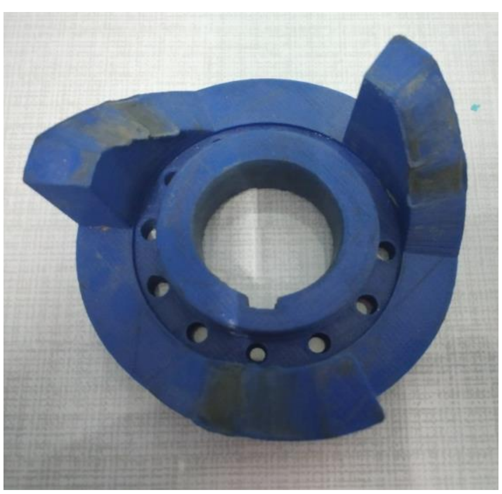

Figure 5: 3D Printed CAM

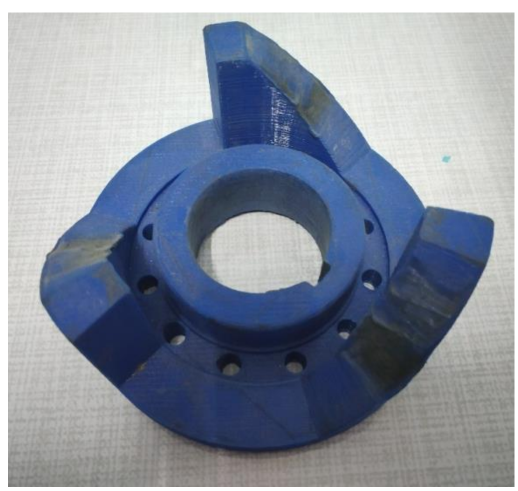

Figure 6: 3D Printed CAM

Figure 7 and 8 shows the 3D printed Calliper which is the component of brake assembly in the automotive. Brake callipers squeeze the brake pads against the surface of the brake rotor to slow or stop the vehicle. Calliper is printed from Poly Lactic Acid (PLA) material in the FDM printer. Figure 7 and figure 8 shows the different angle view of the 3D printed Calliper.

Figure 9 shows the 3D printed Knuckle which is part of the steering and suspension assemble in the automotive. In automotive suspension, a steering knuckle is that part which contains the wheel hub or spindle, and attaches to the suspension and steering components. Knuckle is printed from Poly Lactic Acid (PLA) material in the FDM printer.

Figure 10 shows the 3D printed customized Steering pedal which is the component of the steering assembly. Steering pedal is the sleeve type connection between steering wheel and connecting rode which gives movement to the wheel. Steering pedal sleeve is printed from Poly Lactic Acid (PLA) material in the FDM printer.

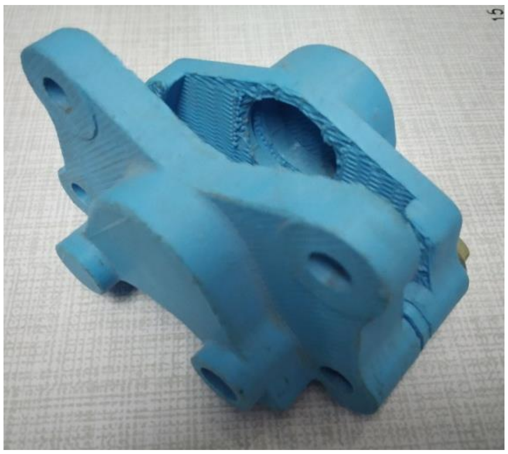

Figure 7: 3D Printed Calliper

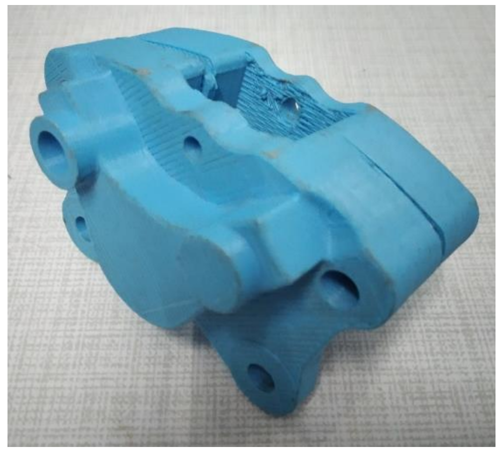

Figure 8: 3D Printed Calliper

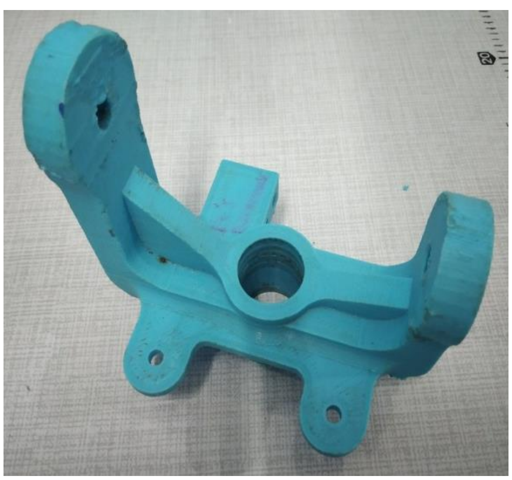

Figure 9: 3D Printed Knuckle

Figure 10: 3D Printed Steering pedal

IV. Results

The results obtained from the test, shows weight difference of the different automobile components by using metal and 3d printed material. As can be seen, a manufacturing time for single unit in conventional manufacturing and in the 3D printing technology. It also shows the weight difference in the performed parts. Observing the change in the surface roughness in the objects, weight of the components decreases as the density of material changes. To evaluate the strength, we perform a dynamic testing using 3D printed parts in All Terrain Vehicle (ATV) at the Silver Oak College. In the dynamic testing in unloaded condition, we found that all the 3D printed performed parts were partially stable and perform a regularly. Table 2 shows a comparison of different parameters between the metal material using conventional manufacturing and 3D printing material using FDM printer.

Table 2

		Aluminium MATERIAL USING CNC/VMC			**PLA/ABS MATERIAL USING 3D PRINTING**		
Sr. No	**Component Name**	**Manufacturing Time**	**Part Weight**	**Approx. Cost**	**Manufacturing Time**	**Part Weight**	**Approx. Cost**
1	Rear Hub	6 hours	175	8000	4 Hour	78 Gm	780
2	Front Hub	6 hours	169	9000	4 Hour	75 GM	750
3	CAM	4 Hour	225	5000	4 Hour	100 Gm	1000
4	Calliper	6 Hour	215	8000	4 Hour 30 Min	95 Gm	950
5	Knuckle	13 Hour	202	11,500	6 Hour	90 Gm	900
6	Steering Pedal	2 Hour	50	2300	1 Hour	22 Gm	220

V. Conclusion

In this work, the impact of 3D printing on manufacturing time, weight and economical significance have been studied for the existing manufacturing techniques like CNC/VMC and 3D Printing technology. The results in the both processes show that,

- The manufacturing time will increase in CNC as complexity will increase and it will be higher than 3D printing.
- As aluminium density is more than double to the PLA material, the weight difference is much higher in the conventional material and technology.
- For the strength requirement, it will be similar or acceptable lower than the aluminium in PLA, but infill pattern of 3D printing gives strength to the part.
- In order to economical significance, the cost for manufacturing a single unit is very much higher than 3D printing. It shows a vast difference in the cost.
- Manufacturing cost in the CNC/VMC is increased due to the destructive manufacturing where waste of material is very high; as 3D printing is additive manufacturing and there are no waste of material.

VI. Future scope of Work

The author wishes to focus on the further scope of work by measuring the strength of parts. Tensile and compressive strength of 3D printed parts will give the best result and give further way to this result dynamically.

VII. Acknowledgement

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