IJISET - International Journal of Innovative Science, Engineering & Technology, Vol. 2 Issue 3, March 2015.
www.ijiset.com
ISSN 2348 – 7968

DESIGN AND OPTIMIZATION OF VENTILATED DISC BRAKE FOR HEAT DISSIPATION

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Abstract

Braking is a process of converting kinetic energy of the moving object into heat energy. It is done by the process of producing friction to stop or slow down the moving object in case of automobiles. The heat produced is stored and later conduct into the air. But during hard braking and routine braking increase its thermal stress, hence this frictional heat stored in the disc would cause excessive temperature .lead to most undesirable effects such as premature wear, elastic instability and brake vibrations. In order to minimize this ventilated disc is used to maximize the heat dissipation. Here various shapes are used as ventilated holes. The modeling is done by SOLIDWORKS and the thermal and structural analysis of disc brake rotor is done using ANSYS , which is a dedicated finite element package used for determining the temperature distribution, variation of the stresses and deformation across the disc brake profile. The best type of Disc brake has been suggested based on the magnitude of Von misses stresses, temperature distribution and deformation.

Keywords- *Disc brake, Heat dissipation, Ventilated holes, Finite element method*

1. INTRODUCTION

Disc brake is one of the types of brake which uses calipers to push the stationary pads to hold the rotating disc produce a friction. Friction slow down the rotation of disc which is attached to the wheel or axle .brakes converts the kinetic energy into the heat and too much of heat cause the ineffective braking known as brake fade. The brake disc made of the aluminum matrix composites. Swapnil R. Abhang, D.P.Bhaskar[4], suggested composite material is more efficient than the cast iron material by thermal and modal analysis to calculate heat flux and deflection. Based on it the composite material can be used for effective braking effect. M.A. Maleque et al [6], analyzed the material to be selected based on the mechanical properties such as compressive strength, friction coefficient, wear resistance, thermal conductivity, specific gravity and cost results aluminum metal matrix is more efficient material to be used as the best material for brake disc. Material change alone won't help in maximizing the heat dissipation of the disc brake .hence solid brake has been made into ventilated disc brake. Conventional ventilated disc brake has circular profile. Hence various profile like circular, square, hexagon, etc... are used to find out maximum heat dissipated and less deformed shape as each profile is analyzed. Thermal and static analysis was done on each profile.

2. THEORETICAL CALCULATION

The Specification of Maruthi Swift car is taken for calculating the heat flux created during maximum speed condition. The maximum friction force created will be found to find the deceleration to find the time taken to stop the vehicle.

Table-1 Disc specification

Disc diameter(D)	240mm
Disc material	Aluminum metal matrix
Coefficient of friction(μ)	0.7
Mass of the vehicle(M)	1400 kg
Maximum speed (V)	45.833 m/s
Acceleration due to gravity (g)	9.81 m/s^2
Area of the disc (A)	0.03573m^2

$F=\mu.M.g$ …… (1)

$= (0.7) (1480) (9.81)$

$=10163.16$ N

Hence deceleration of the vehicle is

$a=F/M$ …… (2)

$=10163.16/1480$

$=6.87 m/s^2$

Time taken to stop the vehicle is

$t=v/a$

$=45.833/6.87$

$=6.67$s.

In this case it is assumed that entire Kinetic energy is converted into heat energy hence Kinetic energy is

$K.E=0.5.M.V^2$ …….. (4)

$=0.5(1480) (45.83^2) =1554.502$KJ

As its kinetic energy is entirely converted which lasts for 6seconds the power produced will be

ISSN 2348 – 7968

P=K.E/t ….. (5)
=1554.502/6.67=233.059 KW

Since about only 60% of the mass of the vehicle will be on the front, the power is reduced.

P=233.059(0.60)/2=69917.66 W

Heat flux is defined as heat power per unit time and per unit area. Hence heat flux will be

H.F=P/t/A …….. (6)
=69917.66/6.67/0.03573
=293378.326 W/m^2

3. Modeling

The modeling of the disc profile is done using solidworks. The conventional ventilated disc is of circle profile and the various profiles have been generated as the same area is selected for other profiles. Hence square, hexagon and circle profile have been modeled.

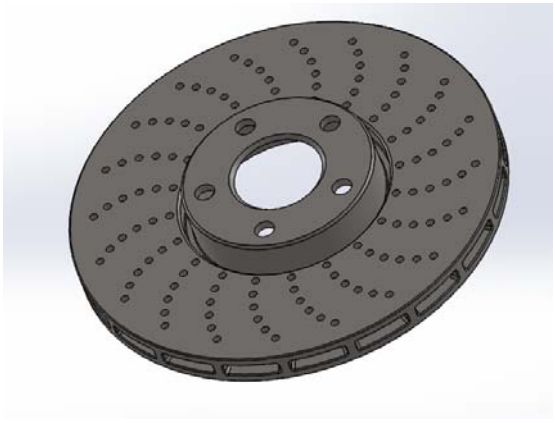

Figure-1 ventilated disc brake with circular profile

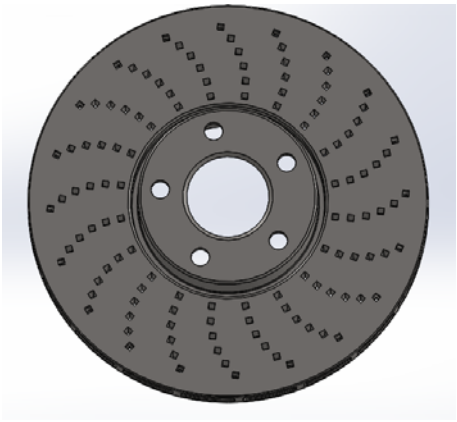

Figure-2ventilated disc brake with square profile

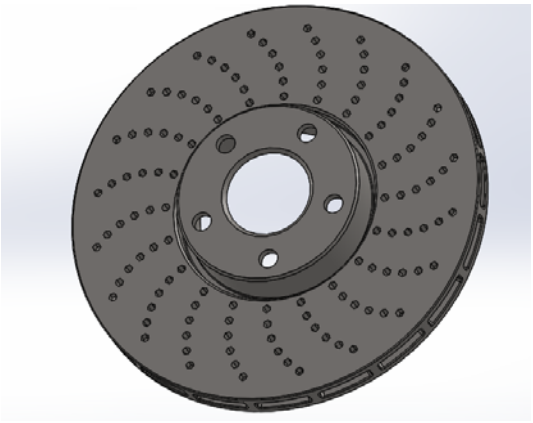

Figure-3 ventilated disc brake with hexagon profile

4. Analysis

The analysis is done using Ansys workbench module.

The various profile of same area yield same deformation in the disc.The model is taken into steady state thermal analysis.

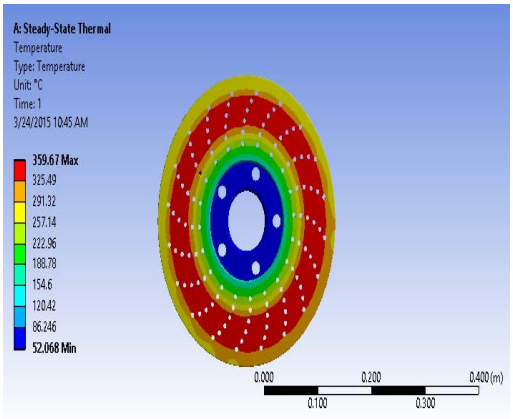

Figure-4 Thermal analysis of circular profile

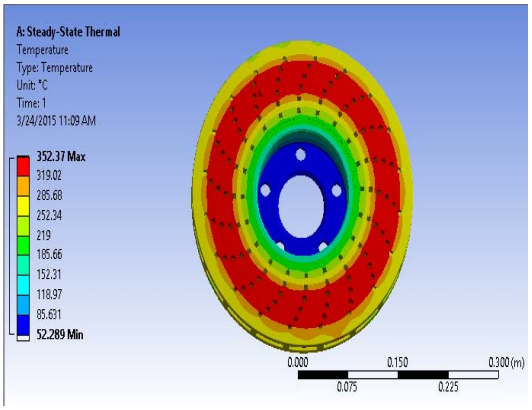

Figure-5 Thermal analysis of square profile

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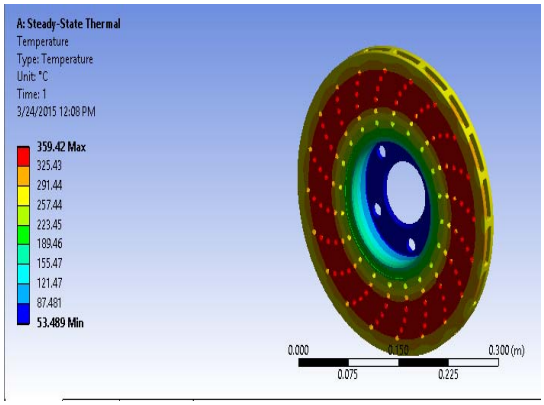

Figure-6 Thermal analysis of Hexagon profile

5. Results and Inference

In this work, the disc of aluminum metal matrix composite material with various profiles of ventilated holes of same area is taken into investigation. various profiles as circle, hexagon and square have been used and found that disc with square profile is best to be used for disc in terms of heat dissipation.

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