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Design and Analysis of Rear Wheel Upright Using 3D Printing Technology

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ABSTRACT

The Rear Upright is the most important part of the rear wheels which is connected to the suspension system and rear wheel hub of a vehicle. It gives a rotating motion to the rear hub using taper bearing fitted inside it to bear radial as well as axial loads in dynamic conditions. The main aim of the Automotive Industry is to increase the overall efficiency and decrease the manufacturing cost. In this paper I have designed the Rear Wheel Upright of an All-Terrain vehicle for two different manufacturing methods using Autodesk Fusion 360 and Solid works 2019 and further done the static structural analysis using ANSYS Workbench 18.1 by constraining the upper arms of the rear upright and applying remote force on the spindle point from contact patch of the tire combining all the lateral and longitudinal forces acting on Upright. Final aim is to show that additive manufacturing is better method than subtractive type manufacturing as it increases the component performance. In this, first I designed for subtractive manufacturing i.e., CNC manufacturing using AL6061 and optimized it by designing lightweight component with needed Factor of Safety which is fabricated by additive manufacturing i.e., 3D Printing using same material. Final output is obtained by applying calculated forces and using Finite Element Analysis (FEA).

Keywords: Terrain vehicle; Rear upright; Additive manufacturing; 3D printing; Lightweight; Structural analysis

INTRODUCTION

Rear Wheel Upright is the connecting link and the load bearing structure between the suspension system and the wheel assembly. In All-Terrain Vehicles (ATVs) it is very important component as the wheel assembly is attached to the hub where the wheel rotates while it is held in stable plain using Upright at every bump and droop. As shown in the Figure 1 both the arms of the Upright are connected to the H-Arm type suspension system and bearings are press fitted into the upright so to give a rotating movement to the hub attached to the upright whereas wheels are mounted on the hub with the help of struts. The shape and size optimization depends on the overall vehicle weight as all the lateral or transverse load of the vehicle acts on a component. Structural Rigidity balance plays a main role in all the Off-road vehicle components as the component should be rigid enough to retain shape change and flexible enough to easily absorb all the forces by optimizing stress concentration areas. So far, no attempt has been made to design and use the additive manufactured upright for All-Terrain Vehicles in Automotive Industry. For the past few decades, 3D printing in the automotive industry was primarily used by carmakers to create automotive prototypes to check their form and fit. Since the metal 3D printing technology is new many mass production industries will get used to it slowly. Additive manufacturing is very helpful in motorsports as it enhances the structural rigidity, reduces weight and maintains Factor of Safety of a component and increases the overall performance [1-3].

THEORY

This whole study is done using manual calculation and Computer Aided Engineering (CAE). This whole study has been followed in two main parts. First by designing two fully enhanced designs for subtractive and additive manufacturing and second by optimizing them uses Finite Elements Analysis software. CAD models of rear upright were developed using software such as Autodesk Fusion 360 and Solid works 2019 and for Static Structural Analysis FEA software Ansys Workbench 18 (Figure 1).

DESIGN

CAD model of the CNC manufactured rear upright was made in Solid works 2019 as shown in Figure 1 whereas the 3D printed design of a rear upright was designed in an Autodesk Fusion 360 using generative design tool as shown in Figure 2. One of the key design decisions taken to design this component is to increase the

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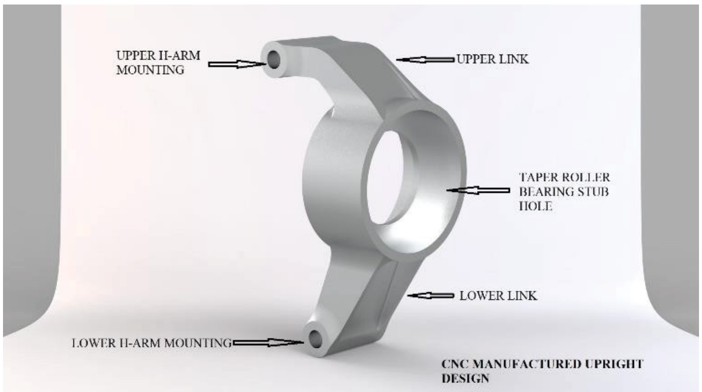

Figure 1: CNC manufactured rear upright design.

Figure 2: 3D printed rear upright design.

overall performance. So, by keeping the different aspects in mind for both the designs Aluminum 6061 T6 has been used [4-6] (Table 1).

Table 1: Upright material properties.

Material Properties	Aluminum 6061 T6
Elastic Modulus	68.9 GPa
Poisson's Ratio	0.33
Elongation	12%
Mass Density	2700 Kg/m³
Tensile Strength	310 MPa
Yield Strength	276 MPa

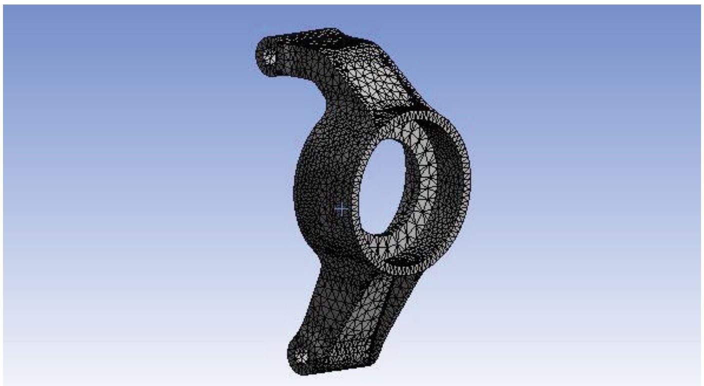

Figure 3: Mesh generation for CNC manufactured rear upright design.

CALCULATIONS

There are three major types of static loads which act on acomponent; they are axial load, radial load and tangential load.

Mass of an ATV (with driver weight) = 230 Kg Mass on one Wheel = 230/4 Kg = 57.5 Kg

Weight of an ATV (with driver weight) = 230 × 9.81 N = 2256.3 N

Weight on one Wheel = 57.5 × 9.81 N = 564.075 N

Lateral Load = Weight on one Wheel = 564.075 N Lateral Load = 1 G = 564.075 N

(For keeping the component in safe zone 2 G load is used) i.e., 564.075 × 2 = 1128.15 N

Longitudinal Load = Tangential Load acting (While turning).

MESH GENERATION

CAD Model of Rear Upright is imported into an Ansys 18.1. For the better simulation result fine mesh is used for mesh generation (Figures 3 and 4) (Tables 2 and 3).

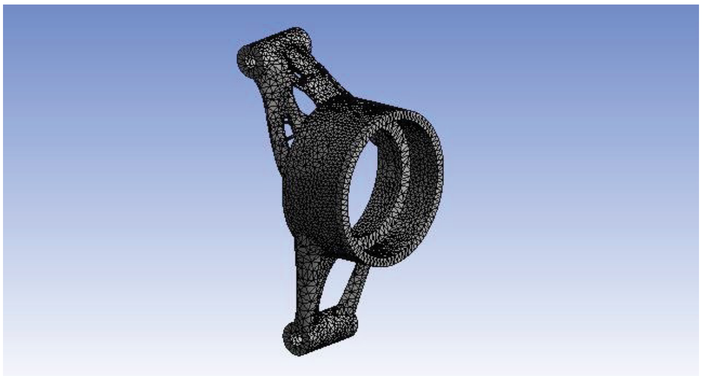

Figure 4: Mesh generation for 3D printed rear upright design.

Table 2: CNC manufactured rear upright specifications.

Nodes	34930
Elements	19807
Mass	403.66 g
Volume	149.503 cm³

Table 3: 3D printed rear upright specifications.

Nodes	48404
Elements	26489
Mass	235.19 g
Volume	87.107 cm³

SIMULATION RESULTS

The Static Structural Analysis of an All-Terrain Vehicle Rear Upright is done in Ansys Workbench 18.1. The applied load on component was determined from above calculation. There are various forces acting on it such as moment, lateral force, turning force as well as loads (Figures 5-10) (Table 4).

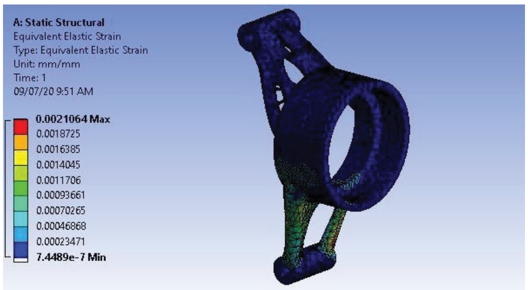

Figure 5: Equivalent von-misses stress (CNC upright design).

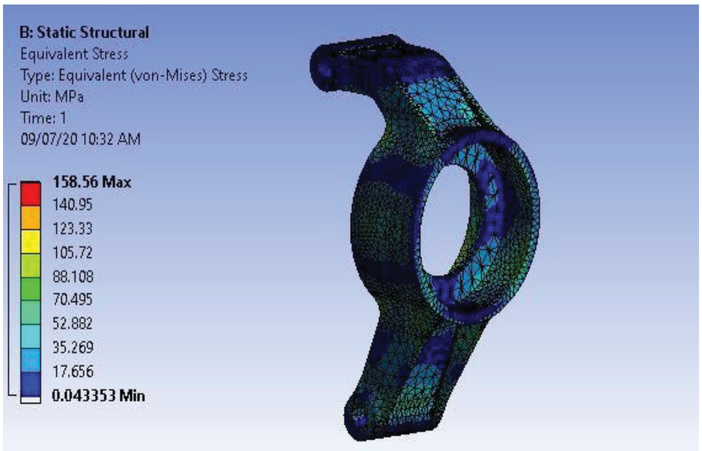

Figure 6: Equivalent elastic strain (CNC upright design).

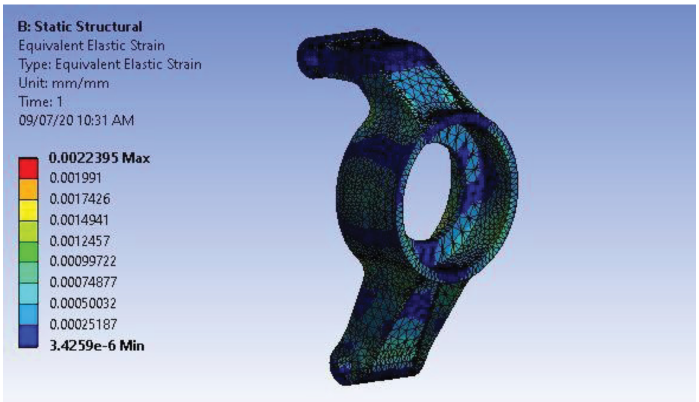

Figure 7: Total deformation (CNC upright design).

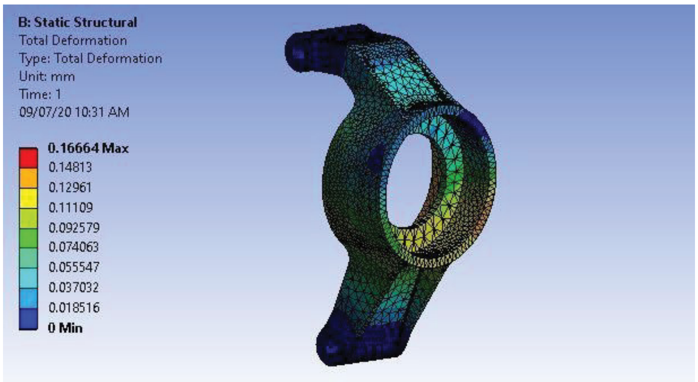

Figure 8: Equivalent von-misses stress (3D printed design).

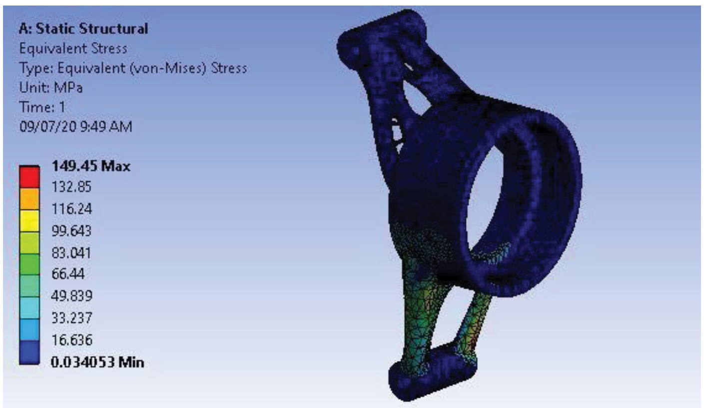

Figure 9: Equivalent elastic strain (3D printed design).

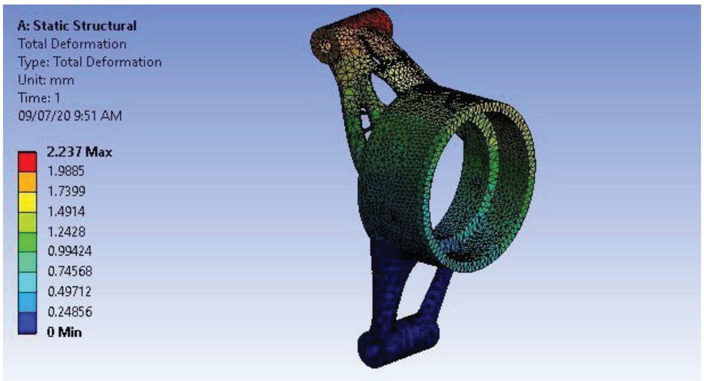

Figure 10: Total deformation (3D printed design).

Table 4: Final results.

Material Properties	CNC Manufactured Upright	3D printed Upright
Equivalent Von-misses Stress	158.56 MPa	149.45 MPa
Equivalent Elastic Strain	0.0022	0.0021
Total Deformation	0.1666 mm	2.237 mm
Mass	403.66 g	235.19 g
Factor of Safety (FOS)	1.74	1.84

DISCUSSION AND CONCLUSION

The Design and Structural Analysis is performed using Solid works 2019, Autodesk Fusion 360 and Ansys Workbench 18.1. The various parameters Such as Von- misses Stress, Elastic Strain and Total Deformation is analyzed in both manufacturing method designed rear uprights. There is a significant decrease in mass of 3D printed design. After decrease in mass the FOS obtained is more in 3D printed design. Hence, we can understand that 3D printed components are the future of automotive industry and motorsports as there is a performance enhancement by just changing the manufacturing technique and designing method.

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