OPTIMIZATION AND ANALYSIS OF DISC BRAKE

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Abstract A disc brake is a type of brake that uses the calipers to squeeze pairs of pads against a disc or a "rotor" to create friction. This action slows the rotation of a shaft, such as a vehicle axle, either to reduce its rotational speed or to hold it stationary. The energy of motion is converted into waste heat which must be dispersed.

In this project here disc brake developed with the help of solid works and analyzed with Ansys, here applied and structural and thermal load on it, and calculated results like deformation and stress and safety factor along with temperature and heat flux values. Here 3 different materials were chosen (steel, cast iron, al-7068) and compared each material results with required tables and graphs, to increase the heat transfer rate here disc rotor optimized with holes and groove cut, finally project conclude project with optimum material with optimum model to improve the performance of vehicle in real time boundary conditions.

1. INTRODUCTION

1.1 Disc brake

A disc brake is a type of brake that uses the calipers to squeeze pairs of pads against a disc or a "rotor" to create friction. This action slows the rotation of a shaft, such as a vehicle axle, either to reduce its rotational speed or to hold it stationary. The energy of motion is converted into waste heat which must be dispersed.

Hydraulically actuated disc brakes are the most commonly used form of brake for motor vehicles, but the principles of a disc brake are applicable to almost any rotating shaft. The components includes the disc, master cylinder, caliper (which contains cylinder and two brake pads) on both side of the disc.

1.2 Design

Development of disc-type brakes began in England in the 1890s. In 1902, the Lanchester Motor Company designed brakes that looked and operated in a similar way to a modern disc-brake system even though the disc was thin and a cable activated the brake pad. Other designs were not practical or widely available in cars for another 60 years. Successful application began in airplanes before World War II, and even the German Tiger tank was fitted with discs in 1942. After the war, technological progress began to arrive in 1949, with caliper-type four wheel disc brakes on the Crosley line, and a Chrysler non-caliper type. In the 1950s, there was a critical demonstration of superiority at the 1953 24 Hours of Le Mans race, which required braking from high speeds several times per lap. The Jaguar racing team won, using disc brake equipped cars, with much of the credit being given to the brakes' superior performance over rivals equipped with drum brakes. Mass production began with the abortive 1949 Crosley experiment, with sustained mass production beginning in 1955 Citroën DS.

Compared to drum brakes, disc brakes offer better stopping performance because the disc is more readily cooled. As a consequence discs are less prone to the brake fade caused when brake components overheat. Disc brakes also recover more quickly from immersion (wet brakes are less effective than dry ones). Most drum brake designs have at least one leading shoe, which gives a servo-effect. By contrast, a disc brake has no self-servo effect and its braking force is always proportional to the pressure placed on the brake pad by the braking system via any brake servo, braking pedal, or lever. This tends to give the driver better "feel" and helps to avoid impending lockup. Drums are also prone to "bell mouthing" and trap worn lining material within the assembly, both causes of various braking problems.

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The disc 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. To slow down the wheel, friction material in the form of brake pads, mounted on the brake caliper, is forced mechanically, hydraulically, pneumatically, or electromagnetically against both sides of the disc. Friction causes the disc and attached wheel to slow or stop.

Aim of the study

The main aim of the project is to develop a disc rotor which is suitable for high speed loading conditions, here developing pulsar 150cc disc brake with the help of solid works, and applying different boundary conditions like different RPM values (50km/h, 80km/h, 110km/h) with 3 different (steel, cast iron, al-7068) materials,to increase the heat transfer rate here modifying disc rotor with different holes, and groove cut on edges. Finally project complete with optimum material/ model with suitable graphs and table and their limitations.

2. LITERATURE REVIEWS

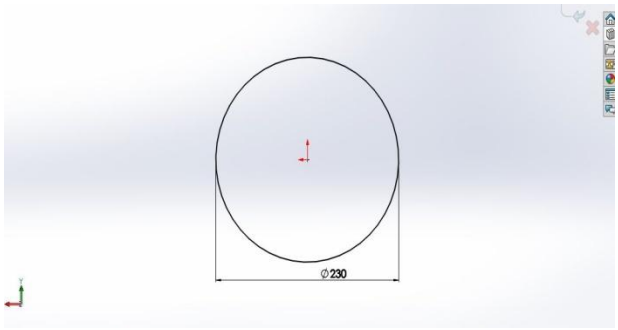
PIOTR GRZEŚ, 2011 [1] the aim of this paper was to investigate the thermal information of the solid disc brake during sudden, emergency braking. In this paper thermal analysis of disc brakes in brake application was done. To obtain the numerical simulation parabolic heat conduction equation for two dimensional model was used. The results show that both rotating speed of disc and contact pressure with specific material properties intensely.

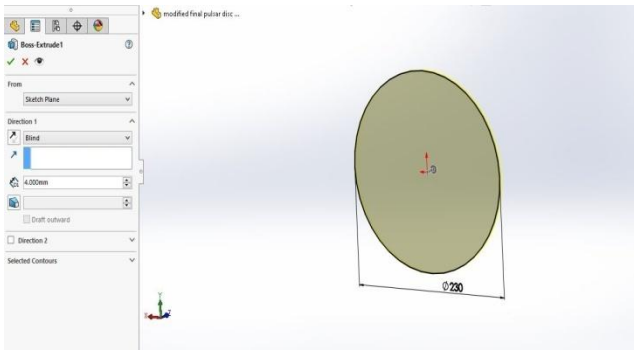
RAJENDRA POHANE, R.G.CHOUDHARI, 2011 [2] FEM model is prepared for contact analysis. A 3D finite element model of the brake pad and the disc is developed to find structural analysis, and transient analysis. The comparison is done between the solid and ventilated disc keeping the equal material properties and constraints and using general purpose finite element analysis. This project discusses how general purpose finite element analysis software can be used to analyze the mechanical stresses & the thermal stresses at disc to pad surface

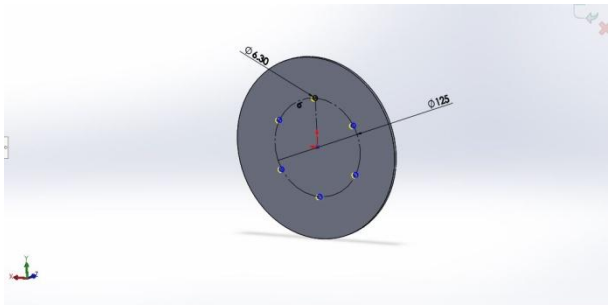
A. Belhocine et al [3] performed numerical simulation for the coupled transient thermal field and stress field was carried out sequentially with the thermal structural coupled method, based on ANSYS software, to evaluate the stress fields of deformations that are established in the disc with the pressure of the pads. The results obtained by the simulation are satisfactorily compared with those of the specialized literatureassumed zero. The numerical simulation for the thermal behavior of disk brake is obtained in the different brake condition.

Venkatramanan R et al [4] investigated and analyzed the temperature distribution of rotor disc during operation using Ansys. This was done to understand the pressure force and friction force on the disc brake material, which can help to reduce the accidents that may happen each day. In this research work design of a disc brake was proposed with copper liner, the heat transfer of existing and hybrid disc was calculated for finding the effectiveness of heat transfer and it was concluded that using a copper liner reduced the maximum temperature attained by the disc

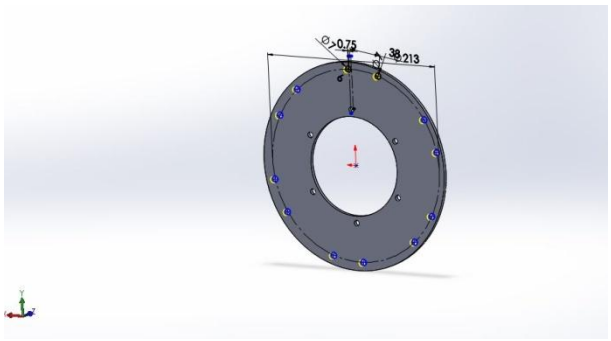
3. DESIGNING PROCESS

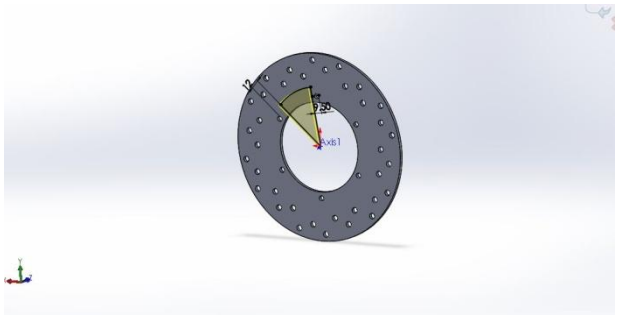


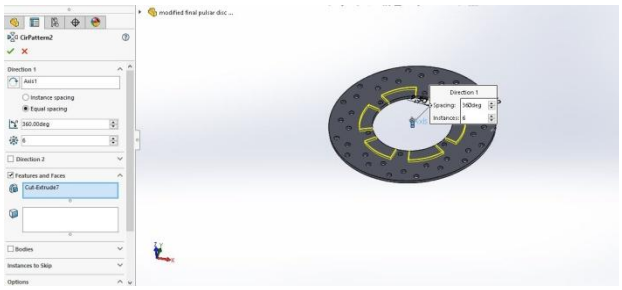


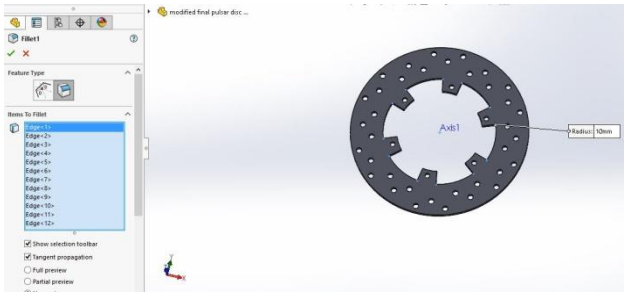


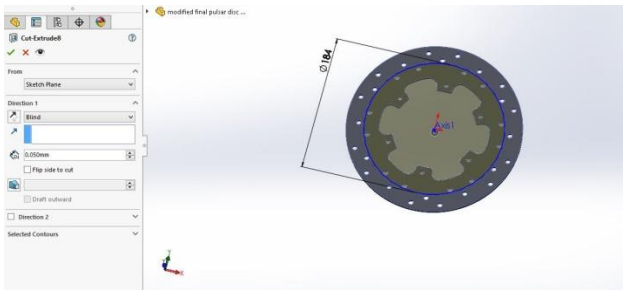
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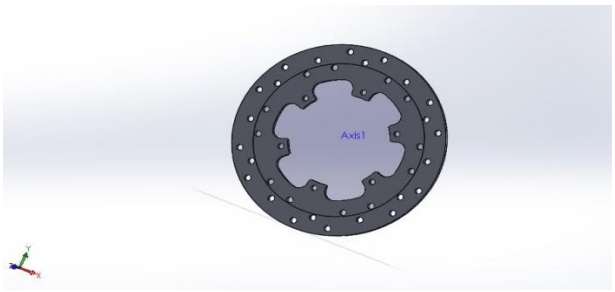








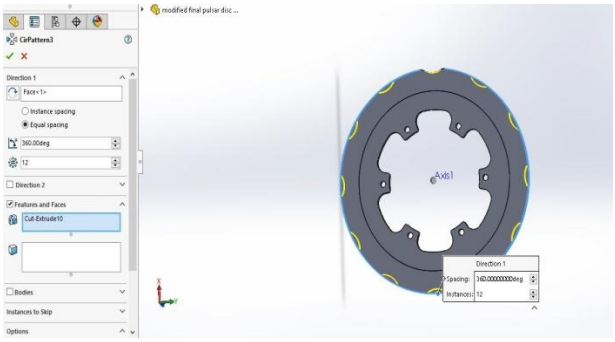


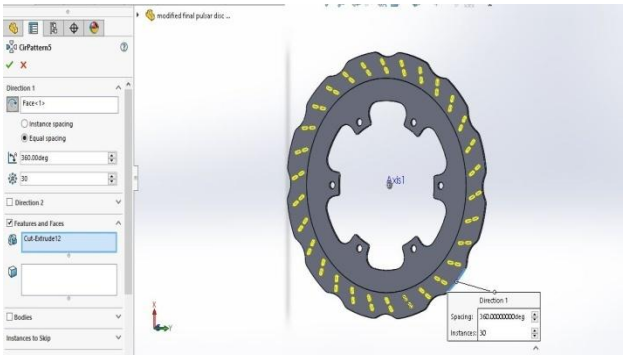


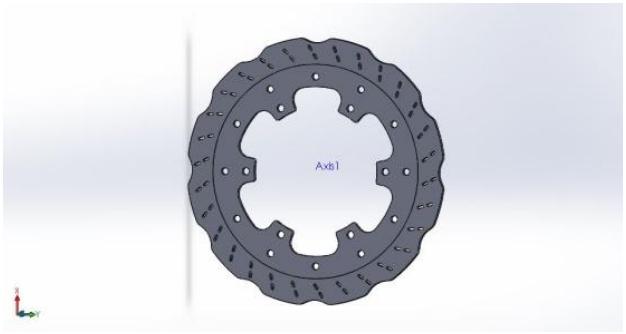
4. EXISTING DESIGN

To create next design following same dimensions and after completing it now using extrude cut and circular pattern option and those images shown in below

Optimized design process







Optimized design

5. ANALYSIS RESULTS

Material properties

Steel

Young's modulus:- 2*10^11 Pa

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Poison ratio: 0.3
Density: 7850 Kg/m^3
Yield strength: 275Mpa
Thermal conductivity: 60.5 w/m-k

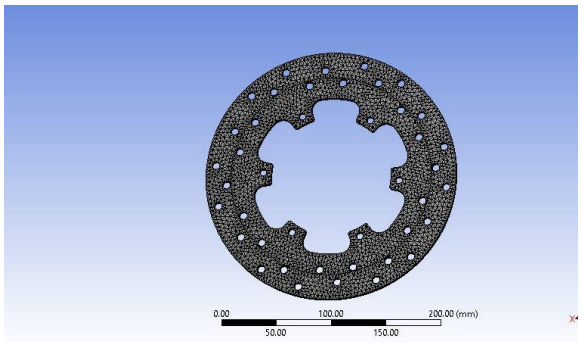
Cast iron

Young's modulus:- 11*10^9 Pa
Poison ratio: 0.3
Density: 7200 Kg/m^3
Yield strength: 306 Mpa
Thermal conductivity: 72 w/m-k

Al-7068

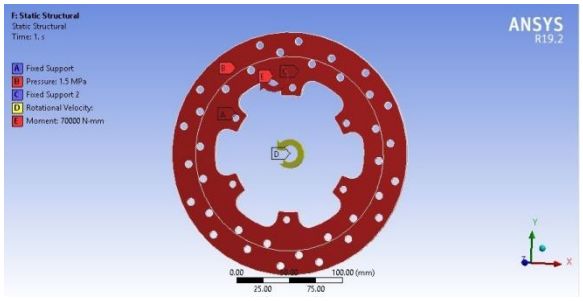
Young's modulus:- 73*10^9 Pa
Poison ratio: 0.3
Density: 2850 Kg/m^3
Yield strength: 590 Mpa
Thermal conductivity: 190 w/m-k

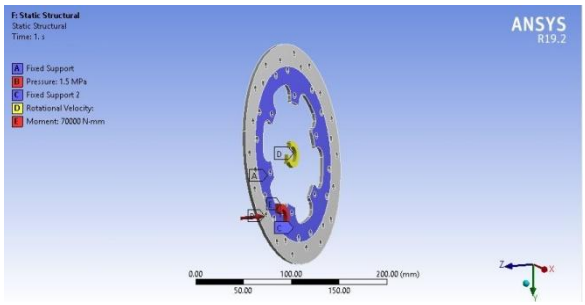
Meshing



Boundary conditions

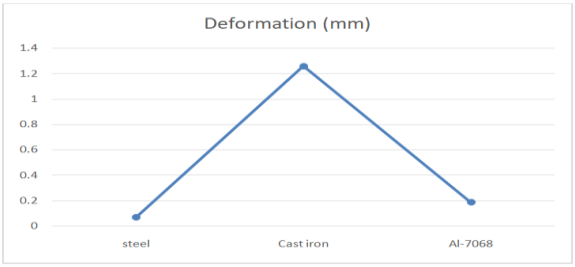
Rpm 1150 (50 Km/h)



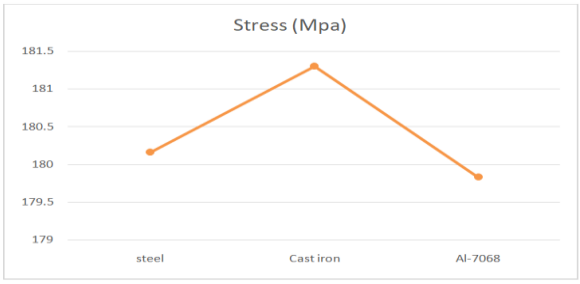


Select fixed support and select area, then apply pressure value 1.5Mpa and then apply torque 70000N-mm, and rotational velocity 1150RPM, 1850RPM 2550RPM, and then solve required results

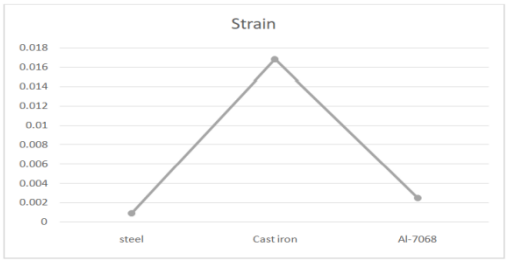
Deformation for 1150RPM



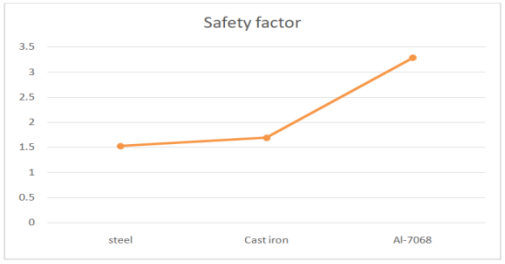
Comparison of deformation for 1150Rpm



Comparison of stress for 1150Rpm



Comparison of strains for 1150Rpm

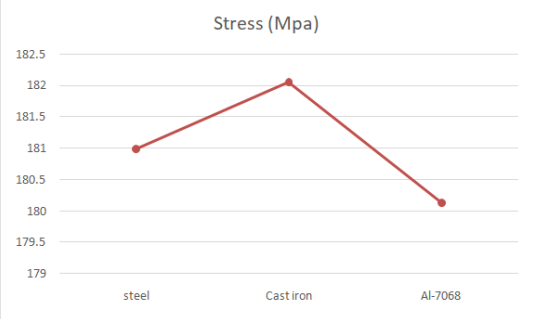


Comparison of safety for 1150Rpm

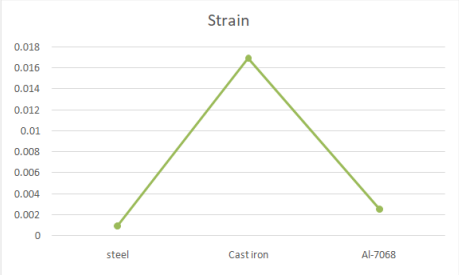


Comparison of deformation for 1850Rpm

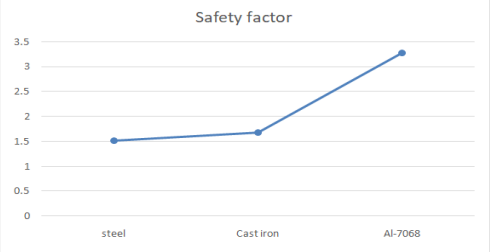
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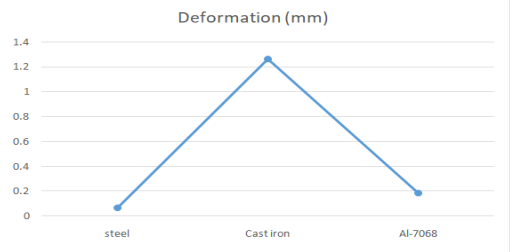
Comparison of stress for 1850Rpm



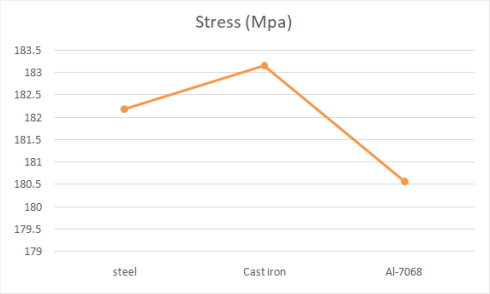
Comparison of strains for 1850Rpm



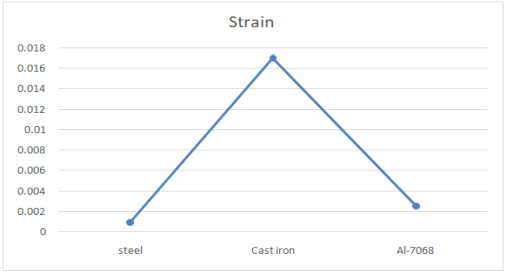
Comparison of safety for 1850Rpm



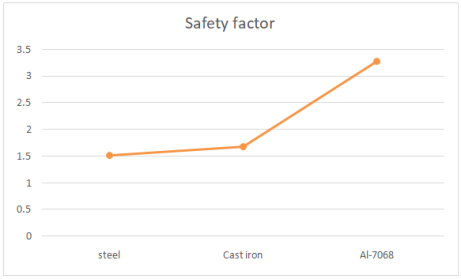
Comparison of deformation for 2250Rpm



Comparison of stress for 2250Rpm

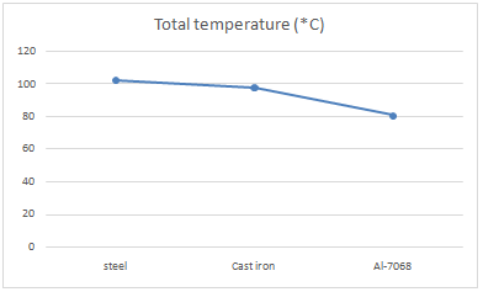


Comparison of strains for 2250Rpm

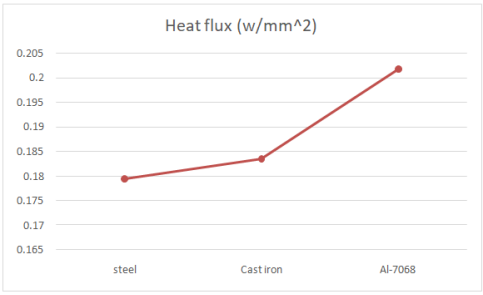


Comparison of safety for 2250Rpm

Thermal Analysis



Total temperature variation



Heat flux analysis

6. CONCLUSIONS

In this project here disc brake developed with the help of solid works and analyzed with Ansys, here applied and structural and thermal load on it, and calculated results like deformation and stress and safety factor along with temperature and heat flux values. Here 3 different materials were chosen (steel, cast iron, al-7068) and compared each material results with required tables and graphs, to increase

the heat transfer rate here disc rotor optimized with holes and groove cut,

From analysis results pulsar disc brake with can withstand 1.5Mpa of pressure on it when it has rotational velocity of 2550rpm, and this 2550rpm value consider as 110Km/h which is maximum speed for pulsar. Here 3 different (steel, cast iron, al-7068) materials were chosen, from results steel material has least amount of deformation value and then cast iron Is having high amount of value, when comparing strength values al-7068 material is having high amount of strength values and also al-7068 material is having least amount of density value compare to steel and cast iron so that this al-7068 material can reduce overall weight of the object, and it can reduce the weight nearly 3 times. And also calculated thermal analysis results, among all materials steel and al-7068 materials both are having same amount of heat transfer rate values, and cast iron is having high amount of heat transfer rate value.

To improve heat transfer rate values here modifying disc rotor with different holes and groove cut, here observed that these groove cut and holes were increasing heat transfer rate values compare to existing design, so that thesis conclude with al-7068 material for optimized design, and this combination can increase the overall performance.

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