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Design & fabrication of Rear Outboard Wheel Assembly for an ATV

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Abstract - *The aim of this paper is to present the detailed report of the project titled as design and fabrication of Rear Outboard Wheel Upright Assembly for an ATV (all-terrain vehicle). The paper covers all the prominent aspects of the project work viz 'literature review', 'design', 'CAE analysis', 'observations', and 'rectifications', etc. The wheel assembly for any vehicle could be bifurcated into two parts. The first part deals with the geometry & the design of Hub & Upright. Whereas the second part deals with the mounting of the assembly. The current project work mainly deals with the first part & gives detailed work procedure related to designing and fabrication of the hub & upright. The first two chapter's deals with introduction of the project and literature review of this project respectively. These chapters form the base of the project work. Following two chapters that is 'chapter 3' and 'chapter 4' deals with all the aspects of design and CAE analysis of the components & features the image gallery which shows the actual fabricated components and assemblies of the system. Safety of a vehicle depends on wheel assembly. A high quality wheel assembly allows vehicle to carry heavy loads, function in extreme weather conditions, and run smoothly on rough roads. A reduction in the weight of components also improves the vehicle's handling performance. It plays a crucial role in minimizing the vertical and roll motion of the vehicle body when it is driven on a rough road. The upright is required to support the load and torque induced by bumping braking, and acceleration. Under operating condition it is subjected to dynamic forces transmitted from strut and wheel. Upright is subjected to time varying loads during its service life which may lead to fatigue failure. The upright accounts for maximum amount of weight of all suspension components, which expedites the necessity of weight reduction.*

Key Words: Wheel Assembly, Wheel Upright, Outboard Braking, Calliper Mounting, All Terrain vehicle.

1. INTRODUCTION

In today's era mass or weight reduction is becoming a core highlighted issue in automobile manufacturing industry to improve fuel efficiency thereby reducing emissions. Weight reduction has been achieved through advances in materials, improved design and analysis methods, fabrication processes and optimization techniques, etc. Design optimization should be implemented to obtain a minimum weight with maximum or feasible performance, based on removal of conflicting constraints, design boundaries, and design uncertainties, such as design clearance and material defects. The upright accounts for maximum amount of weight of all suspension components, which expedites the necessity of weight reduction. In the design optimization of the knuckle component, weight should be minimized, while design factors such as strength, stiffness and durability should be satisfied with design targets. An effective design is one which performs the required task efficiently and is safe under extreme operating conditions, while being economical in the material used as well as the manufacturing process needed yet having an aesthetic appeal. Analysis aids in understanding the behaviour of a component under a particular loading cycle for both failures and redundancies. Therefore analysis gives us a mathematical model which indicates scope for optimization and weight reduction for an overdesigned component.

1.1 Wheel Hub

Wheel hub is the rotary part in the assembly which can transmits the power from axle & rotates the wheel. Wheel hub is the part seems as a plate welded to a cylinder where plate is mounted to rim and cylindrical portion is used to connect with axle. A wheel hub, is an automotive part used in most cars, passenger vehicles and light and heavy trucks. Wheel bearing is used to make a contact between upright and hub. Wheel hub of a car is one of the major and very important components and needs very good material and design in low cost and avoid failure. In disc brake application Disc is mounted on the Hub.

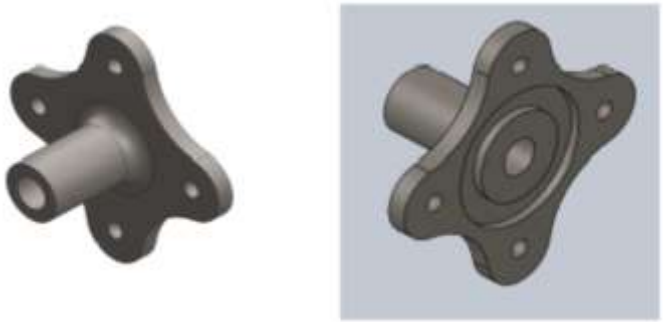

Fig -1: Wheel Hub

Before designing of any components there are various parameter that are to be included in it. Irrespective of other details the main design parameters determine mostly the performance, adaptability with the environment, mates with the sub-component in an assembly, space occupancy etc.

They are Special consideration and often are the constrains which are to be met.

1. Pitch Circle Diameter of Lug Bolts on rim Since stock Maruti rims were chosen to be on the vehicle on all four wheels. In order that the hub to sit on rim, the pitch circle diameter of the rim had to match with the designed hubs. Pitch Circle Diameter of Lug bolts on hub = 110 mm

2. No of Lug bolts and their size
Since the rim had 4 equi-spaced lug bolts holes. With the hole size of 12.5 mm diameter. The holes to match with rim had to be provided on hub.
Four Lug Bolt holes with diameter = 10 mm ø

3. Bearing Provision
The bore on the hub with sufficient tolerance is to be provided for the bearing to sit over the hub. The bearing on hub = 30mm.

4. Common Holes for Rim and Brake disk mounting Common holes for both rim and brake will minimize the number of holes from 8 to 4 on the hub.

As it was mentioned above in design parameters, weight consideration was the main objective. It was necessary to opt the material which could bear the forces induced during the motion as well be light. Considering all the above, it has been decided EN8 seems to be the most viable material for the component. The strength on weight ratio is sufficient to meet our standards.

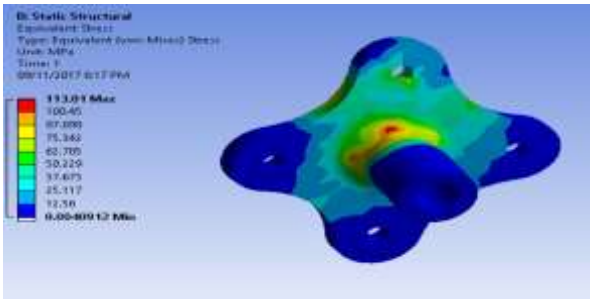

Fig -2: Wheel Hub stress analysis

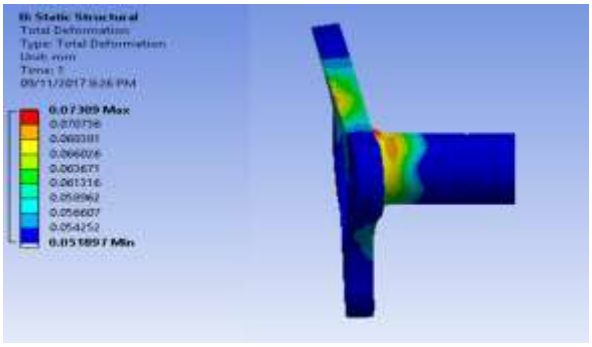

Fig -3: Wheel Hub Deformation analysis

Analysis of Wheel Hub:

Material: EN8
Weight: 1.2 Kg
Maximum Tensile Strength: 550MPa
Maximum Yield Strength: 280MPa
Force: 6000N
Stress: 113MPa
Deformation: 0.0739mm.

1.2 Wheel Upright

Upright is the mounting part which is required to connect all suspension, Braking parts to stabilize the vehicle. The upright is used to connect the chassis to the Wheel Assembly with the help of arms (A-arms), allowing the vehicle to stable and the caliper, allowing the driver to stop the vehicle. The hub is directly connected to the wheel, and is connected to the upright. The upright is to remain stationary relative to the chassis while the hub is to rotate with the wheel.

Fig -4: Rear wheel upright

The parameters that molded the design of the upright were:

1. Project the brake caliper mounts at one side of upright.

2. Provide sufficient thickness to brake caliper mounts to endure sudden torque from the disk.

3. Check alignment of the brake caliper mount on both of the uprights i.e. Left and Right uprights. Since the brake caliper doesn't have plane of symmetry along its center, brake mounts will have different special arrangements along the side of both uprights.

4. Dual bolt holes will be provided to counteract the moment.

5. Have sufficient fillet radius throughout the design to minimize notch sensitivity.

6. Length of upright will be taken as per the suspension design.

7. Upper and lower wishbone mounting will be dependent on the suspension geometry.

8. Bore be provided to accommodate the stub axle.

9. Press fitting tolerance to be provided in the central bore diameter to press fit axle.

10. Sufficient wall thickness to make the component rigid, unsusceptible to external moment.

11. Design optimization will be done after the component is analyzed for various loading cases to relief weight.

As it was mentioned above in design parameters, weight consideration was the main objective. It was necessary to opt the material which could bear the forces induced during the motion as well be light. Considering all the above, it has been decided Aluminium 6061 seems to be the most viable material for the component. The strength on weight ratio is sufficient to meet our standards.

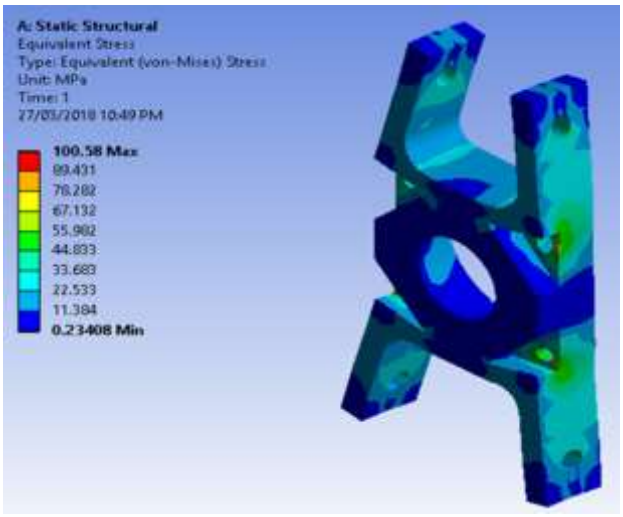

Fig -5: Rear upright stress analysis

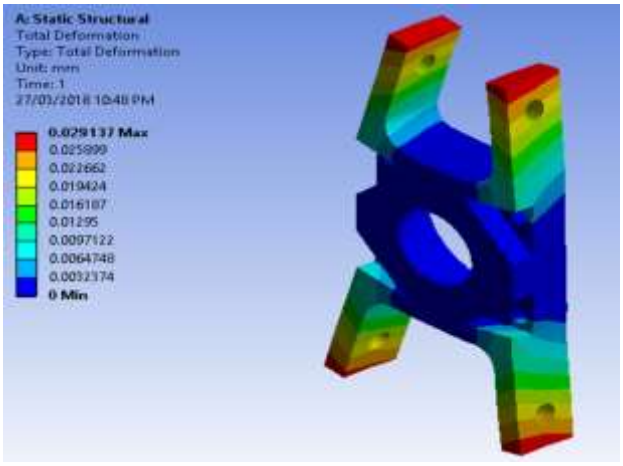

Fig -6: Rear upright Deformation analysis

Analysis of Rear Upright:
Material: Aluminium 6061
Weight: 700 grams
Maximum Tensile Strength: 300MPa
Maximum Yield Strength: 260MPa
Force: 6000N
Stress: 100.58MPa
Deformation: 0.029137mm

1.3 Caliper Mounting

Caliper Mounting plate allows the upright to hold the brake caliper properly. And also helps to mount some other accessories like tie rod for stability of vehicle.

The presence and location of brake calipers can vary depending on the make and model of ATV. If a caliper is present, it will always be found straddling a rotor, also known as a brake disc. While many ATVs have four brake calipers, one for each wheel, it is not uncommon for an ATV to have only three calipers. Typically, a brake caliper straddles each rotor in the Wheel, which is mounted to the wheel hub. In the rear, a rotor may be mounted to the axle.

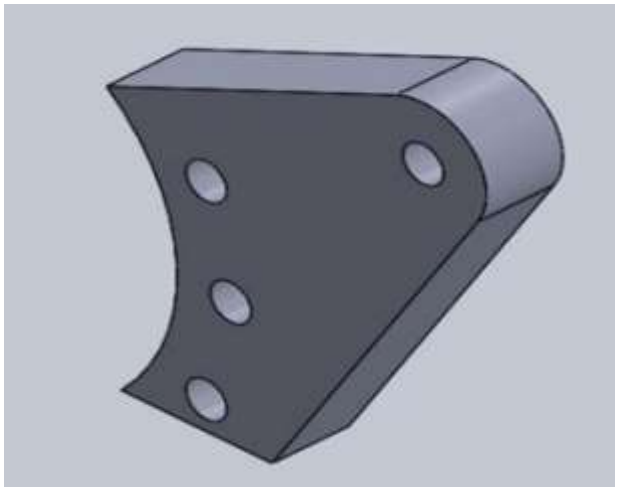

Fig -7: Caliper Mounting

The parameters that molded the design of the Mounting Plate & Caliper Mounting were:

1. Provide sufficient thickness to Mounting Plate so that it can sustain the load.

2. Provide sufficient thickness to Caliper mounting so that it can sustain the braking load.

3. Mounting bracket should be able to mount on upright.

4. Vehicle should be able to stop properly.

5. Dual bolt holes will be provided to counteract the moment.

As it was mentioned above in design parameters, weight consideration was the main objective. it was necessary to opt

the material which could bear the forces induced during the motion as well be light. Considering all the above, it has been decided Mild Steel seems to be the most viable material for the component. The strength on weight ratio is sufficient to meet our standards.

Analysis of Caliper Mounting :

Material: Mild Steel
Weight: 330grams
Maximum Tensile Strength: 500MPa
Maximum Yield Strength: 247MPa
Force: 100N
Stress: 5.9849MPa
Deformation: 0.0932mm

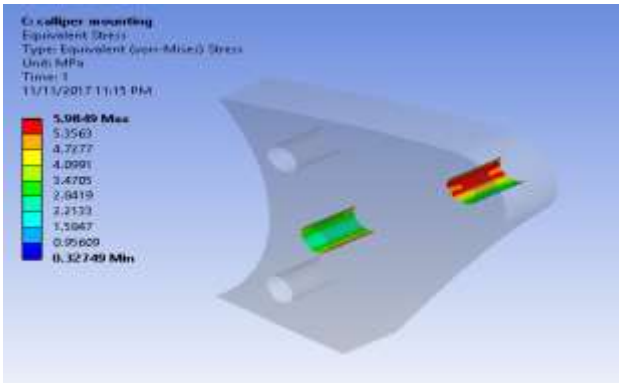

Fig -8: Caliper Mounting stress analysis

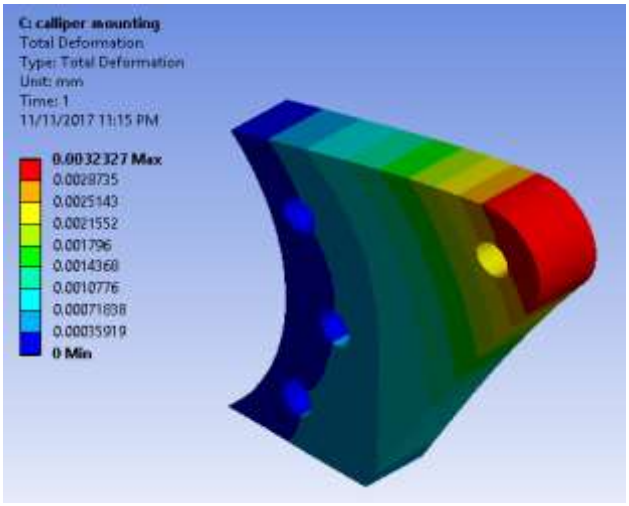

Fig -9 Caliper Mounting deformation analysis

2. Manufacturing

Manufacturing is made with constraint as per the material, its availability, machining cost without affecting the part strength. Thus, CNC machining is preferred for Upright and normal power tools for manufacturing of steering Knuckle & Caliper Mounting.

Table -1: Manufacturing details

Particular	Manufacturing Process	Tools Used	Material
Upright	Operation performed by CNC machine	CNC Machine	Aluminium 6061
Calliper Mounting	Material purchased in the form of plate & Plate drilled and cut as per the requirement by drilling machine power tools.	Power tools.	Mild Steel

Fig -10: Actual Rear upright

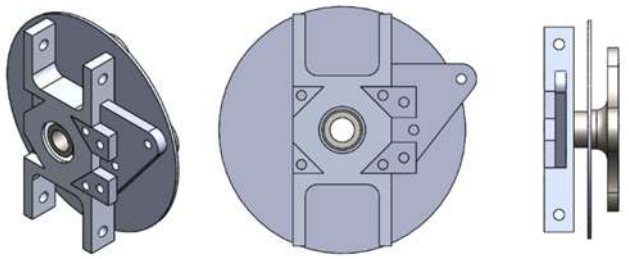

Fig -11: Rear upright assembly

Fig -12: Actual pictures of Rear upright assembly

3. CONCLUSIONS

The purpose of this paper is not only to design and manufacture the upright assemblies for the car, but also to provide an in depth study in the process taken to arrive at the final design. With all the project work presented above it can be conclude that the project work has been successfully completed along with completion of all the objectives.

The conclusions made are as follows:

1. The literature of the wheel assembly indicates that the key points to be consider while designing the assembly is to consider stresses and strength of material.

2. The FEA result indicates that the Wheel assembly is able to perform safely in real track condition as per performance requirement.

3. The material ALUMINIUM 6061 is selected for the fabrication uprights and MS selected for mounting accessories.

4. The fabricated assembly is tested on the ATV and working properly with the desired smoothness and ruggedness.

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