DESIGN AND FABRICATION OF DRIVETRAIN FOR FORMULA STUDENT VEHICLE

M.SRIHARI1, RICKY AMBROSE2, T. SAI TEJA3, T. NISHANTH4, V. SAMUEL JEHOSHAPHAT5
[1]Assistant professor,[2,3,4,5]*Students*
[1,2,3,4,5]*Department of mechanical Engineering, Guru Nanak Institute of Technology, Hyderabad, T.S.*

Abstract -The driveline of an automobile is the group of components that transfer or deliver power to the wheels and ultimately mobilize the vehicle. This excludes the engine or engine that is producing the power. While the drivetrain includes both the engine and the drivetrain. The goal of the powertrain is to couple the motor that generates the force to the drive wheels that use that mechanical force to rotate the axle. This connection involves the physical connection of the two components, which may be on opposite ends of the vehicle and therefore require a long drive shaft. The operating speed of the engine and wheels is also different and must match the correct gear ratio. If the vehicle speed changes, the ideal engine speed must remain approximately constant for efficient operation, and therefore this gear ratio must also be changed either manually, automatically or by an automatic continuous change.

In this project, we want to design and manufacture the key components of the drive train, including the sprocket, intermediate shaft, tripod housing, half-shafts, hubs and overhangs. Various analyzes were carried out during the iteration in order to obtain the best possible design suitable for our vehicle. All load conditions were taken into account and an optimal design was achieved. In the further course of the project, we will explain the various considerations for manufacturing and how they were shortlisted in order to meet our requirements and our budget at the same time. This project also explains the material selection that was made during the design process. The entire component design and the production of the drive train components for our vehicle have been carried out and tested and have proven to be reliable under all possible working conditions.

***Key Words*: Drivetrain, overhanging, sprocket, hubs.**

1.INTRODUCTION

Team Super Ignite is a motorsport team that participates in various Formula Student competitions. The competition consists of static events that include three different presentations on the design, cost and business aspects of the vehicle. There are also dynamic events like the brake pad, acceleration, autocross, endurance and fuel consumption. This partnership was very successful in these competitions because it focused on the events where the team can collect the most points. This can partly contribute to the TSI design philosophy. This philosophy states that we should design the car to win the competition (earn the most points), and to win the competition, we need to design products that are simple and reliable and whose simulations are validated by physical tests. To be successful, we have to consider this philosophy in every design decision. This includes decisions to prioritize the improvement of parts of the car that are most point sensitive. One project that is considered point-sensitive enough to prioritize as a senior project is the powertrain design.

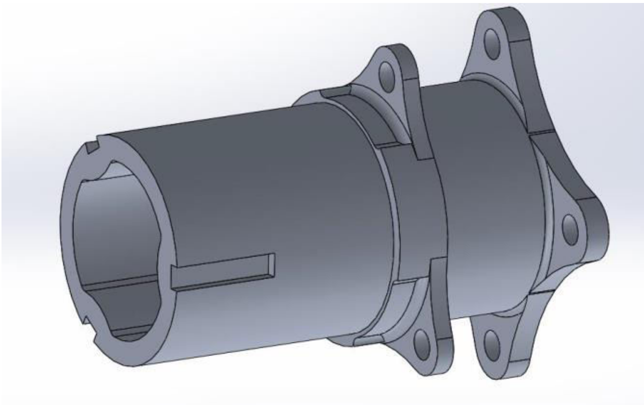
The powertrain is the area of the car that converts the power generated by the engine into power that turns the car's wheels. The results for this project are a propulsion system that helps the team win the competition. A design helps the team win the competition by being a lightweight, reliable design that enhances the design used for the 2020 design. The approach of the past year has been to reduce the weight of the car, the cost and the number of parts of the car. This year the approach is to further improve the spool design compared to last year and to check whether there are ways to transfer the design to the wheels more efficiently and reduce the weight while still being reliable. Reliability is one of the most important factors for this part of the car because the car will not work without a powertrain.This fact only makes this project relevant and meaningful to the team. The benefits to the team after the project are completed include weight savings and improved energy transfer efficiency, which would result in cost savings and better performance in dynamic events, resulting in more points in competitions.

2.DESIGN AND ANALYSIS OF DRIVETRAIN COMPONENTS

Rear hub:

Design Consideration;

1. Wheel offset
2. Track width
3. Tripod dimensions
4. Disc PCD
5. Wheel PCD



Rear Hubs

Material Description:

Aluminium 7075-T6

Yield strength-400Mpa

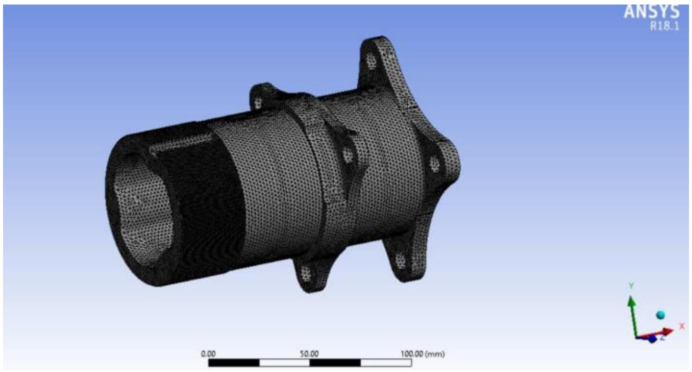
Ultimate tensile Strength-520MPa

Meshing:

International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 04 Issue: 06 | June -2020 ISSN: 2582-3930

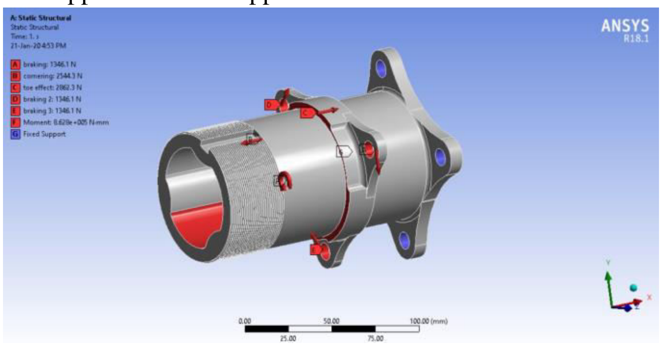
Method: Tetrahedrons
Size: 2mm

Statistics	
Nodes	617934
Elements	413499



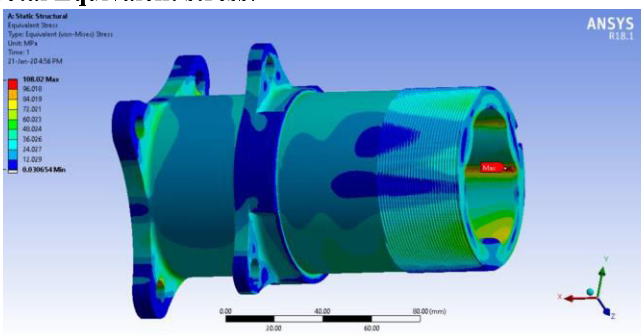
Meshing

Analysis;
During Cornering and braking:
Load application and supports



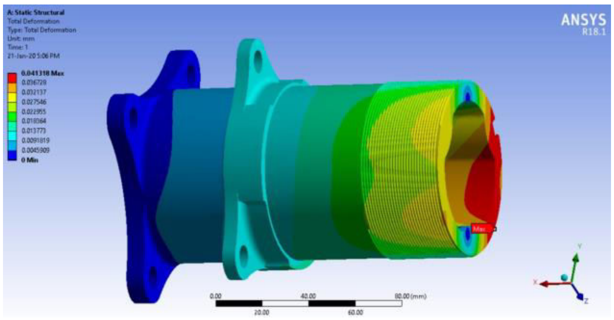
Boundary Constraints

Total Equivalent stress:



Equivalent Stress Plot

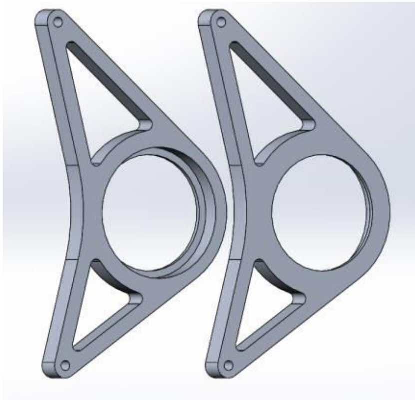
FOS-3.7
Total Deformation:



Total Deformation

Overhanging arms

Design consideration:
Spool dimensions and position

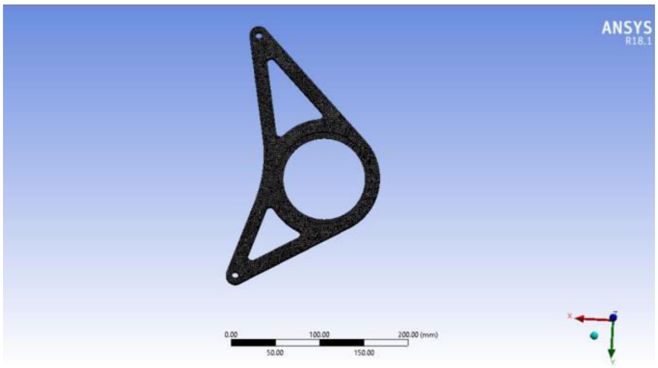


Overhanging Arms

Material description:
Aluminium 6061-T6
Yield strength-276MPa
Ultimate Strength-310Mpa

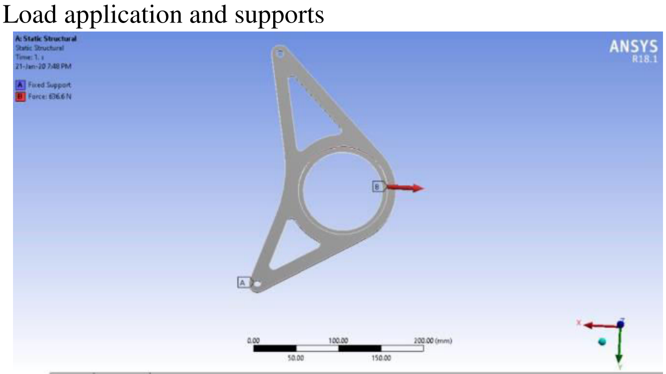
Meshing;
Method-Tetrahedrons
Size-2mm

Statistics	
Nodes	398845
Elements	274045



Meshing

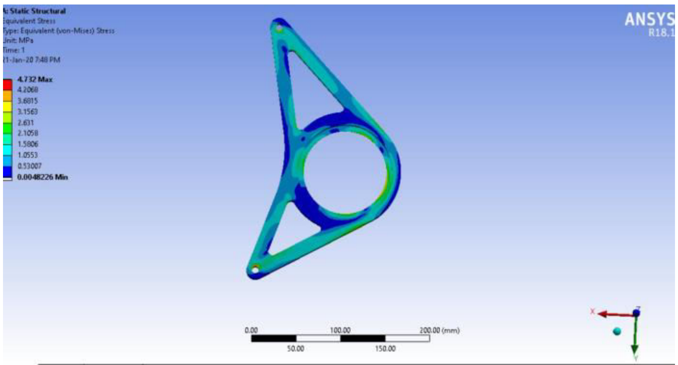
Analysis;
Weight transfer during acceleration:
Load application and supports



Boundary conditions

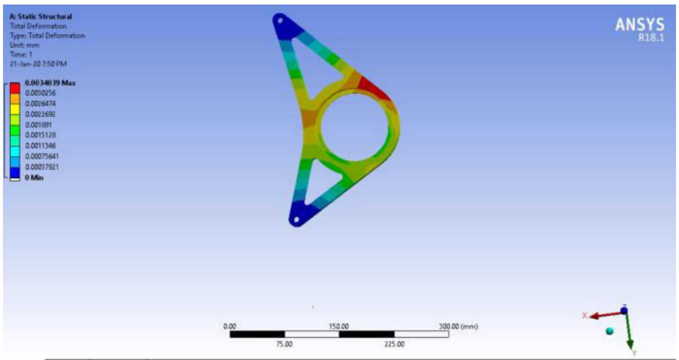
Equivalent stress:

International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 04 Issue: 06 | June -2020 ISSN: 2582-3930



Equivalent Stress Plot

Total Deformation:



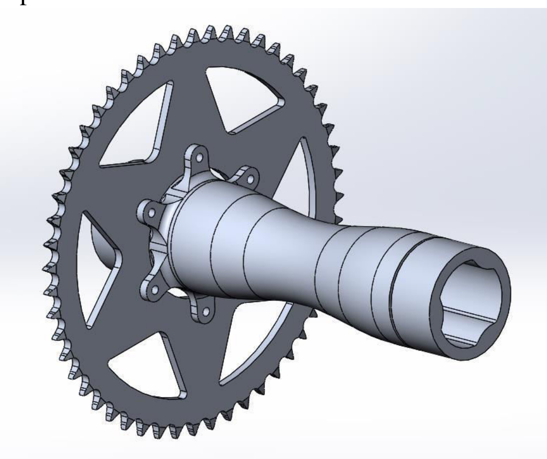
Total Deformation

Spool

Design consideration

Tripod dimensions

Engine placement



Spool Drive Setup

Material description:

Aluminium 6061-T6

Yield strength-276MPa

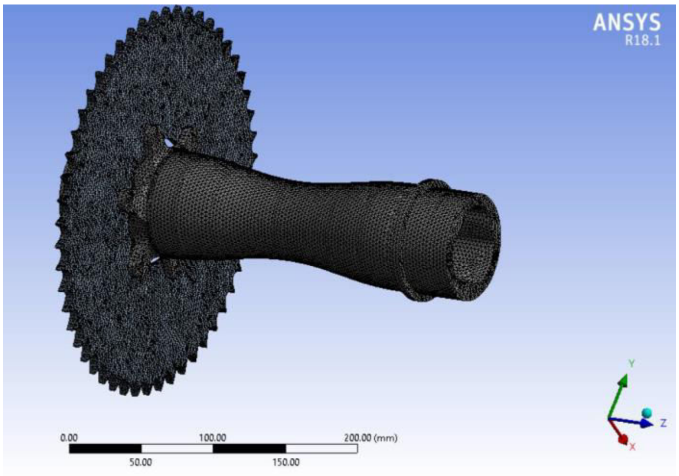
Ultimate Strength-310Mpa

Meshing;

Method-Tetrahedrons

Size-3mm

Statistics	
Nodes	580873
Elements	392806

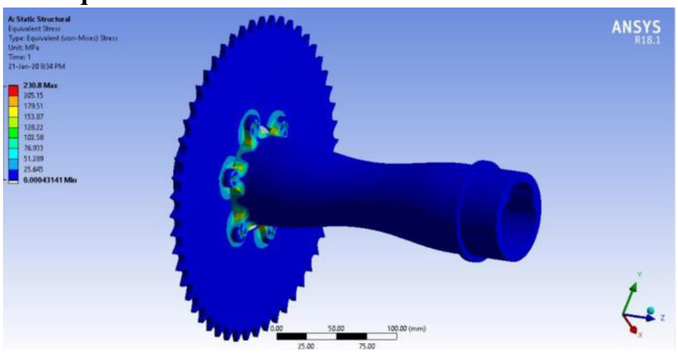


Meshing

Analysis

By applying max engine torque and braking torque

Max equivalent stress:



Equivalent Stress Plot

FOS=1.2

Sprocket

Design considerations

Chain Number

Design speed and torque

Sprocket design

Material description

Aluminium 7075-T6

Yield strength- 503 MPa

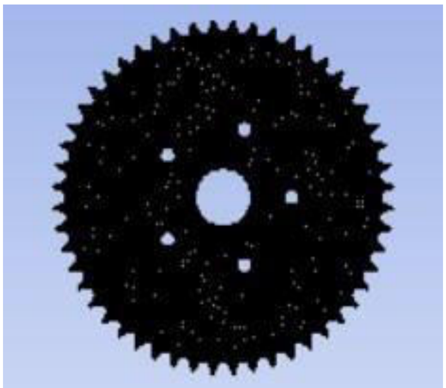
Ultimate Strength-572 MPa

Meshing

Method – Hexdominent

Size – 1.5mm

International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 04 Issue: 06 | June -2020 ISSN: 2582-3930

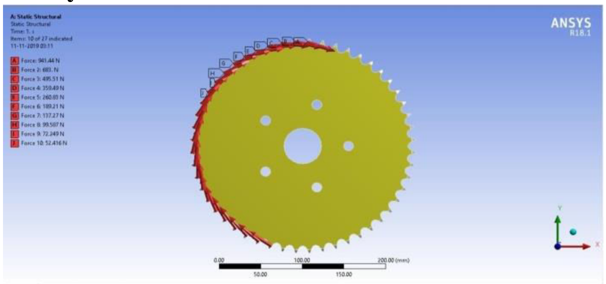


Meshing

Analysis

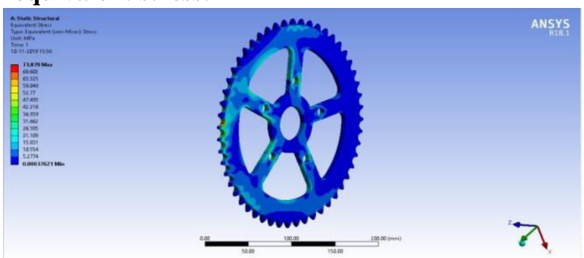
By applying max engine torque

Boundary conditions



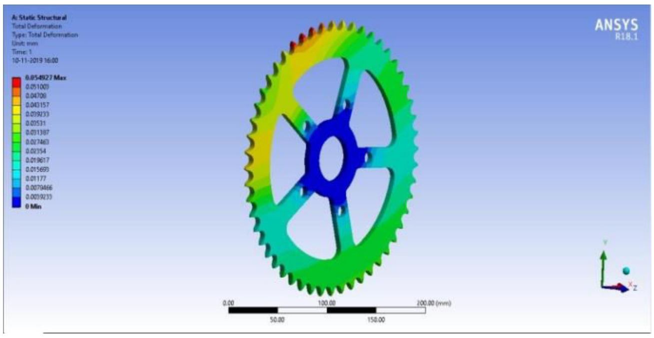
Force on tooth

Max equivalent stress:



von-mises stress

Total deformation:



Total deformation

F.O.S: 3.5

3.FABRICATION

In this section of the report any and all content pertaining to how my subsystem was manufactured will be included. This involves any major design changes, and their justifications, that were made to accommodate any unforeseen variables that occurred during build phase of the project. Also, I will post more information on the CNC independent study and how that knowledge was applicable to my project.

FABRUCATION OF HUBS

Material Selection: -

The strength and weight the hubs rely on the material used for manufacturing the hubs. The material selection is an important consideration.

Aluminum alloy is used for making of the Overhanging Component.

Aluminium 7075-T6

Yield strength-400Mpa

Ultimate tensile Strength-520Mpa

The rear hubs have been manufactured out of 7075 aluminum by considering weight reduction. The rear hubs incorporate a tripod housing coordinated on CMM that is inserted into the hub, eliminating weight issues with the EN-24. Aluminum is the material chosen for rear hubs considering the torque exerted by half shaft into the hubs.

The outer part of hubs is made by turning on lathe and the inner part and mountings are made with the CNC process.

Hubs fabricated with CNC

FABRICATION OF SPROCKET

Material Selection: -

The strength and weight the sprocket relies on the material used for manufacturing the sprocket. The material selection is an important consideration.

Aluminum alloy is used for making of the sprocket.

Properties of Aluminum alloy 7075-T6

Density = 2810 Kg /m^3

Tensile yield strength = 503 MPa

Tensile ultimate strength = 572 MPa.

Young's modulus = 10.3 *10^3 Ksi

Fatigue strength = 159 MPa

The fabrication of sprocket is made with Al-7075-T6 by considering the torque applied and weight of the sprocket. By considering all the parameters and design we fabricated our sprocket in CNC process.

Volume: 04 Issue: 06 | June -2020 ISSN: 2582-3930

Final sprocket

FABRICATION OF OVERHANGING ARMS

Material selection: -

The brackets are made of 6061-T6 aluminum. This is one of the strongest alloys available allowing us to create the lightest bracket possible to handle the loads we expect to see in the brackets. CNC machining facilities are readily available for student use, so we are able to create complicated geometries to within high tolerances. While always thinking about the cost report, we must notice that all aluminum is treated the same. This means that more expensive 6061 should always be used instead of 7075 and 2024 to allow us to create smaller and lighter parts for the less price. The thickness of the brackets is determined by the choice of the bearings.

The support brackets are by far the easiest pieces on the car to manufacture. The design lends itself nicely to single setup machining in a CNC mill. All the milling operations are done from one side of the aluminum plate, so the part only needs to be clamped and located in the machine once. After locating the part in the machine, a CNC operation is run to cut out the weight saving pockets, the bearing pockets and the through holes.

Final overhanging arms and chain tensioners

FABRICATION OF INTERMEDIAT SHAFT

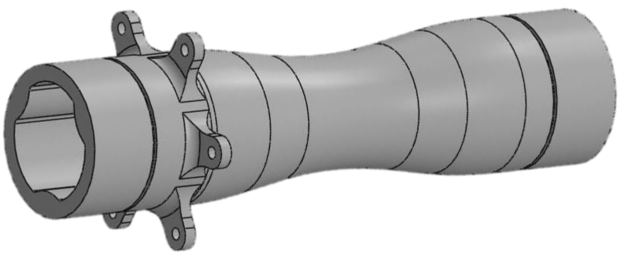
Material selection: -

The shaft is made up of 6061-T6 aluminum. This is one of the strongest alloys available allowing us to create the lightest shaft possible to handle the loads we expect to see in the shafts. CNC machining facilities are readily available for student use, so we are able to create complicated geometries to within high tolerances. While always thinking about the cost report, we must notice that all aluminum is treated the same. This means that more expensive 6061 should always be used instead of 7075 and 2024 to allow us to create smaller and lighter parts for the less price.

After the designing stage, manufacturing has to begin. A combination of lathe and CNC manufacturing was selected so that time and money spent on this stage is reduced. The aluminium was brought to the required external shape with multiple turning operations, and a rough cylindrical shape was used for the sprocket mounting that will be finalised in the CNC machine.

Lathe turning of shaft

After the shape of the shaft was manufactured, the groves for the tripod were embossed by the milling machine. Manufacturing of the shaft/spool was completed within a time period of 5 days.



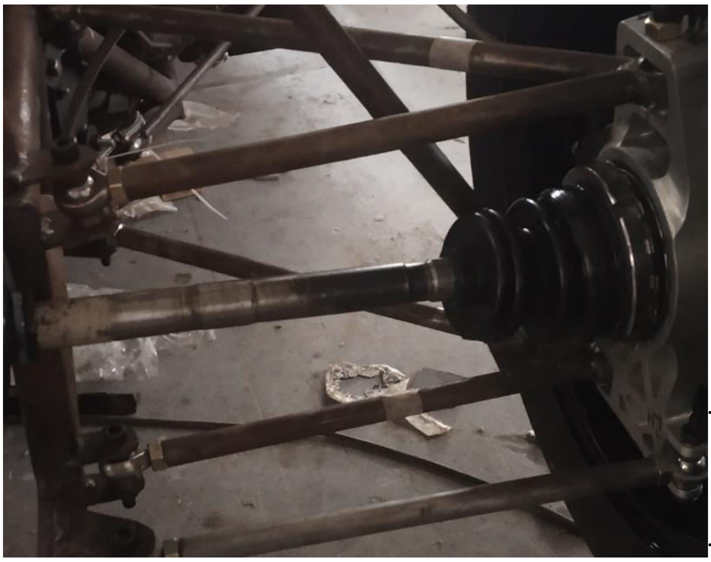
Final shaft with all grooves and mounts

Final shaft with full assembly

FABRICATION OF HALF SHAFTS

We used a standard OEM RZEPPA joints for our vehicle. As we mentioned previously, we have to modify our shafts in such a way that they have tripod needle bearings on both sides.

So, we cut the two shafts and welded them with tug welding and did finishing over lathe turning.



Half shafts

4.RESULT

The drivetrain components that are designed and manufactured have proven to be successful in providing optimum performance from the vehicle. The simple design and light weight components used helped the vehicle perform with minimal repair work performed. While we understand analytical and simulation-based analysis isn’t enough in determining the reliability of the components designed, we have performed severe testing on the components in various road conditions ranging from smooth asphalt to off-roading, in different weather conditions ranging from heat to rainy conditions. There were no squeaks and the components were free moving without any resistance from the bearings. The designed components were simulated to be above the factor of safety.

5. CONCLUSIONS

In this project, we designed and manufactured the key components of the drive train, including the sprocket, intermediate shaft, tripod housing, half-shafts, hubs and overhangs. Various analyzes were carried out during the iteration in order to obtain the best possible design suitable for our vehicle. All load conditions were taken into account and an optimal design was achieved. This time we reduced the total number of components as minimum as possible. We have a shaft, ball bearings, spool; they are the only rotating parts this year also, we decided to use a tripod set up on two sides of the intermediate shaft so that we won't get any backlash in the assembly. In order to make components lighter and compact, we have designed the intermediate shaft and wheel hubs with tripod housings. This reduced the mass of Rotating components considerably and also helpful in ease of assembly and disassembly of the drivetrain setup. The benefits to the team after the project was completed included weight savings and improved energy transfer efficiency, which resulted in cost savings and better performance in dynamic events.

5.ACKNOWLEDGEMENT

The major project entitled “DESIGN AND FABRICATION OF DRIVETRAIN FOR FORMULA STUDENTVEHCLE” Is the sum of total efforts of our batch We wish to convey our sincere thanks to our internal guide **Mr. Srihari**, Assistant professor in Mechanical Engineering, for his profession encouragement in starting this project and academic guidance during the course this project.

We wish to convey our sincere thanks to**Dr. B. Vijaya Kumar**, Head of the Department, Mechanical Engineering, for his professional advice, encouragement in starting this project and academic guidance during thisproject

6.REFERENCES

. Suryawanshi B. K. and Damle P. G., "Review of Design of Hybrid Aluminum/Composite Drive Shaft for Automobile," International Journal of Innovative Technology and Exploring Engineering, vol. 2, no. 4, 2013.

. Strong A. B., Fundamentals of Composites Manufacturing Materials, Methods and Applications, Dearborn: Society of Manufacturing Engineers, 2008.

3. Parsons, J., "The Design of Formula SAE Half Shafts for Optimum Vehicle Acceleration," SAE Technical Paper 2013-01-1772, 2013, doi:10.4271/2013-01-1772.

4. Khoshravan M. and A P., "Design of a Composite Drive Shaft and its Coupling for Automotive Application," Journal of Applied Research and Technology, vol. 10, no. 6, pp. 826-834, 2012.

5. Kliger, H., Yates, D., and Davis, G., "Economic and Manufacturing Considerations for Composite Driveshafts," SAE Technical Paper 800005, 1980, doi:10.4271/800005.
6. Lee D. G., Kim H. S., Kim J. W. and Kim J. K., "Design and Manufacture of an automotive hybrid aluminum/composite drive shaft," Composite Structures, vol. 63, pp. 87-99, 2004.