Design and Fabrication of Wheel Assembly

Submitted in partial fulfillment of the requirements
Of the degree of

BACHELOR OF TECHNOLOGY
IN
MECHANICAL ENGINEERING

By

AAKASH JAWLA(1614101001)
RAHUL ANAND(1614101129)
AMAN GUPTA(1614105003)
JIWAN JYOTI JENA(1614105007)

Supervisor:

Prof. Sambasivam Anivel

SCHOOL OF MCHANICAL ENGINEERING
GALGOTIAS UNIVERSITY
GREATER NOIDA
2019-20

CERTIFICATE

This is to certify that the Research work titled **Design and Fabrication of Wheel Assembly** that is being submitted by **Aakash Jawla, Rahul Anand, Aman Gupta and Jiwan Jyoti Jena** is in partial fulfillment of the requirements for the award of **Bachelor of Technology**, is a record of Bonafede work done under my guidance. The contents of this research work, in full or in parts, have neither been taken from any other source nor have been submitted to any other Institute or University for award of any degree or diploma.

Supervisor

Internal Examiner **External Examiner**

Approval Sheet

This thesis/dissertation/project report entitled **Design and Fabrication of Wheel Assembly** by **Aakash Jawla, Rahul Anand, Aman Gupta and Jiwan Jyoti Jena** is approved for the degree of bachelor of technology in mechanical engineering.

Examiners

_____

_____

_____

Supervisor

_____

Dean

_____

Date: _____

Place: _____

Declaration

I declare that this written submission represents my ideas in my own words and where others' ideas or words have been included, I have adequately cited and referenced the original sources. I also declare that I have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in my submission. I understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

Name of Student	**Enrollment No.**	**Signature**
Aakash Jawla	1614101001	
Rahul Anand	1614101129	
Aman Gupta	1614105003	
Jiwan Jyoti Jena	1614105007	

Date: _____

ACKNOWLEDGEMENT

We the students, School of Mechanical Engineering, Galgotias University, would like to thank everyone involved in our project. The project was made possible by the collective and significant contributions made by the honorable CEO of the university, Mr. Dhruv Galgotia, the students, staff and faculty of Galgotias University.

We would like to individually thank the following people for their support:

Mr. Dhruv Galgotia (CEO, Galgotias University) for their huge financial help to the team.

Mr. S.N. Satyapatty (Dean - School of Mechanical Engineering) for his continuous support to the team.

Mr. Sambasivam Anivel. (Faculty Advisor) for his continuous advice on technical parts.

Mr. Pradeep (Superintendent of workshop) for his guidance to the team with manufacturing and fabrication process.

All the Galgotias University students, faculty and staff who have helped us.

Thank You!

_____

(Aakash Jawla)

_____

(Rahul Anand)

_____

(Aman Gupta)

_____

(Jiwan Jyoti Jena)

(Department of Mechanical engineering)

ABSTRACT

This report highlights the Designing and Fabrication of the most important component of a Formula Style Vehicle which constitutes Wheel Assembly.

This team of students focuses on designing the Wheel Assembly which can withstand huge forces that works their way on the vehicle during sudden acceleration, while turning the car on high speed during cornering and great breaking forces for stopping the vehicle. The Wheel Assembly must withstand these forces and even should overcome them in different temperature conditions.

The most basic Wheel Assembly includes parts such as Hubs, Rotor, Brake Disc, A-arms, Ball Bearings, Studs and Retaining Rings.

The overall outcomes of project and researches like these include solution of various design problem and difficulties and also presenting solutions to these problems.

TABLE OF CONTENT

List of Figures

List of Tables

1. EXECUTIVE SUMMARY

The goal of this design project is to design, analyze and fabricate a wheel assembly for the Galgotias University FSAE team. Through extensive research and design changes, the wheel assembly has been optimized to its furthest potential with the given scope of time and other teams design. Critical features that are essential for the performance of wheel assembly are enough rigidity, low weight and its optimization to contain all the components of the wheel assembly within itself.

One of the most important factors that drives the initial stage of design process of any wheel assembly was the usage of 13-inch tyres for the car. The 13-inch tyres directly influence the size of hubs and even the size of brake disc that is to be designed for the vehicle. Once all the points regarding the size of the wheel were finalized by the team, the students move towards the portion of rule book ensures that weather the selected things lie in the parameters stated by the event organizers. Now the designing will be commenced based on these parameters in a manner that takes in these rules in addition to the metric values determined before the initial designing phase and the overall manufacturability of the wheel assembly.

During the manufacturing stage of the wheel assembly it was essential that the concept designed through our CAD(SOLIDWORKS) would be the same without any assumptions on the spot. To perform this, an extensive process was performed where each component of the wheel assembly was extruded and fabricated to the exact specification of the model. This was later verified through dimensions and the components 3-Dimensional placement in Solidworks.

Finally, after the completion of the chassis all the design metrics and required testing by the FSAE guidelines were performed to ensure it was fit for the competition. The wheel assembly design and manufacturing were a complete concept success. The report below includes the design process and the fabrication of the entire design. At the end of the report the team has included the sections of recommendations/suggestions for the future wheel assembly design groups/teams.

2. INTRODUCTION

2.1 PROJECT BACKGROUND

Wheel Assembly

An automobile is said to function appropriately only when all its systems are working as they are required to work. The engine produces power and gives it to the drive train through a clutch. The portion of the drive which transmits this power from the drive train to the wheel and which connects the main frame of the body with the wheels through the suspension arms is known as the Wheel Assembly. It is a part of the final drive. Thus, it serves the function of transmitting the power from the drive shaft to the wheels. Besides as the suspension arms are also connected to it, the wheel assembly also transfers the bump force from the ground to the suspension arms.

2.2 RESEARCH POURPOSE AND MEANING

The sole purpose of research is to develop the understanding of how a wheel assembly which is accommodated inside a vehicle works for that particular type of vehicle. It helps us to develop our thinking in particular way which is progressive and integrating to develop new system of device for different kinds of vehicle, through the knowledge and understanding gained which serves the meaning.

2.3 OBJECTIVE OF STUDY

The objective of study is to design and fabricate a Wheel Assembly for the Formula Student team of Galgotias University. The team is eventually going to participate in the event which competes on the designing and fabrication processes that are involved in the fabrication of the vehicle for the competition. The study helps us to integrate our knowledge by giving the conceptual clarity on the most basic to the advanced foam of designing the particular mechanical part of the vehicle through the data that is already present and well researched by the scholars in the past and also gives us the way form where to start and where to go with the new data.

3. PROBLEM STATEMENT

The problem that most of the formula student faces while designing wheel assembly for the vehicle is how to dissipate the amount of heat generated while braking the vehicle. Braking in the vehicle is the most crucial aspect and the students have to come up with different design solutions and have to select the most appropriate one to commence with the fabrication. The major problem encountered by the formula student while designing a wheel assembly is making the design as simple as possible, as the level of complexity increases in the design the level of failure also increases significantly.

Getting confused and complexing the design is very common in formula student and that too in wheel assembly. Another problem that arises in this part that the wheel assembly related with the misconception. Most students think that wheel assembly must not be light weight and the reason behind this is that light weight might not be very stable at the time of instant cornering and hard turns, but the real reason depends upon mostly the amount of power that is supplied by the engine.

Talking about the problem faced while designing the wheel assembly, if the weight of overall assembly is not kept in watch then the weight might drastically increase so it is incredibly important to keep the weight under proposed limits of the assembly.

4. METHODOLOGY

We have started with finalizing the type of brake calipers that we want to use for the car and eventually after team discussion it was decided that KBX is the one we are selection. Reasons for selecting KBX is really simple, these calipers are having two pistons one for each brake pad and despite having two piston these are small in size and because of small size they are very light in weight which helps to keep the overall weight of car in watch. The mounting points of these calipers also matches with the designed mounting points of hubs accurately. After selecting the type of caliper process becomes easy as now, we have to decide the diameter of our disc and in this case it is. Various holes are drilled in the disc the reason behind this is that these holes do not make any impact/changes on the stress and strain of the disc also it helps to reduce the weight of the disc to a drastic to a drastic level. Holes in the disc are also helpful because they help in the process of heat dissipation as when the disc of breaks heat it makes an impact on the braking efficiency so it is also important that disc should remain cool in this process. The above fact of heat dissipation leads us to the goal of this research and helps us understand about heating of the disc. The Analysis in ANSYS is carried by following method.

A. First of all, the profiles are created in Creo parametric 2.0.

B. After starting ANSYS 15.0, the mode of analysis is taken as steady state thermal.

C. The material properties are defined for the profile models.

D. The model is then subjected to meshing as Fine.

E. After meshing, the boundary conditions are applied to the brake disc.

F. The parameters whose solution is required are selected from the solution bar.

5. LITERATURE REVIEW

The literature reviews are considered because of keywords like FSAE, Wheel Assembly, Optimization, Solidworks, Ansys, Workbench, AISI-4130, Forces, Material, Thermal Analysis, etc. required for designing of Wheel Assembly and Disk Brakes for FSAE vehicle. Studies on Powertrain system is also taken into consideration.

These papers are dedicated for the designing of wheel assembly, disk brakes and study of powertrain systems.

5.1 International Journal of Current Engineering and Technology Designing and Optimization of Wheel Assembly of a Formula Student Car

ISSN 2277 – 4106,
Special Issue-4,
15 March 2016

Joijode Vrushabh Umesh†* and Yadav Abhishek†

Abstract

In a Formula Student Car, those parts which connect the main frame of the body with the wheels through suspension arms are known as the Wheel Assembly. They are part of Final drive also. While designing any vehicle, the designing of the wheel assembly is critical. this is due to the fact that many forces act on the wheel assembly during accelerating, braking, cornering and tilting. Furthermore, the Wheel Assembly's failure posses hazardous risk to human life. Therefore, it is very important to design every components of wheel considering all the factors which can cause to the failure by developing a safe Design. Also, the components must be designed in a way to minimize weight at the same time and care must be taken that they do not cross a certain limit of stress value.

In this Paper the design of the Wheel Assembly has been presented along with optimization of the same components for R12 Rims with wet Tires (165×60). The weight of the Vehicle is considered to be 300 kg along with the driver. The paper illustrates the forces acting on the components, the failure criteria and the optimization of the components. Optimization has been carried out by doing analysis of the components in Hyper mesh. The paper deals with finding out the dimensions of the individual components and also detecting the probable regions of stress concentration. The Wheel Assembly designed in the paper is of Team Veloce, VIT, Pune. The design procedure follows all the rules laid down by FSAE Rule Book for Formula Type Cars

Conclusion

- For a component Undergoing fatigue loading, the design criteria must always be Fatigue or Endurance Strength.
- For carrying out optimization, material should be removed from the low stress concentration areas.
- In order to minimize stress concentration areas, sharp corners and edges should be avoided.
- If the component is subjected to fatigue failure like knuckle, then analysis of the components must be carried out in order to obtain actual stresses inducted in the component.
- For accurate result of anaylis, mesh quality must be high(HYPER MESH WORKS) and failing elements must be less than 3%.
- As a spindle serves as a component on which the assembly is press fitted, its factor of safety is taken high.

5.2 International Journal of Current Engineering and Technology

ISSN 2277 – 4106

Vol.8, No.2,

March/April 2018

Design and ANSYS analysis of Components of Wheel Assembly of SAE Car

Sameer Santosh Mahadik

Abstract

This paper aims to produce the light weight assembly in order to increase the vehicle performance. Different kinds forces act applied directly in dynamic condition such as braking, acceleration and bump conditions. So, this paper deals with calculation of various loads and their simulation. The FEA result proved the upright assembly to be able to work safely in real track condition as per the requirement.

Conclusion

The purpose of this project is was to design and fabricate the uprights and assemblies for the car and to provide an in-depth knowledge in the process taken to conclude final design. With the overall design being carefully considered beforehand, the manufacturing process being controlled closely, and that many design features have been proven effective within the performance requirement of the vehicle. The FEA proved that the upright assembly was more than sufficient to work safely in real conditions as requirements.

5.3 International Journal of Technical Innovation in Modern Engineering & Science (IJTIMES)

ISSN: 2455-2585

Volume 4, Issue 6,

June-2018

Thermal Analysis of Disc brake Using ANSYS

Avinash Singh Thakur, Asst. Prof. P.S. Dhakad

Abstract

The disc brake is a mechanism that used for reducing speed or discontinuing the cycle of the vehicle. many times using the brake for vehicle starts to heat producing during braking process, such that disc brake undergoes breakage due to high Temperature. Disc brake design is done through Solidwork and analysis is completed by using ANSYS workbench. The main purpose of this project is to study the Thermal analysis of the Materials for the Cast Iron, and Stainless steel. A comparison between the two materials for the Thermal values and material properties obtained from the Thermal analysis low thermal gradient material is preferred. Hence best appropriate design, low thermal gradient material cast iron is chosen for the Disc Brakes for better result.

Conclusion

The above study can provide a useful design and help to improve the brake performance of disc brake system. From the above result, from our study of various design patterns for different materials we have observed that the maximum temperature rise of cast iron disc is much small with compared to stainless steel and therefore on the basic of thermal investigation, cast iron is the best desirable substantial for manufacturing disc brake. Though, cast iron disc brake some drawback of getting corroded when it comes in contact with wetness and hence it cannot be used in two wheelers and thus we prefer stainless steel.

The present study can provide a useful de-sign tool and improve the brake performance of Disc brake system. The values achieved from the investigation are less than their permissible values. Hence the brake Disc analysis is safe depend on the strength and rigidity criteria. From the above study work the following conclusions are made:

- Profiles made up of Cast iron also have better heat dissipation rate but the tendency of the cast iron is that it gets corroded when comes in contact with water or moisture. Hence it is not suitable for production purpose.
- Maximum temperature found on cast iron disc brake was 56.93 0C and temperature drop was 33.67 0C.
- Maximum temperature found on stainless steel disc brake was 69.81 0C and temperature drop was 25.64 0C.
- Maximum temperature drop was found on stainless steel disc so it was is suitable for design.

5.4 International Research Journal of Engineering and Technology

ISSN: 2395-0056,

Volume: 06, Issue: 03,

Mar 2019

Analysis and Design of a Formula SAE Powertrain

Prasantha Laxman Pujari

Abstract

This project was to design and develop the powertrain system for a SAE formula car and the car. He made a comparison between CBR250R and CBR600RR for a formula vehicle. He chose CBR250R over CBR600RR because of its lighter weight, availability, higher fuel efficiency and also, it remains in power band for longer time.

Conclusion

He performed simulation for the Honda CBR250R and the Honda CBR600RR engines on different track layouts with varying weights of the car. The results indicated that at lower weights, both engines performed similarly, while at higher weights; the CBR250RR lost its advantage. However, the difference in lap-times over a simulated circuit was less than 1 second under ideal conditions. It was expected that when the driver's accuracy and real conditions are taken into account, the performance difference would be much lesser.

6. PRELIMINARY DESIGN DECISIONS

Before actual designing of wheel assembly some critical decision was made that will decide the direction of the path for the designing of wheel assembly. The reason behind this section was to address the choices made in advance and explain why the particular decision is made and how the whole designing procedure will be carried out.

6.1 3Brake Disc vs 4Brake Disc

While designing for the FSAE wheel Assembly there are two very different approaches that could be followed by the designing team.

FSAE can posses two different approaches one in which the ream uses only 3disc brakes for manipulating the speed of car and some on the other hand have 4disc brakes. In a 3disc brake system two discs are fitted in the front wheel one for each wheel and the third and most crucial brake was set either on the drive train i.e., driven sprocket or on the axle. The other type consists of one brake disc for each wheel. These both approaches have different type of advantages. 3disc brake approach can be possibly little light in weight and 4-disc brake approach can provide more stability. As the track specified for the race have a greater number of turns so the designing group collectively decided to go with the 4disc brake approach because it will provide amazing feedback at the time of cornering as well as great amount of confidence to the driver and the car overall is stable.

7. VEHICLE WHEEL BASE

The regulation of FSAE require that the car have a minimum track length of 1250mm from centers of ground contact while the steering wheel is straight as per rule specified. Important characteristics to consider for the car wheel base include weight, turning radius and ease of transportation and these factors directly influence the designing of the wheel assembly.

If we study the hairpin turns used in the endurance trail for the vehicle needs to take, the turn radius is an important factor that we need to keep in mind while designing the wheel assembly. The assumption provided by the rules is that the track has a minimum width of 11.5 feet. During a hairpin turn the radius the radius of race track or the path that allows minimum speed through a turn is the outside radius of the turn. Knowing the radius, we can look at the trend of what wheel angle in our wheel assembly is needed to make it around a 14.75 feet radius turn. The smaller the wheel base the smaller the wheel angle in the wheel assembly is needed to achieve the hair pin turn.

Less important but still a point to consider is ease of transportation. Both the track and wheel base with wheel assembly will determine how the team can get the vehicle to driving courses and competition. Having the smallest wheel base will allow for optimal transportation. Thus, to help reduce the weight of the wheel assembly, avoid wheel interference with the suspension during sharp turns, and to allow easier vehicle transportation to and from driving sites.

8. MATERIAL SELECTION

The FSAE car is generally designed and constructed out of a material that is manufacturable through machining, welding and thus can withstand forces that will not fail while under different kinds of loads. The material that has to be selected for the fabrication of wheel assembly generally includes Aluminum metal because removing material from the surface of it is very easy and appropriate angles can be easily provided. One of another metal required for the manufacturing of part like brake disc is Stainless steel. There are different pre manufactured ball bearings that are required in the hubs.

9. OUTLOOK

Wheel assembly consists of different kind of components which include hubs, rotor and ball bearing. To understand the working of the wheel assembly, we must understand that how is wheel assembly connected and adjoined. The photographs of each component of the wheel assembly is shown below.

First of all, the most important component of wheel assembly is hub, which is also called the chassis of wheel assembly. It is designed in such a manner that it has a big hole in the center. After this, the rotor is designed, the rotor is designed so that it could fit inside the hub. Before adjusting the rotor inside the hub, ball bearing is preset inside them(hub) or pre fixed inside the hubs by the helps of a press fit. The brake disc was mounted on the rotor which is later press fitted inside hubs and the assembly is completed. This whole component assembly is now attached with the chassis of car using A-arms. Studs that are pre-fit inside the rotor of wheel assembly use to stick out on which the wheels are tightened and car comes on the ground by the helps of this wheel assembly which means that wheel assembly acts as the legs of the vehicle.

10. SOLUTION

As one of the major problems stated in the problem statement is that how weight of the assembly and eventually weight of the car might increase drastically if it is not kept in a continuous watch. To counter this problem, we as student designer have to decide that how much weight of the car is to be pre fixed before actually starting to design the vehicle. The reason behind this particular decision is we as designer get the actual idea of how much we can spend (in terms of weight) while designing. This is similar to setting the pre-budget plan for the car which will indicate us that how much we could spend on it.

Another major problem that arises was regarding the heat produced by the brakes at the time of braking. We as students conducted some research by keeping stainless steel as the base for making the brake disc for the wheel assembly. All the calculations for the same are provided in the research paper.

The goal was not restricted to just slow down the car at the time of braking or to stop it, the student team also focused on reducing the overall weight of the assembly by keeping the same set of the tyres. The advantage that the team got was in the form of knowledge about the track conditions and weather conditions because the venue of race was known (as announced by the event manager).

This gave team, liberty to use, same set of tyres for the competition and one part of the design as a solution is pre achieved as the weight of the tyres with the rims is pre known giving the team of designers and fabricators a small window of manipulating the design and the weight as pre set was kept in watch and under control.

11. HUBS

- Hub is connected to the chassis of the car via A-arms.
- Hub is the chassis of all the components of wheel assembly i.e. it holds every component in it.
- Bearing sits inside the hub on which Rotor is Press-Fitted.
- Front hubs of car are responsible for proper steering.

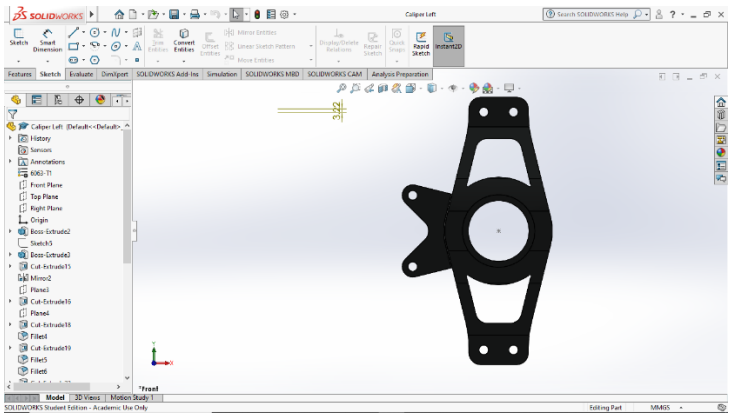

Fig:1 Design of HUB

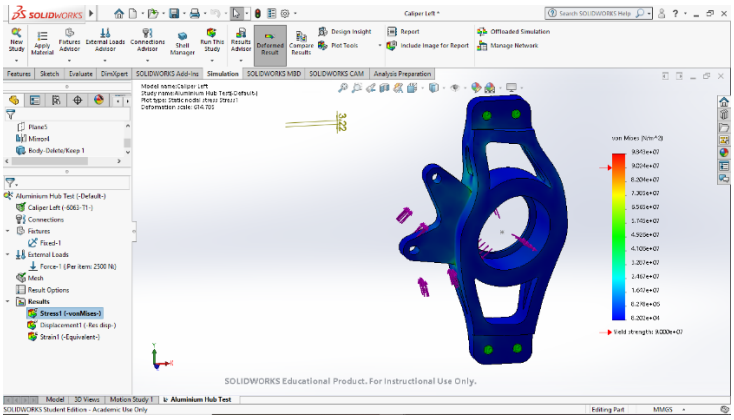

Fig:2 Stress

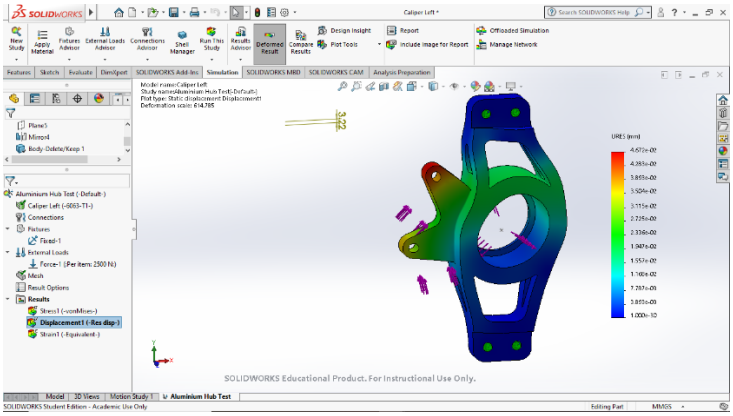

Fig:3 Displacement

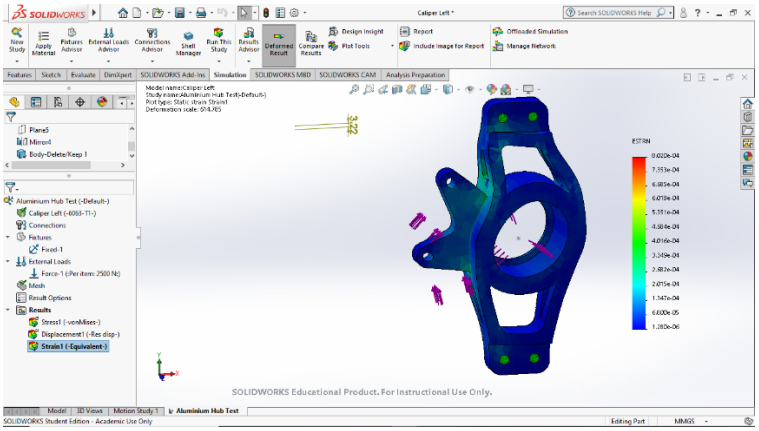

Fig:4 Shear Stress

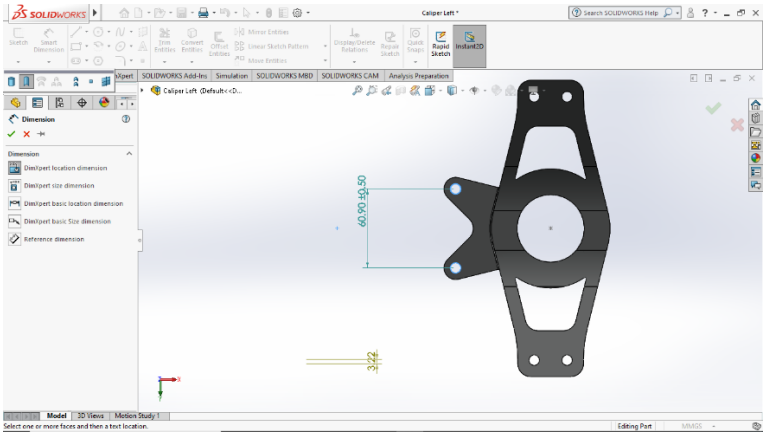

Fig:5 Dimension

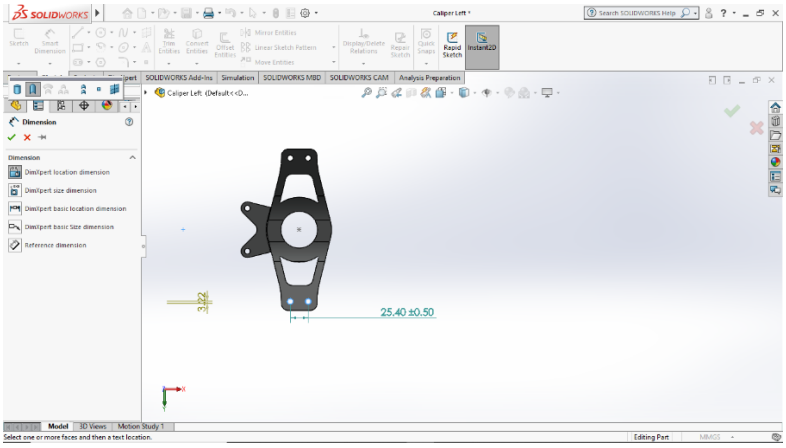

Fig:6 Dimension

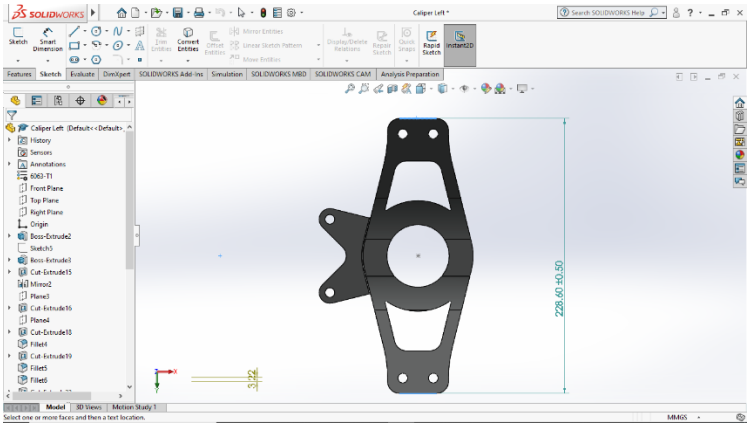

Fig:7 Dimension

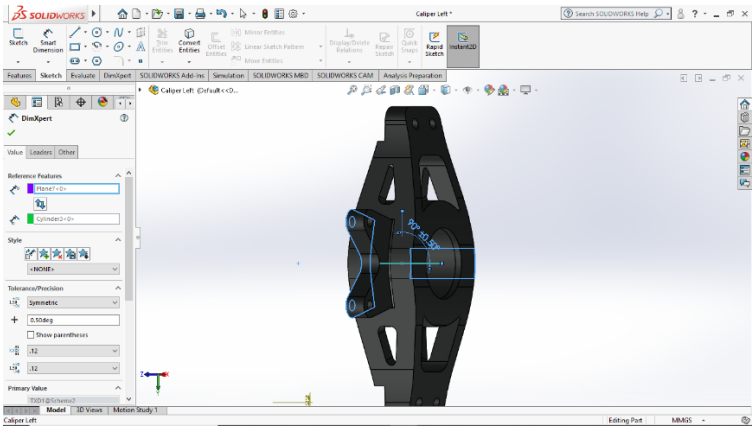

Fig:8 Dimension

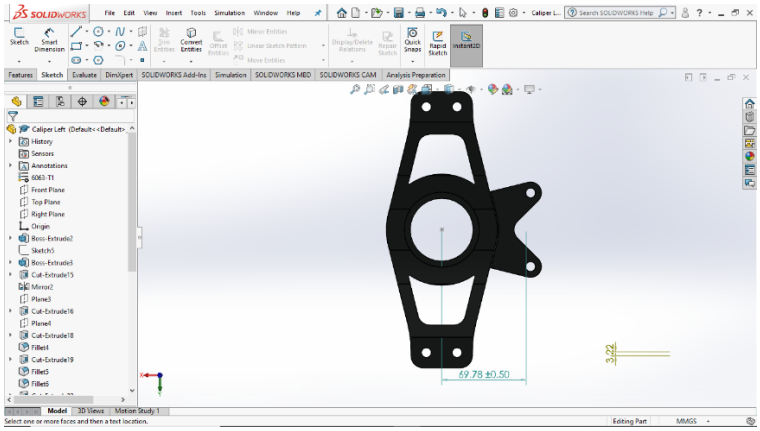

Fig:9 Dimensions

12. ROTOR

- Rotor is the most important component in the wheel assembly as it holds every other component in its place.
- Rotor is fitted inside the hub using bearings inside the hub.
- Rotor is fitted four studs which are responsible for the holding of the rim.
- Rotor is fitted inside the hub using a press fit machine.

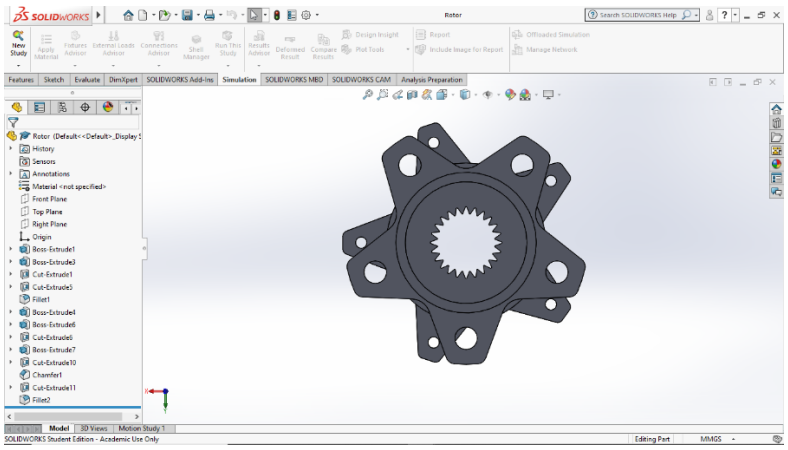

Fig:10 Rotor Front View

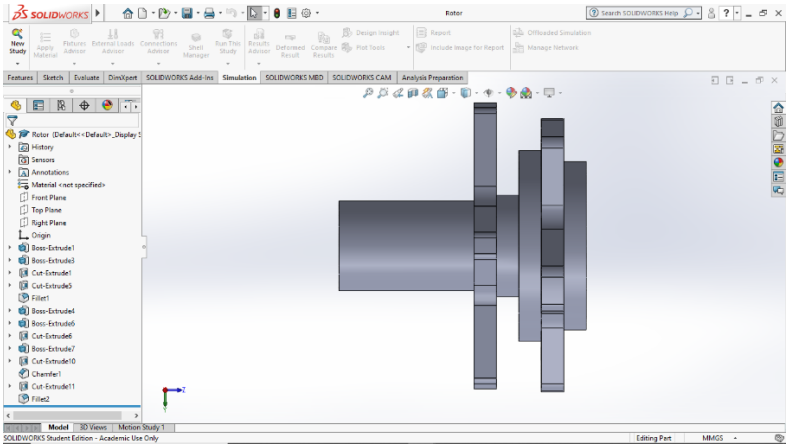

Fig:11 Side View

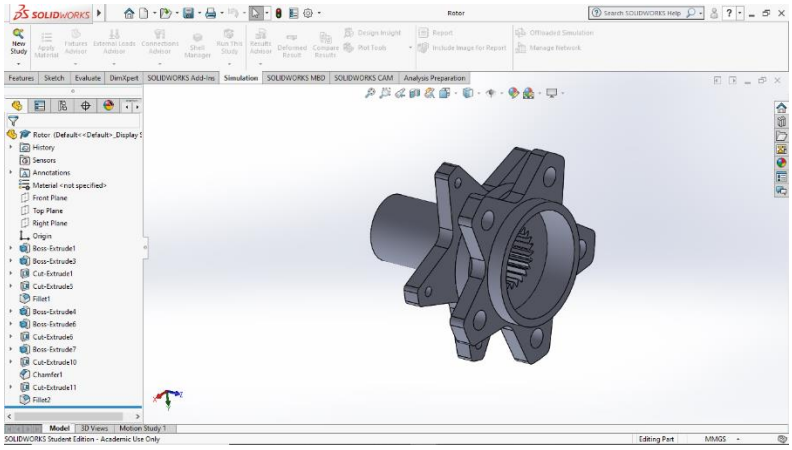

Fig:12 Top View

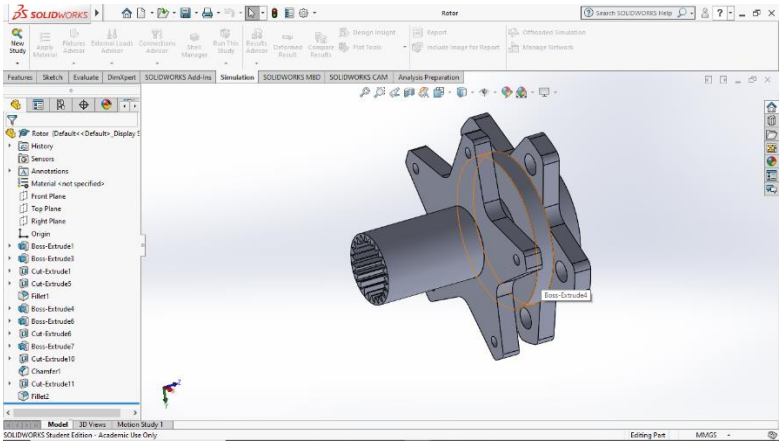

Fig:13 Back View

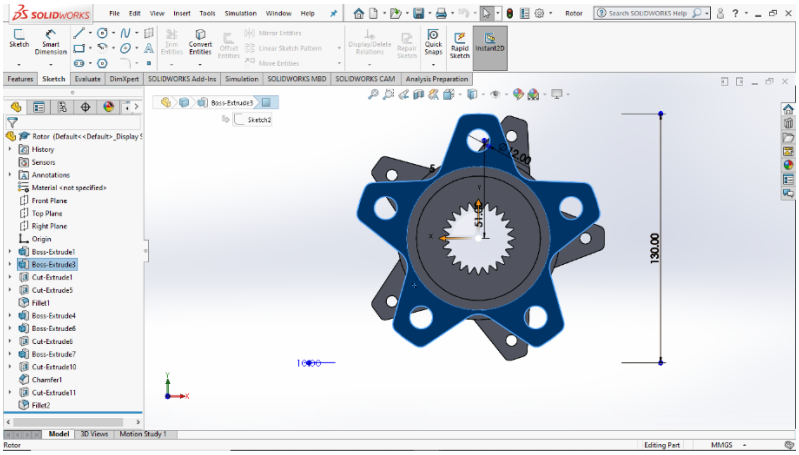

Fig:14 Dimensions

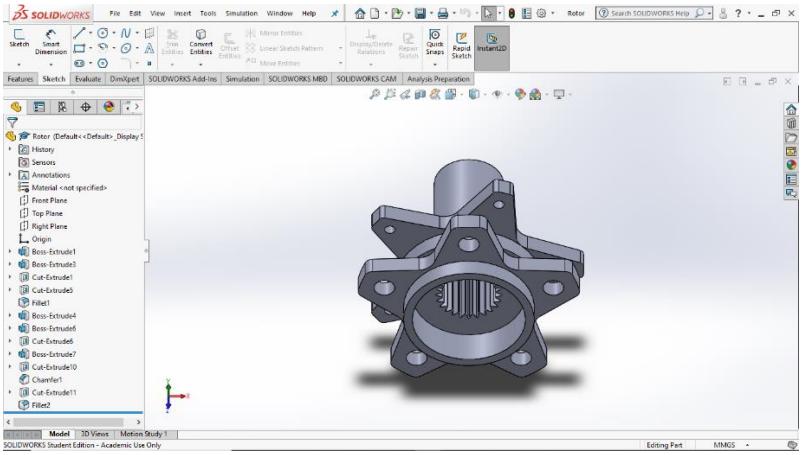

Fig:15 Top View

13.DISC

- Disk or Brake Disk is the most crucial component for reducing the speed of vehicle or for bringing it to zero.
- Brake disk is mounted on the rotor as it rotates at the same rpm as of tyres.
- Disk generally consists of various holes in it so as to disperse the heat generated at the braking.
- Brake by fluid is the most common way of braking and brake by wire is also used.

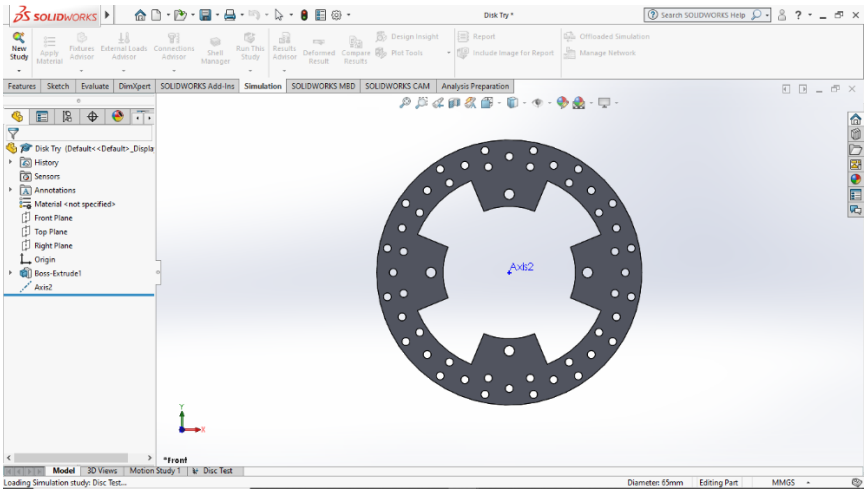

Fig:16 Disc Front View

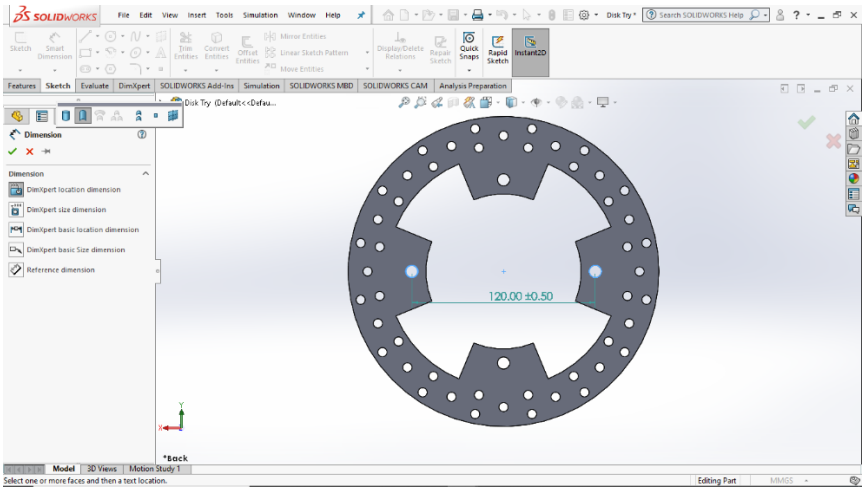

Fig:17 Dimension

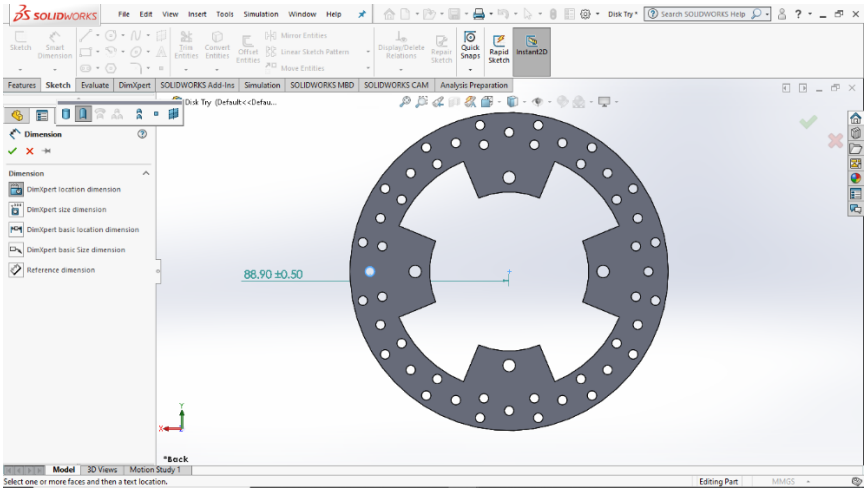

Fig:18 Dimension

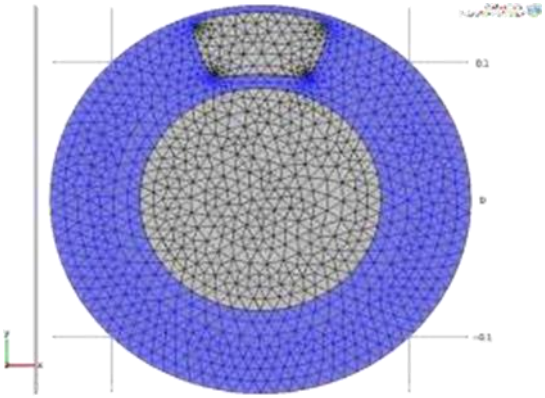

Fig:19 Meshing Disc

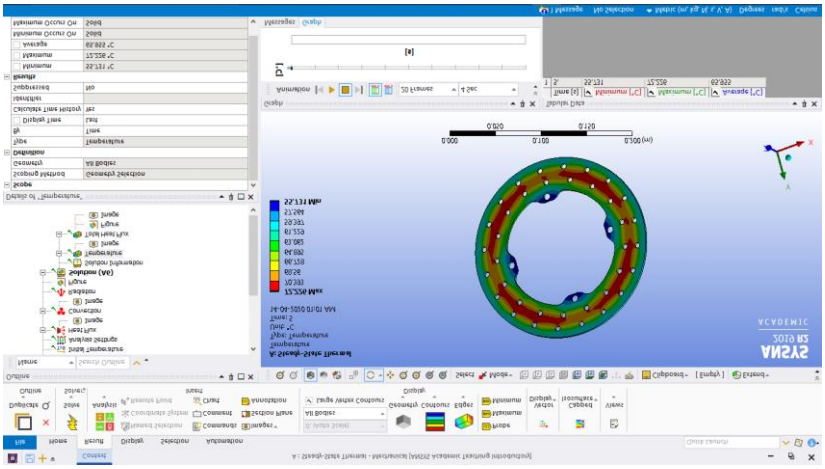

Fig:20 Thermal Analysis

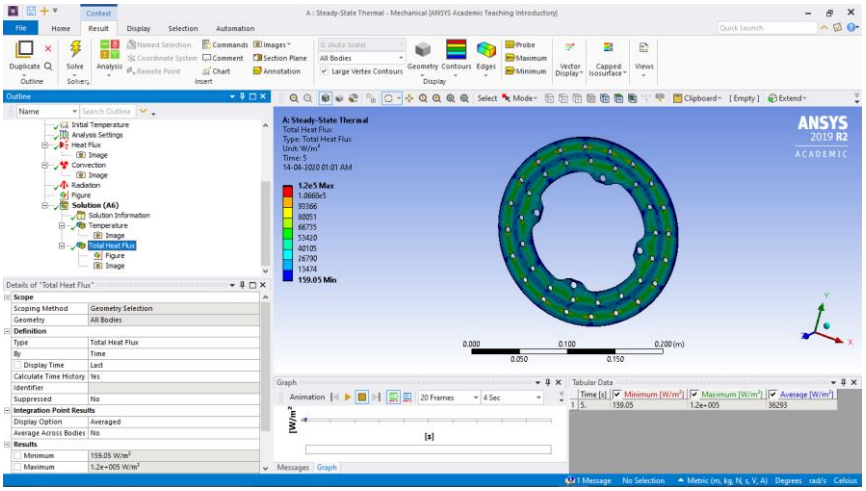

Fig:21 Thermal Analysis

14. CALCULATION'S

The calculations are done by considering the weight of vehicle 300kg & top speed of 100kmph.

1) Mass of the vehicle: 300kg.
2) Maximum speed of vehicle: 100kmph.
3) Kinetic energy of the vehicle :0.5mv^2
4) Rotor disc diameter in meter:0.200m *5)* Permissible temperature in Celsius: 2500 C.
6) Pressure applied on the brake pads: 1Mpa.
7) Tangential force acting on the disc:2835.20 N.
8) Generated heat flux for above condition for stainless steel: 23148.14 watt/m^2.

$$Power = Force \times \Delta$$

Friction Force $f_f = \mu_d \times A_p \times pr \times n$

Heat Partition Coefficient: $p = \frac{\sqrt{k_d \times \rho_d \times c_d} \times s_d}{\sqrt{k_d \times \rho_d \times c_d} \times s_d + \sqrt{k_p \times \rho_p \times c_p} \times s_p}$

Heat Absorbed: $H_d = p \times H$

Convection: $H_{convectin} = h \times A \times \Delta T$

Radiation: $H_{rad} = \sigma \times A \times \Delta T^4$

Temperature Rise: $\nabla T_d = \frac{H_d - H_{convection} - H_{Rad}}{m_d \times c_d}$

Property	Stainless Steel
Density	7800
Youngs Modulus	200
Poisons Ratio	0.3
Thermal Conductivity	28
Specific Heat	500
Coefficient of Friction	0.23

Table: 1

S.NO	PARAMETER	MAXIMUM VALUE	MINIMUM VALUE
1.	EQUIVALENT STRAIN	2.281E-04	6.5696E-07
2.	EQUIVALENT STRESS	6.136E+07	1.216E+05
3.	TOTAL DEFORMATION	0.007	00
4.	HEAT FLUX	1.6991E+05	634
5.	TEMPERATURE	117.68	81.64

Table: 2

15.TOOLS USED

The fabrication department of Automantra Racing has used various tools for the manufacturing of this year's wheel assembly. The team followed proper safety procedures while fabricating the vehicles wheel assembly and a proper safety standard have been maintained under the guidance and supervision of teachers in the laboratory of Galgotias University.

15.1 CNC MACHINE

The most important role while fabricating the wheel assembly was of CNC or Computer Numatics Controlled Machine in which proper dimensions and a proper CAD design was entered using appropriate software and a Block of Aluminum was fitted inside the machining area CNC and a proper monitoring of dimensions is done time to time with the help of various tools like scale and Vernier Caliper.

15.2 PRESS FIT MACHINE

Another most important machine that is required for the fabrication is press fitting machine. The ball bearing and the rotor were easily pushed inside the cavity of hub.

16. DESIGN EVALUATION

The design group consider this year wheel assembly design as a completely successful mission. Overall, this year's design of wheel assembly helped the team of Galgotias University to stay strong in the event and helped the team to give a huge competition to other FSAE teams the event site. We have learned a lot from the design that we have made and are even looking forward to work harder to further iterate the design and learn even more in the near and far future with leaving no stone unturned.

17. PATH FORWARD

The key points that are required to be followed for the designing is the regular communication with the chassis design team. It is very important to understand the intent of every designer and also what kind of thought process the other designer posses while designing the vehicle.

Regular interaction will give the group an idea about how to iterate the design again and again and will eventually help the group to reach the optimum level of designing of a particular part, in this case, wheel assembly.

Another most important thing is to understand that how long will it take the vehicle to be fabricated after the design phase is completed and how much time is actually provided before the starting of actual testing of the component and collection of data is also very important for the future to understand about the mistake that have been made or what are the potential mistakes that could be possible made while designing the component.

Factor of safety is also important to address because as high as the factor of safety will be more will be the driver safe will show casing the action on the race track which eventually leads to the important key of factor of safety for the driver, it should not be forgotten in any of the case while designing the vehicle's components.

18. REFERENCES

1. International Journal of Research in Engineering and Technology, “THERMAL ANALYSIS OF BRAKE DISC”, Swapnil.D.Kulkarni, J.J.Salunke, [eISSN: 2319-1163].
2. International Journal of Recent Trends in Engineering & Research, “Disc Brake Rotor Selection through Finite Element Analysis”, Swapnil Umale, Dheeraj Varma, Volume 02, Issue 4; April - 2016 [ISSN: 2455-1457].
3. International Journal for Research in Applied Science & Engineering Technology, “Failure Analysis and Design of Disc in Two Wheeler”, Ranjan Kumar , Manoj Narwariya, Volume 8 Issue II Feb 2020, ISSN: 2321-9653.
4. International Research Journal of Engineering and Technology, “Design and Thermal Analysis of Disc Brake for Minimizing Temperature”, e-ISSN: 2395 0056.
5. International Journal of Mechanical Engineering and Technology, “STRUCTURAL AND THERMAL ANALYSIS OF DISC BRAKE USING SOLIDWORKS AND ANSYS”, Rakesh Jaiswal, Anupam Raj Jha, Anush Karki, Debayan Das, Pawan Jaiswal, Saurav Rajgadia and Ankit Basnet, Volume 7, Issue 1, Jan-Feb 2016, ISSN Online: 0976-6359.
6. Journal of Engineering Science and Technology Review, “Experimental and Numerical Thermal Analysis of Formula Student Racing Car Disc Brake Design”, Manthan Vidiya and Balbir Singh.
7. International Journal of Current Engineering and Technology, “Design and ANSYS analysis of Components of Wheel Assembly of SAE Car”, Sameer Santosh Mahadik, E-ISSN 2277 – 4106, P-ISSN 2347 – 5161.
8. IJSRD - International Journal for Scientific Research & Development| Vol. 4, Issue 02, 2016 | ISSN (online): 2321-0613.
9. Force Calculation in Upright of a Fsae Race Car Anshul Dhakar and Rishav Ranjan Department of Mechanical Engineering, RV College of Engineering, Bangalore, India.
10. G Milliken, W. F., and Milliken, D. L., “Race Car Vehicle Dynamics”, SAE Inc. Milliken, 1995.
11. http://web.mit.edu/3.35/www/Lecture_notes/Total-Life.pdf
12. IOP Conf. Series: Materials Science and Engineering 376 (2018) 012102 doi:10.1088/1757-899X/376/1/012102 “Design of efficient powertrain system for a motorsports race car using a bike engine” Ramesh K M, Vinaykumar Manjunath Naik, Sathyanarayana, M Lokesha, Mangalore Institute of Technology and Engineering.
13. International Research Journal of Engineering and Technology (IRJET) “Analysis and Design of a Formula SAE Powertrain”, Prasantha Laxman Pujari, G.V. Acharya Institute of Engineering and Technology, Volume: 06 Issue: 03 Mar 2019.

19. PUBLICATION DETAILS

The paper of GROUP 12 is published by INTERNATIONAL JOURNAL FOR RESEARCH IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY (IJRASET), Volume 8 Issue IV Apr 2020.

The paper is available on www.ijraset.com .

Design and Thermal Analysis of Brake Disc for Optimum Performance

Aakash Jawla[1], Rahul Anand[2], Shobhit Agarwal[3], Aman Gupta[4], Jiwan Jyoti Jena[5]
1, 2, 3, 4, 5
School of Mechanical Engineering, Galgotias University. Greater Noida, India

Abstract: While designing a formula car the first thing that came into mind is safety as we know a formula car experience immense mechanical & kinetic loads mostly during braking. This paper addresses at designing and thermal analysing Disk (Brakes Disk) of Formula SAE car for Automantra Racing, SAE team of Galgotias University. When the brakes are applied to the moving vehicle, all the kinetic energy of the vehicle get converted into equivalent amount of heat generation. But during the hard braking there is induction of thermal stress which generates excessive amount of heat & we all know that a small portion of disk is in contact with friction pads of callipers. The Aim of this project is to study the Thermal analysis of the materials for Stainless steel. Disc brake design is done through SolidWorks and analysis is completed by using ANSYS workbench Keywords: SolidWorks, FSAE, Ansys, Thermal Analysis

INTRODUCTION

AUTOMANTRA RACING is the formula student team of students studying in Galgotias University, Gautam Buddha Nagar, U.P., INDIA. The team works together to participate in an engineering design competition with the collective aim of building an open wheeled formula style student concept car which is completely fabricated by the students to participate in the Formula Bharat event by Formula SAE International.

Here, at Automantra Racing, the students collectively aim to design and analyse the brake disc on its thermal results and put out the best possible results for a certain material that has been taken to achieve maximum efficiency and the paper will serve as a base for the students that are willing to work on the same in near future. Brakes are broadly classified into two types: -

1) *Axial Brakes:* In these types of brakes, the force acting on the braking system is in the axial direction to the brakes. For example: - In disc brake the piston is acting on the axial direction on the disc by brake pads.
2) *Radial Brakes:* In these types of brakes, the force acting on the braking system is in perpendicular direction to axial direction. Radial brake is sub-divided into internal and external brakes.

The type of braking system that we are experimenting here is of axial type. Brake disc is one of the most important components of any vehicle that comprises it. There is another way of braking that includes drum brakes but in comparison to disc brakes they are less efficient and disc brakes are even less bulky with an added feature of less weight. The disc brakes supply driver with an extra bit of confidence while braking as the output tends to be faster and accountable. The feedback that the driver gets from a disc brake is comparatively easy to judge and the decision taking time reduces and the action on the racetrack increases.

LITERATURE REVIEW

A. "Disc Brake Rotor Selection through Finite Element Analysis" by Swapnil Umale, Dheeraj Varma this research paper gives us information about working principle characteristics, applications & various loads acting of disc brakes along with broad descriptions.

B. "Thermal Analysis of Disc brake Using ANSYS" by Avinash Singh Thakur, Asst. Prof. P.S. Dhakad helps us is selection material for our disk. As the maximum temperature rise of cast iron disc is much small with compared to stainless steel, cast iron is the best desirable for manufacturing disc brake. But cast-iron disc brake gets corroded when it comes in contact with wetness and hence it cannot be used, thus we prefer stainless steel.

C. "Experimental and Numerical Thermal Analysis of Formula Student Racing Car Disc Brake Design" Manthan Vidiya and Balbir Singh this paper belongs to 'Formula Manipal', the official Formula student team of Manipal University, India. This paper provides us formulas for calculating Heat Generated, Friction Force, Heat flux, Heat Absorbed & Change in Temperature.

D. "Thermal Analysis Of Brake Disc" by Swapnil.D.Kulkarni , J.J.Salunke this paper is from Mechanical Engineering Department, DIEMS, Maharashtra, India Introduce us with procedure followed during the analysis by performing an analysis on disc with 3 different materials.

THEORY

Brake is the part in a vehicle that resist the motion of the vehicle's wheel on the will of the driver. One of the most used types of brake is the desk brake. It is a kind of mechanical brake and works on the principle Pascal's Law of pressure.

In disk brakes pads are pushed against the disk which rotates with the wheel. The friction between the pads and disk resists the rotation of the brake disk and simultaneously the rotation of the wheel.

Due to the friction between pads and disk, the disk gets hotter due to conversion of the kinetic energy of the wheel into thermal energy of the brake disk. The heat generated in the disk dissipated into the air and the disc gets cooler again. The dissipation is necessary for braking because if the heat doesn't dissipate, the disk will get excessively hot and eventually the breaking mechanism will fail. Due to this reason the disk should be designed will well so that the heat transfer from the disk to the air should be optimum.

METHODOLOGY

We have started with finalising the type of brake callipers that we want to use for the car and eventually after team discussion it was decided that KBX is the one we are selection. Reasons for selecting KBX is really simple, these callipers are having two pistons one for each brake

pad and despite having two piston these are small in size and because of small size they are very light in weight which helps to keep the overall weight of car in watch. The mounting points of these callipers also matches with the designed mounting points of hubs accurately. After selecting the type of calliper process becomes easy as now, we have to decide the diameter of our disc and in this case it is. Various holes are drilled in the disc the reason behind this is that these holes do not make any impact/changes on the stress and strain of the disc also it helps to reduce the weight of the disc to a drastic to a drastic level. Holes in the disc are also helpful because they help in the process of heat dissipation as when the disc of breaks heat it makes an impact on the braking efficiency so it is also important that disc should remain cool in this process.

The above fact of heat dissipation leads us to the goal of this research and helps us understand about heating of the disc. The Analysis in ANSYS is carried by following method.

A. First of all, the profiles are created in Creo parametric 2.0.
B. After starting ANSYS 15.0, the mode of analysis is taken as steady state thermal.
C. The material properties are defined for the profile models.
D. The model is then subjected to meshing as Fine.
E. After meshing, the boundary conditions are applied to the brake disc.
F. The parameters whose solution is required are selected from the solution bar.

CALCULATIONS

The calculations are done by considering the weight of vehicle 300kg & top speed of 100kmph.

1) Mass of the vehicle: 300kg.
2) Maximum speed of vehicle: 100kmph.
3) Kinetic energy of the vehicle :$0.5mv^2$
4) Rotor disc diameter in meter:0.200m *5)* Permissible temperature in Celsius: 2500 C.
6) Pressure applied on the brake pads: 1Mpa.
7) Tangential force acting on the disc:2835.20 N.
8) Generated heat flux for above condition for stainless steel: 23148.14 watt/m^2.

A. Formulas Used

= × Δ

Friction Force = × × ×

× × × × × × Heat Partition Coefficient: = $\frac{\sqrt{k_d \times \rho_d \times c_d} \times s_d}{\sqrt{\quad} \quad \sqrt{\quad}}$

Heat Absorbed: = ×

Convection: = *h*
× × Δ

Radiation: =
× × Δ

Temperature Rise: ∇ = ———————

×

MATERIAL SELECTION

Selection of material for manufacturing is also a very complex and important aspect. While selecting materials various factors can be taken into consideration such as thermal conductivity, coefficient of friction & corrosivity etc.

TABLE 1

Property	Stainless Steel
Density	7800
Youngs Modulus	200
Poisons Ratio	0.3
Thermal Conductivity	28
Specific Heat	500
Coefficient of Friction	0.23

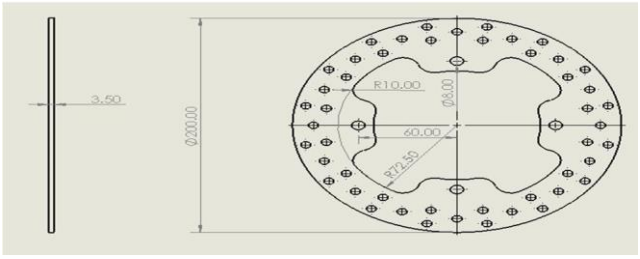

Figure 1: CAD Drawing of AR20 Disk

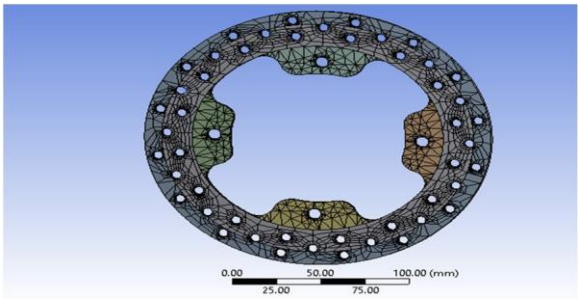

Figure 2: Meshing Details

RESULT

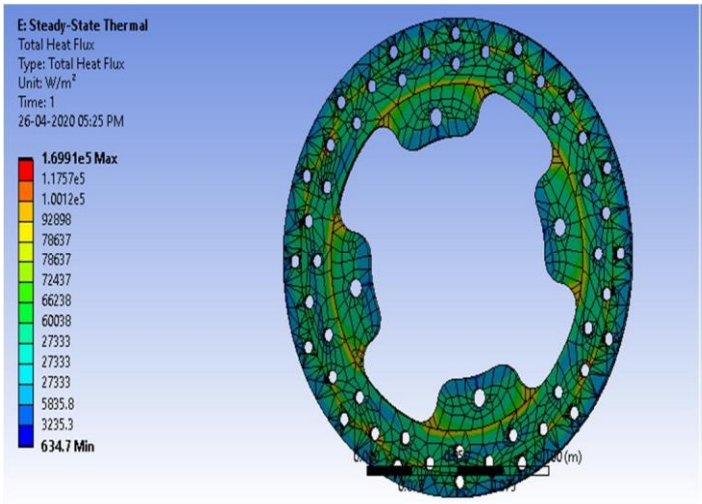

Figure 3: Heat Flux on Disc

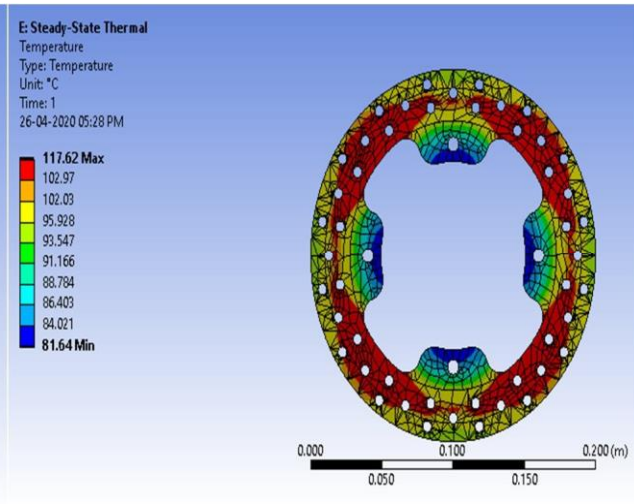

Figure 4: Temperature

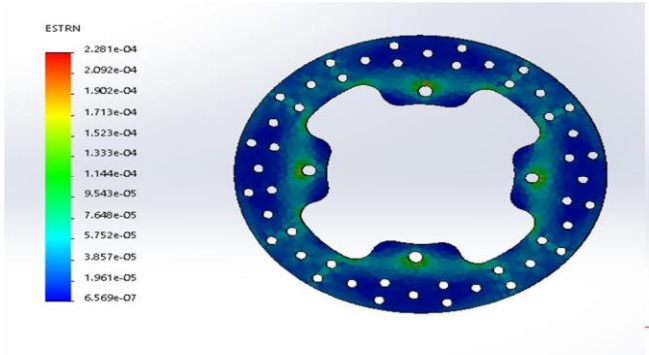

Figure 5: Equivalent Strain

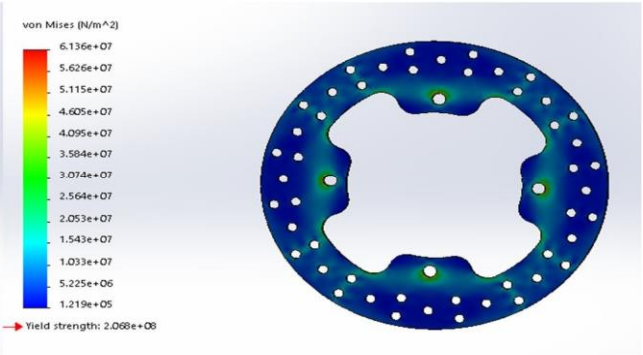

Figure 6: Equivalent Stress

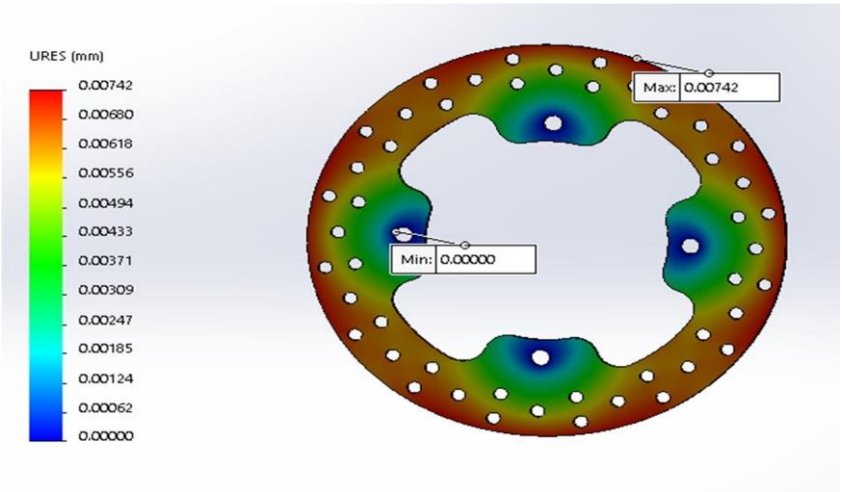

Figure 7: Total Displacement

TABLE 2

S.NO	PARAMETER	MAXIMUM VALUE	MINIMUM VALUE
1.	EQUIVALENT STRAIN	2.281E-04	6.5696E-07
2.	EQUIVALENT STRESS	6.136E+07	1.216E+05
3.	TOTAL DEFORMATION	0.007	00

4.	HEAT FLUX	1.6991E+05	634
5.	TEMPERATURE	117.68	81.64

REFERENCES

[1] International Journal of Research in Engineering and Technology, "THERMAL ANALYSIS OF BRAKE DISC", Swapnil.D.Kulkarni, J.J.Salunke, [eISSN: 2319-1163]

[2] International Journal of Recent Trends in Engineering & Research, "Disc Brake Rotor Selection through Finite Element Analysis", Swapnil Umale, Dheeraj Varma, Volume 02, Issue 4; April - 2016 [ISSN: 2455-1457]

[3] International Journal for Research in Applied Science & Engineering Technology, "Failure Analysis and Design of Disc in Two Wheeler", Ranjan Kumar , Manoj Narwariya, Volume 8 Issue II Feb 2020, ISSN: 2321-9653.

[4] International Research Journal of Engineering and Technology, "Design and Thermal Analysis of Disc Brake for Minimizing Temperature", e-ISSN: 2395 0056

[5] International Journal of Mechanical Engineering and Technology, "STRUCTURAL AND THERMAL ANALYSIS OF DISC BRAKE USING SOLIDWORKS AND ANSYS", Rakesh Jaiswal, Anupam Raj Jha, Anush Karki, Debayan Das, Pawan Jaiswal, Saurav Rajgadia and Ankit Basnet, Volume 7, Issue 1, Jan-Feb 2016, ISSN Online: 0976-6359

[6] Journal of Engineering Science and Technology Review, "Experimental and Numerical Thermal Analysis of Formula Student Racing Car Disc Brake Design", Manthan Vidiya and Balbir Singh.