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A Review on Design Optimization and Analysis of Brake System with Student SAE International Safety Rules

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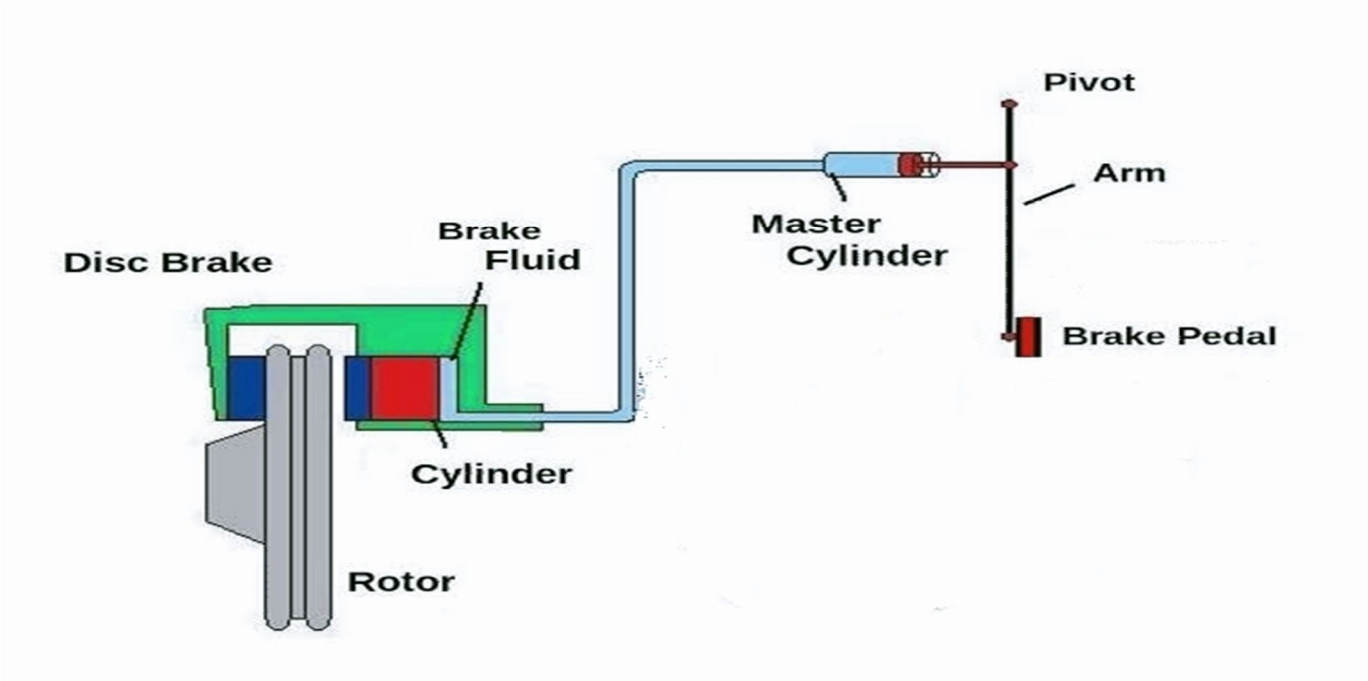
Abstract: ***Formula Student Competitions are held globally. In these competition students design, fabricate and compete with a formula style race car. The braking system is the most important system in a car. If the brakes fail, the Result may be disastrous. An FSAE race car brake system is different from the conventional brakes. Thus the methodology followed while designing such a braking system Is different. We as a part of an FSAE team have taken up this project to develop a Hydraulic Braking system of an FSAE car. The design of an effective braking system plays a major role in high Performance formula cars since the stopping distance and speed control during cornering are the important part of any race. Everyone wants their Car to go fast, but the braking system should be capable to stop Immediately and safely. Any car with a highly effective braking system Fills confidence in the driver. It also increases driving pleasure.***

Keywords: callipers, Wilwood, Master cylinder, Rotors, Ansys

I. INTRODUCTION

Braking system Braking system is an essential part of any automobile. In passenger road vehicles braking systems are a crucial safety system that allow drivers to reduce the speed of the vehicle to avoid collisions and maintain safe travelling speeds. For race cars, the primary function of the braking system is to allow the driver to decelerate the Vehicle at the maximum rate possible. The main difference between passenger and racing vehicle Braking systems is that racing braking systems must endure much higher temperatures and stresses Throughout an entire race. In FSAE spec race cars, the typical braking system consists of a direct Acting hydraulic braking circuit acting on the brake callipers, with solid rotors attached to the hubs of the vehicle. The brake rotors are designed with cut outs such that the rotor and pad temperatures Do not exceed the limits of the materials.



A brake is a device used to generate an artificial frictional which is applied to moving member of the machine, for stopping motion. For the execution of the braking operation, the brakes pad and disc absorb the kinetic energy from the wheel. The energy absorbed By brake is generating heat. This heat is passing into the atmosphere and stops the vehicle, so the braking system should have the Following ability;

1) The brake disc having the ability to transfer heat to the atmosphere and maintain a constant temperature to improve the Performance of the disc.
2) Anti-wear property of the brakes must be good.
3) The driver must have had proper control of the vehicle during brake applied and the vehicle should not skid.
4) The brakes must be having enough power to stop the vehicle with in a minimum distance in case emergency.

II. LITERATURE REVIEW

1) Vivek Singh Negi, Nayan Deshpande Volume 4 issue 11 November (2017): The braking system contribute majorly in terms of safety and handling. Importance of reliable braking system in any vehicle is paramount. The common goal of designing braking system is to implement a fully effective braking system in allocated space. The energy conversion, transforming kinetic energy in heat is achieved by fiction between brake rotor and pads. The components use in system has selected according to their limitations and specifications like Master cylinder Their various types of master cylinder provided but Tandem master cylinder provides split circuiting for each pair of wheels. This allows driver to break even if one of the circuits fails due to leakage. Hence, tandem master cylinder was selected. Brake rotors-There are two types of brakes, viz. disc brakes and drum brakes. Disc brakes are widely used since they are more efficient. They are better in heat dissipation and cool relatively quickly. The material used for rotor is Stainless steel of grade 410. Brake Callipers-Due to dynamic weight transfer, more braking force is required at the front as compared to rear. The brake force distribution required is 70 % in front and 30 % in rear. Brake Pedal Box-The mounting of brake pedal, along with acceleration pedal should use packaging space wisely. One of the important considerations while placing pedal box is that driver should be able to reach both pedals comfortably. The length of pedal is defined by pedal ratio to be used.

2) Mohd Usama, Gagan Singhal, "Design and Analysis of Braking System for FSAE", International Journal for Scientific Research & Development, Volume:06, Issue: 02 2018, ISSN (online): 2321-0613.-we cannot hold control on it and ultimately accidents would occur. So, each and every motor vehicle requires a reliable braking system. So, for this we have to verify the design of braking system on the basis of calculation. When we go for designing of braking system the first problem comes into mind- "From where the calculation should be started? For better controllability of vehicle, it is essential that all the four wheels should be locked-up at the same time. Maximum braking efficiency can be achieved only at particular barking ratio. The second objective of this is to find out the compatibility of the APACHE RTR 180 brake disc (rear) on the basis of structural and thermal analysis. The brake system must be capable of locking all four wheels during the test. The brake pedal shall be designed to withstand a force of 2000 N without any failure of the brake system or pedal box The kinetic energy of vehicle gets dissipated into atmosphere through the brake disc and it is achieved by intense rubbing action between brake disc and pads. So, brake disc should be capable enough to withstand under such extreme conditions.

3) Rohit Kawada, Gaurav Pardeshi, Sagar Jadhav, Amar Jadhav, "Design and Analysis of Brake System of a Single Seat Race Car", International Journal of Research in Engineering and Technology, Volume:07, Issue: 03 March 2020, EISSN: 2395-0056.According to them Fundamentals of vehicle statics and dynamics were kept in the core of designing. They used SOLIDWORKS and ANSYS for analysis of brake disc, considering structural and thermal stresses. They kept all the discs as identical and as front wheels would be subjected for maximum braking force due to weight transfer, the analysis was done for only one disc. During braking process, the disc has to save about 80-90% of kinetic energy of vehicle as heat, only 10% to 20% thermal energy dissipated as convection and radiation into the into the environment.it was observed that maximum intensity of stress and strain is located at the under-cut area of brake disc and hence maximum deformation in that area. And the factor of safety was found highly reliable according to the design. The maximum temperature that can be developed in the disc was found to be 621.14o Celsius. They concluded that a rationalized method was developed to design or select any component, especially the dimensions of brake disc. Each and every component of brake system such as brake disc, caliper, master cylinder etc. are tested under extreme condition. Various factors affecting the net heat generation and dissipation from the disc brake is determined by the generation of heat by using velocity of car.

4) Swapnil R. Abhang, D.P. Bhaskar, "Designed Analysis of Disc Brake", International Journal of Engineering Trends and Technology (IJETT),Volume 8, Number 4, Feb 2014, ISSN: 2231-5381.-The disc brake is a wheel brake which slows rotation of the wheel by the friction caused by pushing brake pads against a brake disc with a set of callipers. The brake disc (or rotor in American English) is usually made of cast iron, but may in some cases be made of composites such as reinforced carbon–carbon or ceramic matrix composites. This is connected to the wheel and/or the axle.Friction causes the disc and attached wheel to slow or stop. Brakes convert motion to heat, and if the brakes get too hot, they become less effective, a phenomenon known as brake fade.A disc brake consists of a cast iron disc bolted to the wheel hub and a stationary housing called calliper. The calliper is connected to some stationary part of the vehicle like the axle casing or the stub axle as is cast in two parts each part containing a piston. Discs are made up mainly Gray cast iron, so discs are damaged in one of three ways: scarring, cracking, warping or excessive rusting. When a vehicle is decelerated, load is transferred to the front wheels – this means that the front brakes do most of the work in stopping the vehicle. The discs are commonly made from cast iron and a certain amount of what is known as "surface rust" is normal. Sometimes a loud noise or high-pitched squeal occurs when the brakes are applied. ANSYS is one of the useful software for design analysis in mechanical engineering. This software is based on the Finite Element Method (FEM) to simulate the working conditions of your designs and predict their behaviour. The standard disc brake two wheelers model using in Ansys, done the Thermal and Modal Analysis calculate the deflection, total heat flux, Frequency and temperature of disc brake model. This is important to understand action force and friction force on the disc brake new material, which use disc brake works more efficiently, which can help to reduce the accident that may happen in each day. We can conclude that following a systematic approach for design and analysis is helpful in creating a better design. After going through several research papers and articles we decided to designed and manufactured lightweight braking system . Material selection plays a vital role in the design and analysis process. Various factors like strength, weight to strength ratio, cost, availability should be considered while selecting the material.

III. CONCLUSION

We can conclude that following a systematic approach for design and analysis is helpful in creating a better design. After going through several research papers and articles we decided to designed and manufactured lightweight braking system. Material selection plays a vital role in the design and analysis process. Various factors like strength, weight to strength ratio, cost, availability should be considered while selecting the material.

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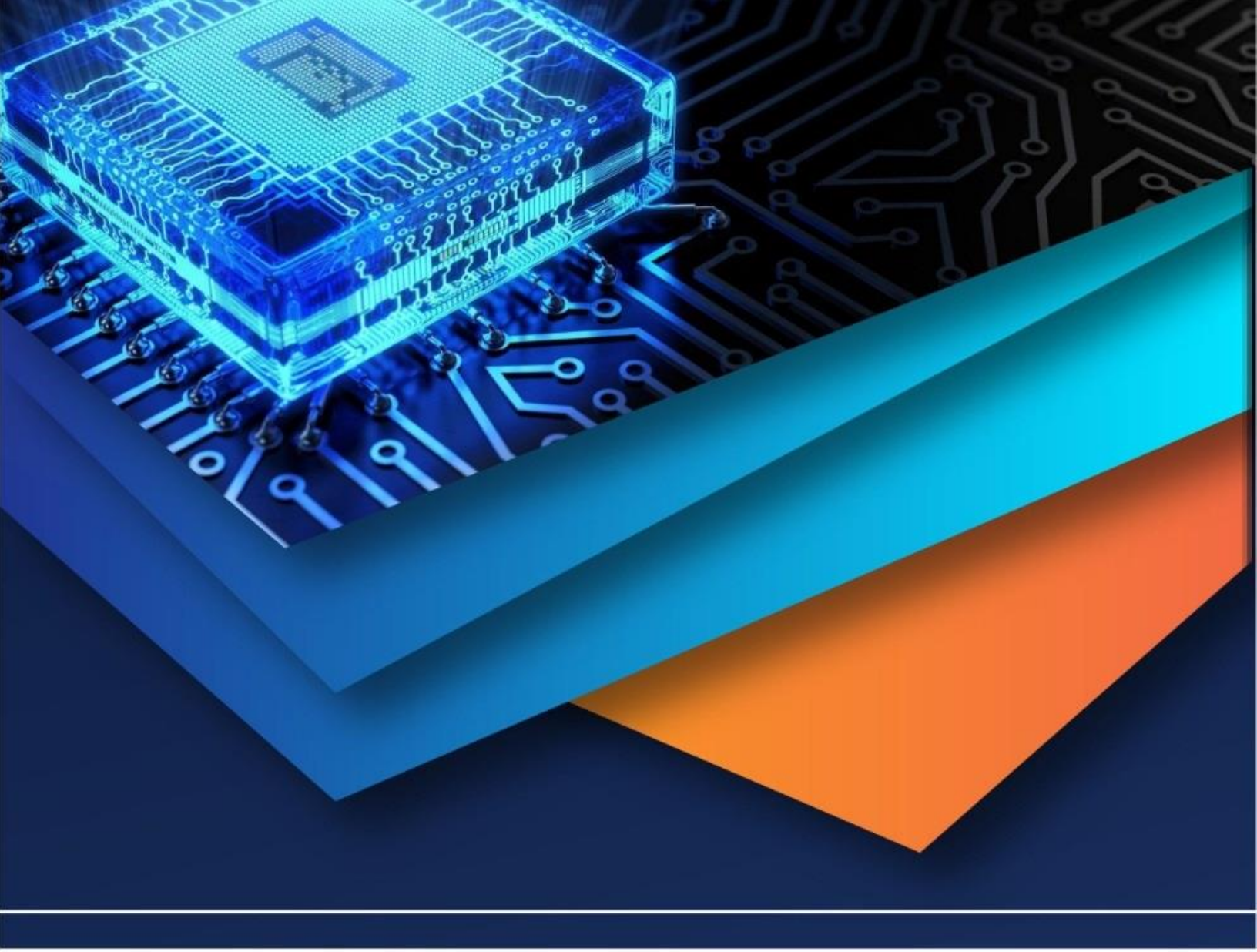

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