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Steady State Thermal Analysis of Rotor Disc Break

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Abstract : *The disc brake is a device for slowing or stopping the rotation of a wheel. Repetitive braking of the vehicle leads to heat generation during each braking event. Transient Thermal and Structural Analysis of the Rotor Disc of Disk Brake is aimed at evaluating the performance of disc brake rotor of a car under severe braking conditions and there by assist in disc rotor design and analysis. Design of Disc brake model is carried out by using solid works and analysis work is carried by using ANSYS. The main purpose of this study is to analysis the thermo mechanical behavior of the dry contact of the brake disc during the braking phase. Design & analysis is performed for determining the total heat flux which is caused by using different materials which will reduce thermal loss.*

Keywords: *Ansys, Braking, Disc break rotor, Total Heat Flux , Transient Thermal, Rotation*

I. Introduction

A disc brake is a type of brake that uses calipers to squeeze [1] pairs of pads against a disc in order to create friction that retards 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. Hydraulic 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. 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. 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*. To retard 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. The development of disc-type brakes began in England in the 1890s, but they were not practical or widely available for another 60 years. Successful application required technological progress, which began to arrive in the 1950s, leading to a critical demonstration of superiority at the Le Mans auto race in 1953. The Jaguar racing team won, using disc brake equipped cars, with much of the credit being given to the brakes' superior performance over rivals from firms like Ferrari, equipped with drum brakes. Mass production quickly followed with the 1955 Citroën DS.

II. Finite Element Model

Modelling And Finite Element Analysis A three-dimensional model of the rotar disc developed using solid works software. A 20 nodes tetrahedral element was used for the solid mesh. Sensitivity analysis was performed to obtain the optimum element size. These analyses were performed iteratively at different element lengths until the solution obtained appropriate accuracy. Convergence [4] of the stresses was observed, as the mesh size was successively refined. The element size of 1 mm was finally considered. A total of 213081 elements and 298472 nodes were generated with 5mm element length. Finite element analysis (FEA) is widely used in the numerical Solution of many problems in engineering and technology. The problem include design of shafts, trusses, bridges, aero plane structures, buildings, heating and ventilation, fluid Flow, electric and magnetic fields, and so on. The main advantage of using finite element analysis is that many alternative designs can be

Tried out for their validity, safety, and integrity using the computer, even before the first prototype is built. Finite element analysis uses the idea of dividing a [2] large body into small parts called elements, connected at predefined points called nodes. Element behavior is approximated in terms of the nodal variables called degrees of freedom. Elements are assembled with due consideration of loading and boundary conditions, this results in a finite number of equations. Fig.2 shows finite element model.

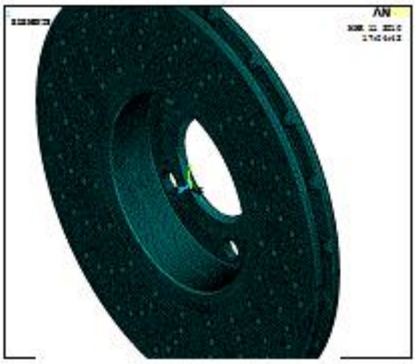

Fig1:finite element model of rotar disc break

III. Design Of Disc Break Rotor

Rotor was drafted by using solid woks software .It is multiplatform CAD/CAM/CAE software developed by DASSAULT systems.

S.NO	PARAMETERS	DIMENSIONS
1	Outer diameter	288mm
2	Inner diameter	161mm
3	Disk thickness	10mm
4	clamp holes	5

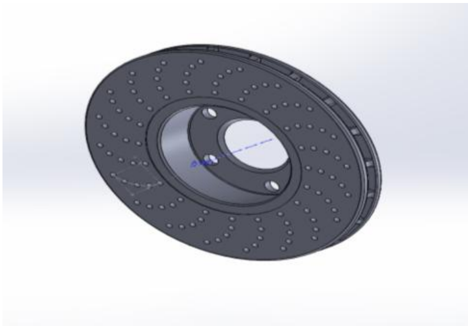

Fig 2. Design of Disc Break

IV. Results And Discussion

Aluminum

After iron, aluminium is now the second most widely used metal in the world. The properties of aluminium include: low density and therefore low weight, high strength, superior malleability, easy machining, excellent corrosion resistance and good thermal and electrical conductivity are amongst[3] aluminium's most important properties. Aluminium is also very easy to recycle.

Weight

One of the best known properties of aluminium is that it is light, with a density one third that of steel, 2,700 kg/m3. The low density of aluminium accounts for it being lightweight but this does not affect its strength.

Conductivity

Aluminium is an excellent conductor of heat and electricity. An aluminium conductor weighs approximately half as much as a copper conductor having the same conductivity.

General properties	
Thermal expansion	23.1 µm/(m·K) (at 25 °C)
Thermal conductivity	237 W/(m·K)
Electrical resistivity	28.2 nΩ·m (at 20 °C)
Magnetic ordering	paramagnetic

Structural Steel

Structural steel is a category of steel used as a construction material for making structural steel shapes. A structural steel shape is a profile, formed with a specific cross section and following certain standards for chemical composition and mechanical properties. Structural steel shapes, sizes, composition, strengths, storage practices, etc., are regulated by standards in most industrialized countries.

MATERIAL	TEMPERATURE ^{O}C	TOTAL HEAT FLUXW/M^2	DIRECTION OF HEAT FLUX W/M^2(X-AXIS)	THERMAL ERROR
Al	50	1211.8	938.76	6.0345X10^{-5}
structural steel	50	1200.7	929.77	0.00023201

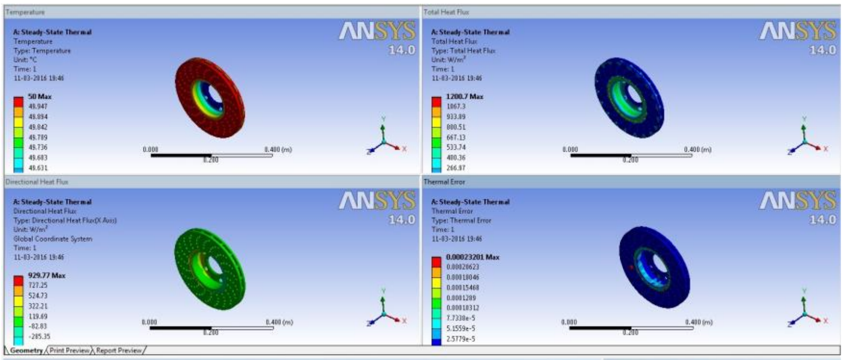

Fig 3.Shows steady state thermal analysis by using Structural steel

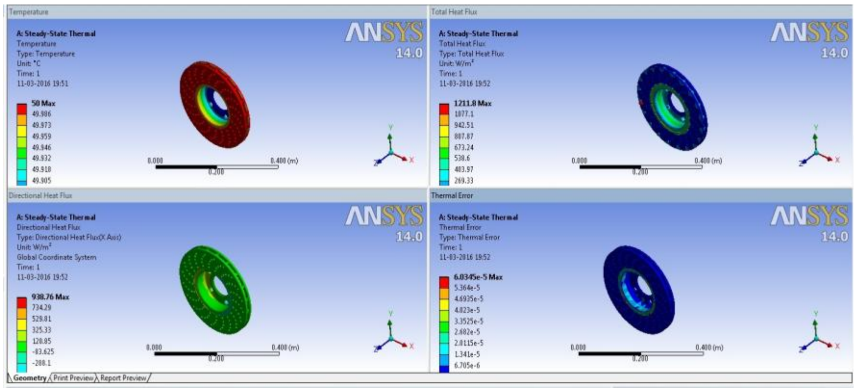

Fig 4. Shows steady state thermal analysis by using AL

V. Conclusions

An analysis of disc brake has been carried out using **20 node 187** through **ANSYS (F.E.A)** software. A steady thermal analysis is carried out**.** The maximum temperature applied for disc break is 50^{o}c for the materials 1,2. Steady state thermal analysis is carried for determine the total heat flux which will damage the rotar disc plate. Convection heat transfer co-efficient is applied for determine the total heat flux density. It is observed that when convection heat transfer is applied to al & structural steel thermal heat flux is less in structural steel when compared to al .So it is concluded that structural steel is best when compared to al.

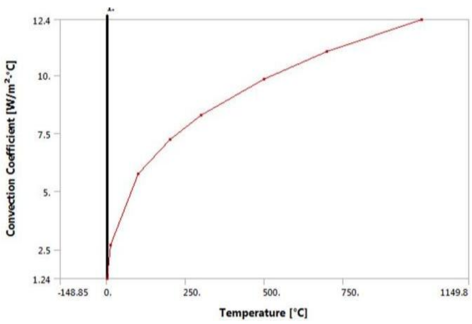

Fig 5. Shows convection heat tranfer

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