Design and analysis of All-Terrain Vehicle (ATV)

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Abstract
This design and analysis aimed at the production of an ATV fun off-road, versatile, secure, lasting and high-quality vehicle. The vehicle shall comply with the requirements of the regulations. This vehicle must be able to negotiate with confidence and ease the most difficult terrain. By dividing the vehicle into its main subsystems we have achieved these objectives. The ATV architecture is based to demonstrate its competence in the car industry through the principles of engineering sciences. The concept helps to illustrate how the vehicle is constructed and methodologically employed.

It was designed to meet international standards and at the same time to be cost-efficient. It was designed to meet international standards. Each program was designed to boost each component's performance. This vehicle can handle almost all-terrain, which is the main goal of an all-terrain vehicle. Teams started to design each major component of the vehicle by conducting extensive research.

The authors considered that each component is important and planned the entire vehicle to maximize each component while considering how it will affect other components. That forced authors to think out of the box, to investigate and to redesign components to have a successful design.

Keywords: All-Terrain Vehicle (ATV), frame design, CVT, Factor of Safety.

1. Introduction

Automotive, motor vehicle or automobile is a wheeled motor vehicle that also carries it's motor or engine. The term car comes from the French vehicles of the old Greek terms (driving, "self") and cell phones of the Latin word ("movable"), which is a moving vehicle itself.

Cars can be categorized by various criteria and goals. Comprehensive classification is therefore inadequate, as a vehicle may or may not fully fulfill the specifications of many categories. Table 1 below summarizes the most commonly used general categorization.

Table 1.1- Classification of Automobiles

HLDI classification	Definition
Sports	Those cars with significant high-performance features
Luxury	Higher-end cars that are not classified as sports
Large	Length more than 495.3 cm (195 in) and wheelbase more than 279.4 cm (110 in)
Midsize	Length 457.3–495.3 cm (180–195 in) and wheelbase 266.8–279.4 cm (105–110 in)
Small	Length less than 457.2 cm (180 in) and wheelbase less than 266.7 cm (105 in)

The American National Standards Institute (ANSI) is a vehicle that travels on a low-pressure tire, with the operator's seat, along with the control steering handlebars. The ATV is also known as a quad, quad, three-wheeler or four-wheeler. It is designed to accommodate a broader variety of fields than most other vehicles. As the name suggests.

ATVs are designed to be used by a single person, the driver sits on them and drives them like a motorcycle, but additional wheels provide higher-speed stability. Sperry-Rand Tri-Cart was the first three-wheeled ATV. It was founded in 1967 in the Cranbrook Academy of Arts near Detroit as a John Plessinger graduate project. Instead of sitting-in, the Tri-Cart was ridden straddle.

The primary aim of this project is to design and fabricate an All-Terrain Vehicle. A four-wheeler that will take on rugged non-motor-able roads with ease and have paramount importance to driver safety. We have strived to self-design and manufacture most of our components while some have been readily bought from the market and customized as per our requirements. As a guideline, we have taken the rules and guidelines stipulated for SAEINDIA BAJA 2013. We shall use a Briggs & Stratton 10 Hp OHV Model 205432 engine as our power source. All other components selected have been elaborated in detail.

1.1 Frame Design

The initial material chosen for fabricating the Roll cage was AISI 4130. The dimensions of the chosen pipe were 1.25-inch outer diameter and 2mm thickness. Due to its high yield strength, we could make use of pipes with larger Outer Diameter and less thickness which helped in reducing the weight of our Roll cage substantially. But, due to the unavailability of material in small quantity (suitable for constructing a single vehicle), we were forced to use a more commonly available material i.e., AISI 1018. Circular pipes of 1-inch outer diameter and the wall thickness of 3 mm were used and square pipes of 1.25-inch sides were used for the base. MIG Welding was utilized as it provides better strength and clean welds.

The change in material and thickness, though reduced the manufacturing cost, posed a serious problem of increase in mass which also decreased the FOS from 2.12 to 1.87 in a front impact condition. Hence, the entire frame was re-analyzed after taking into consideration the new data that had been introduced.

1.1.1 Deciding Material Properties

Material Selection – 20% of the weight of our vehicle is off the roll cage. So, we decided to use alloy steel of high yield strength. This ensured that pipe of larger diameter and less thickness can be used thus reducing the overall weight of our roll cage. The most suitable for our purpose was the use of AISI 4130 steel. However, the cost of the material in a small quantity was not feasible for our project. Evaluating other options based on our requirements, the most suitable next choice was AISI 1018.

- Primary Members: O.D. – 1inch, Thickness – 3mm
- Secondary Members: O.D. – 1inch, Thickness – 2mm

Secondary members of less thickness were used to reduce the weight of our roll cage. Another important design objective was to pack all parts more efficiently to reduce the length of the rolling cage. This has been successfully obtained through our compact design.

Solidworks was used for Modelling and analysis of our design, the results of which are shown below. Proper mounting points for engine, Gearbox, and Suspension links are provided in roll cage. Electric arc welding was used for the welding roll cage.

First, a prototype of PVC pipes before manufacturing roll cage was made to check space as well as comfort for the driver. After satisfactory ergonomics were tested, the final roll-cage was fabricated.

1.2 Analysis of Frame:

The frame was designed and analyzed using SolidWorks (design and analysis software). As there are no fixed amounts of force that a vehicle can endure in a frontal collision and by using entities such as mass (vehicle) and its presumed top speed; a maximum force of only 18000 N was derived, but there may be even serious conditions of collision than the ones that are projected. Hence, a benchmark (of maximum endurable force) was to be finalized at which our vehicle could sustain a collision and still have an FOS of at least 2. According to U.S.A. automotive industry norms, all vehicles must be tested at a force of 10G's, since an average human body can only endure a force of 9G's. A force of 10G's comes out to be around 29,345 N or 30,000 N. Hence, the frame was tested at a force of 30,000 N in front impact producing a FOS of 2.1 was achieved, but the impact caused a huge displacement of the force throughout the frame.

The redundancies against this were chalked out and the frame was further optimized to get an F.O.S. of 5.1, where a crumple zone was generated in the front part of the frame which absorbed most of the damage leaving the cock-pit safe for the driver, was chosen as our final design. Figure 1, shows the stress distribution in the frame (it may be noted that the entire stress concentrates in the crumple zone) and figure 2, depicts the displacement of the frame in case of front collision at 30,000 N.

The frame was also tested under conditions of a rear impact, bump impact, rollover, etc. The drawings of the frame with necessary dimensions are shown in figures 4,5,6 and 7. The frame was fabricated using the MIG welding set-up in the Welding Shop of our College. It was coated with red-oxide to prevent rusting. Further chains were attached to the frame and holes drilled wherever required. A few new braces were so added where the physical satisfaction of the frame was not achieved. Finally, very thin sheet metal (mild steel) was welded to the surface and was used to generate a characteristic body of the vehicle. Later the entire frame was spray painted.

1.3 Engine & Transmission

The construction of a power train has been highlighted. Our goal is to use the power of 10 HP and to supply the tires efficiently for maximum performance. The optimization of many desirable features, including traction power, accelerating, top speed and reliability, are included in the design of the drive train. The engine generates the highest torque, below and below that power band, the engine does not have sufficient torque to overcome the strong torque and accelerate the vehicle. Each internal combustion engine has an engine powerband (accelerate range). It is seen that less quantity of power within the power band is not sufficient for the performance required.

We have either loads of gear speeds or a CVT (variable transmission constantly). Therefore. The belt drive (CVT) is a system that is much smoother than a traditional transmission and that can work with the highest engine speed. Rather of a traditional clutch based multi-engine transmission, the CVT transmits power from the engine through the car, requiring a constant shift to reduction ratios. It consists of two variable pitch sweaters, the drive and the brake, which change their ratios semi-dependently depending on the RPM and torque they spin at.

The drive line design aims to remove as many power losses as possible from the motor to the wheels. The drive train is composed of the CVT, chain and pipe and differential for achieving this task.

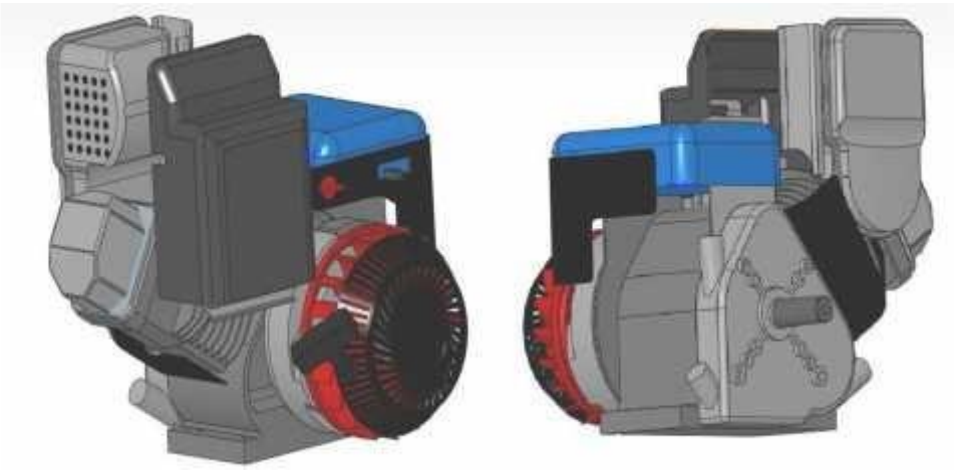

Figure 1.1- Left and Right View of the Engine

The size is 23x 8x 12 of the pipe to use. The CVT gear decrease is 0.75%:1 and thus serves as an "overdriving" for the car as the engine reaches its governed rpm limit 3800 rpm. The CVT reduces at low engine speeds by 3.83:1 which means that torque is required, despite its ability to transfer torque over a higher number of suspension joints, for half the shafts. Such characteristics build a vehicle that uses the maximum power to drive smoothly, easily and with low maintenance. The vehicle as an off-road driver is intended to cut our top speed to 45 kmph.

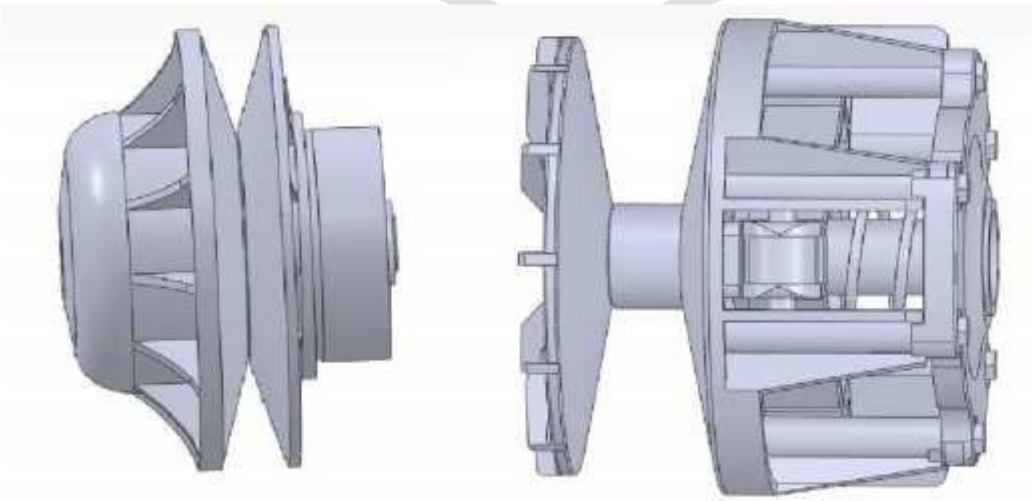

Fig 1.2: Cone Pulleys of the CVT

Fig 1.3: Engine mounting position

1.4 View of Roll Cage

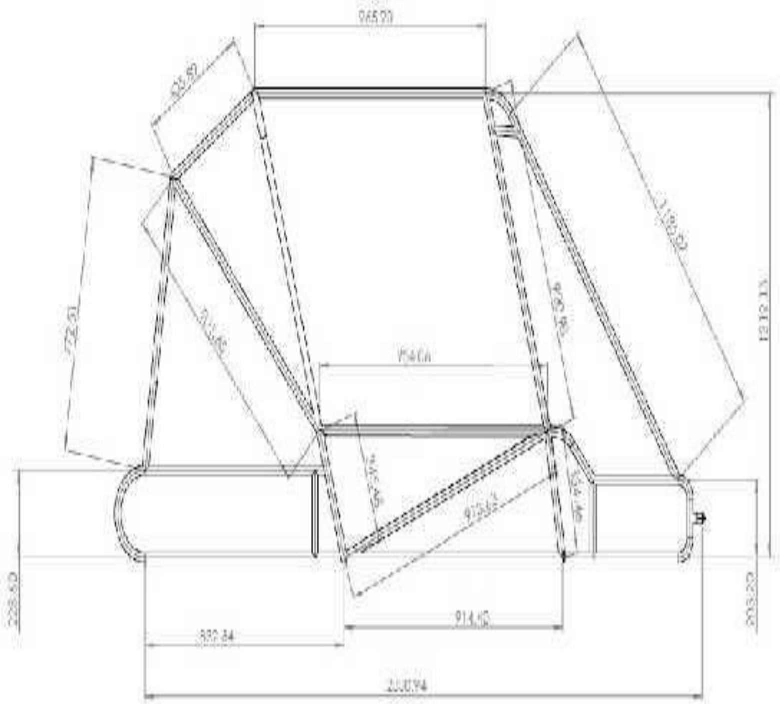

Fig 1.4: Side View of Roll Cage

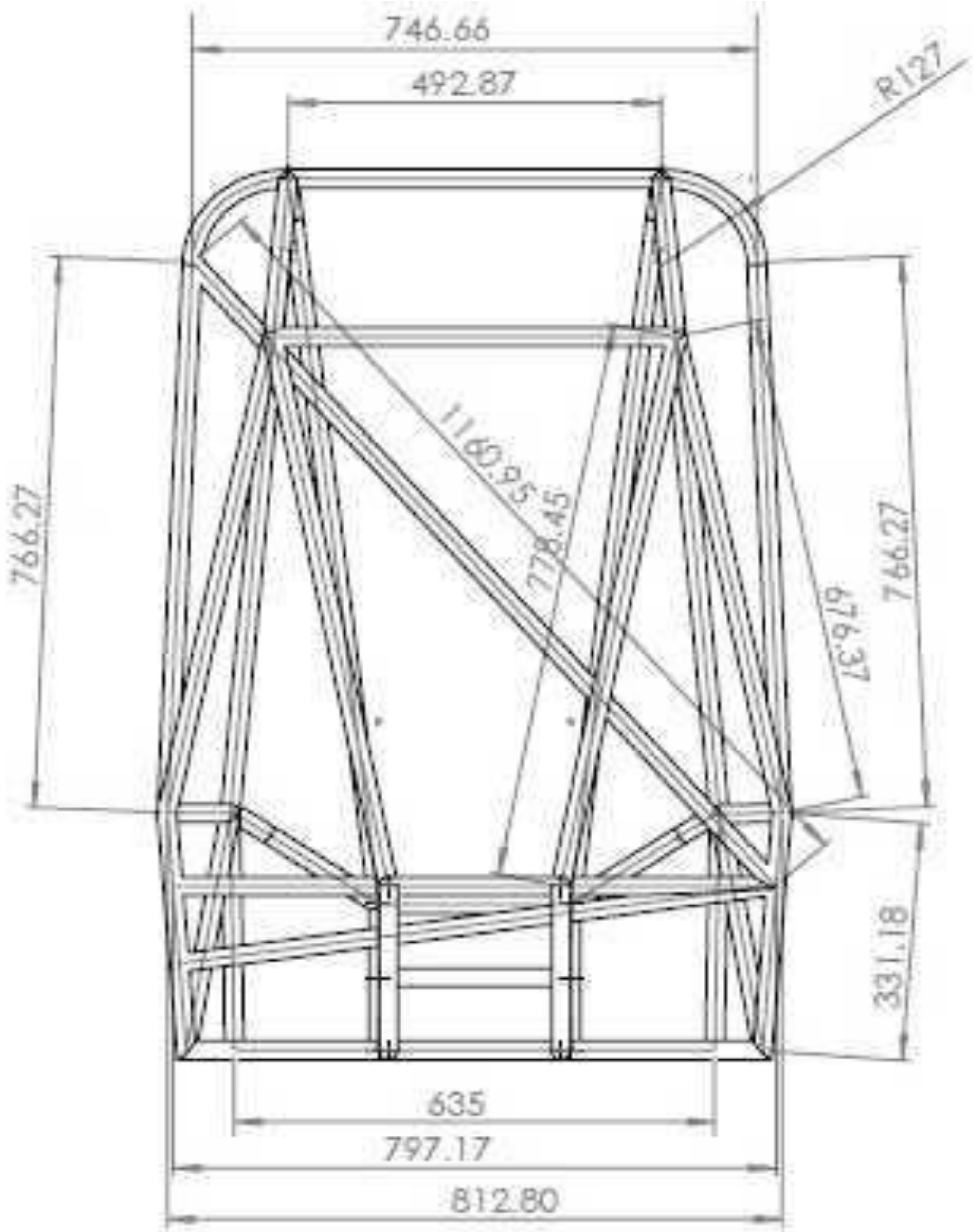

Fig 1.5: Front View of Roll Cage

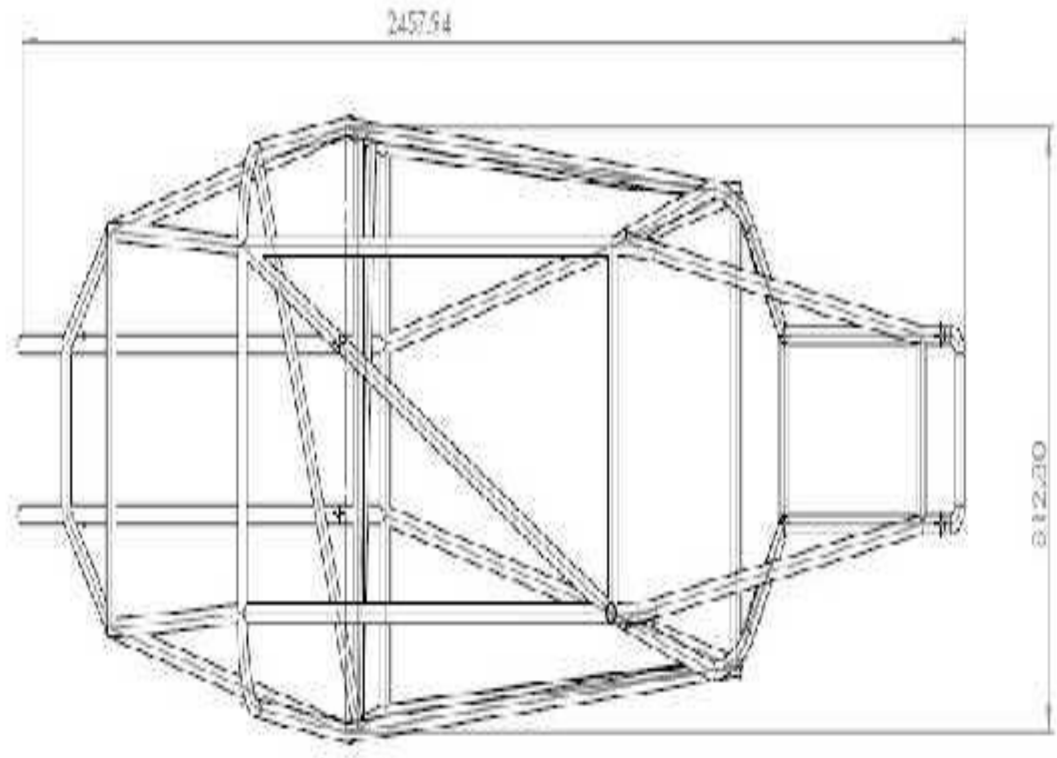

Fig 1.6: Top View of Roll Cage

2.2.1 Conclusion

All tests can be performed in ANSYS with a view to safety. It is possible to build a chassis with better modifications. It is evident from a large amount of research and simulation that the vehicles are subject to a wide variety of often unpredictable loads.

This paper successfully shows the tests which have proved this chassis is partially safe. For other tests, similar reasoning and processes can be implemented with slight adjustments. All the above areas should be very careful in ensuring driver safety and the survival of the frame. It will help to understand better the essence of the conditions of off-road loading for vehicles on ATV.

To determine the static stress distribution and the fatigue life of the chassis with finite element simulation, a detailed survey has been carried out for the following areas.

1. First, it deals with the literature in respect of simulation of static and dynamic analysis histories involved in the chassis design and analysis of bending, torsion and fatigue life analysis.
2. Secondly, it covers some of the research work in the development of the static and dynamic simulation of chassis frame analysis for off-highway way application with an emphasis on the prediction of fatigue life and stress distribution of the critical area.
3. It also covers some of the earlier works of modeling, design, and analysis of an automotive initiation.

Methodology

This section discusses how to build a chassis and how to model the chassis as well as the factors considered during the design process. In the field of safety and esthetics, we built the roll cage They are the two variables that matter most to us, and they are therefore of great importance.

3.1 Design Process

Two phases have been used to build the frame. The first or preliminary design uses mock chassis to decide where all parts and boundaries of the Formula SAE competition rules were placed. Solidworks used the second or comprehensive version to describe the details on the preliminary design packaging in its unique position for all components. Solidworks ' usage to finalize the frame design simplifies the chassis development process. All sections, including curve angles, notch angles, and articulation parameters are given by the software.

3.2 Solidworks Modelling

The Vehicle Dynamics team used the same calculation to determine suspension A-arm endpoints or hardening points when the minimum required size for the footwell was determined. The construction of the frame from the front end of the frame was started when the suspension geometry was provided.

- The frame was well triangulated to allow tensile and compressive forces to work on tubes. It was kept in mind.
- For suspension brackets designs were added.
- The mainframe nodes where suspenses components would be connected were the endpoints of bracket sketches. It was the same for the back.
- The regulatory specifications were taken into account as the design was carried out (front bulkhead, front support structure bulkhead, etc.) •
- Cockpit and footwell measurements of mock were used to produce the final front wireframe model.

Once the sketch was finished, the sketch was added with weldings. The roll-hoop, bracing etc laws have been extended to the tubing dimensions. For the profiling of pipes, the trim and extend feature was used to achieve a simple profile.

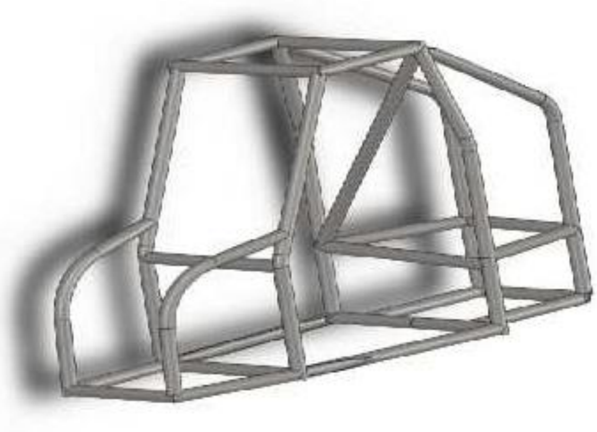

Fig 3.1: Chassis Modelling

Engine Mount

4.1 Introduction:

Engine assemblies are used for attaching a car engine to the vehicle frame. Typically they are made of rubber and metal. On one hand, the metal portion is connected to the motor and on the other the frame. The rubber has a little flexibility in between (so the shaking of the engine doesn't make the car shake). Newer cars may use slightly different mounts, but their purpose is similar. Link the engine to the automotive frame. The number of mounts depends on how the vehicle is fixed.

4.2 Working of Engine Mount:

Machine mounts separate you from the vibration and harmonic of the internal combustion engine. It will feel exactly how rough your vehicle motor is, even though it is working properly, without those simple things. The mounts for the engine are rubber insulators mounted between the motor in a vehicle and the frame. They keep the motor in place while absorbing engine vibrations, producing a smooth, relaxed feel in the car.

They are of rubber to absorb vibrations, but certain manufacturers have successfully tried to use a fluid (oil) mount to dampen vibrations. These mounts transfer vibration for certain performance applications, such as polyurethane and solid steel mounted mounts, but can resist abusive and powerful applications in racing where comfortable and smooth-riding is not a problem. In addition to keeping the motor in place, motor sections also keep the surrounding steel around the motor from shaking the car. The engine is attached to the chassis on one end and the vehicle frame on the other.

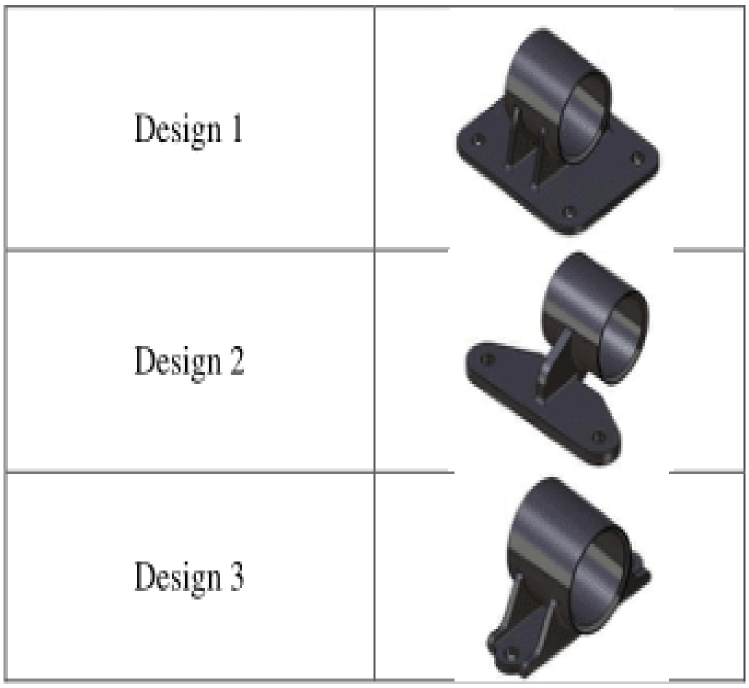

Fig 3.2: Design of Engine Mount

Material and Fabrication Process

There are many mechanical processes used in the fabrication of the project and the manufacturing, these processes are noted below.

5.1 Material Used:

a) AISI 1018 and 4130 pipes are good choices for chassis in a Baja vehicle.
b) Mild/low carbon steel AISI 1018 is excellent softening and produces a standard hard case.
c) Mild/low carbon steel from AISI 1018 offers a good balance between strength, hardness and ductility. AISI 1018 PIPE also contains improved work properties and hardness of Brinell.
d) Suitable for industrial processes, such as welding, forging, heating, machining and heat treatment and most importantly it is very strong and can resist large forces due to the tubular structure.

5.2 Fabrication Process

Fig 5.1: Chassis

Fig 5.2: Engine Mounting Position

Fig 5.3 : All-Terrain Vehicle

Conclusion & Future Scope

6.1 Conclusion

The construction weight of the frame was 40 kg in weight and 2250 N-m / deg torsional rigidity. Such values were substantially reduced during the design this year to achieve a lightweight 1940 N-m / deg torsional steepness frame. The chassis completion is an important milestone for each team every year. Another part of the car is motivated by a completed chassis because the team members now can see what has been in the design phase for months. Each team is committed to completing its picture early, giving it a chance to test its car for two to three months each time.

The designer has to have his or her design finished before the start of construction to finish the frame by the date that the team sets in place. Before construction began, our concept was ready.

The construction of the steel pipe space frame enables team members to learn basic manufacturing skills through sheet metal work, tube fitting and welding. That also causes the members of tubes which are used in an integral part of the car to be proud of themselves.

A pillar of the FSAE project is the design and development of the chassis. The several specifics to be taken into account in this technique provide young engineers with great practicality and give them a leg when done.

6.2 Future Scope

Overall, one of today's most lucrative verticals, the overall demand for all-terrain vehicles (ATV) is expected at the end of (final year) to produce respectable returns. In addition to providing detailed information on the product and type ranges of this business area, the report has been explicitly formulated concerning the regional landscape of the entire terrain vehicle (ATV) industry.

There is broad potential for more chassis simulation work to solve problems associated with vibration, frequency response and mode form analysis.

The potential research would be useful if the torsional strength of the chassis was to be calculated, including the suspension, the design of endless springs and the differential loading of the chassis spring mounts utilizing the hoist. Some helpful steps are the detection of the camber and the toe reaction at the ground contact point to a lateral force.

This chassis structure should be further analyzed, particularly for structural dynamic behaviors and quality audits for improved refinement in terms of overall performance. The general advice is focused on this, to research the structural analysis and to cover the whole lorry system and then to focus on other areas such as the chassis. The research can help to change the human body as it can be applied to current working conditions.

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