

# Transient Thermal Analysis of the Disc of Disc Brake

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**Abstract:** To improve the performance of the Disc Brake under various braking condition the Thermal Analysis is needed, to calculate Heat flux and Temperature of the Disc. An Investigation into usage of new material is important to increase our resource and to improve braking effect. The suitable composite material have lower in density so that the weight of the Disc is reduce as compare to use of Gray Cast Iron . The Analysis is done by using Ansys 15.0 software.

**Keywords:** Disc of Disc brake, Ansys, Heat Flux

## 1. Introduction

In a Disc brake system a set of pads is pressed against a rotating disc and due to friction, heat is generated at the disc-pad interface by the action brake is applied ,This heat ultimately transfers to the environment by convection & the disc cools down. The rate of cooling is depends upon thermal conductivity of material (k), heat transfer coefficient (h) & surrounding condition. High thermal conductivity material easily transfers heat from one faces to another face then they are released to the environment. When vehicle is in motion then heat transfer to environment by forced convection and after braking action is comes under natural convection.

### 1) Disc of Disc Brake

The Discs are commonly of Gray Cast Iron, It is used because of having good compressive strength, easily available, lower in cost and lower machining cost but it has lower thermal properties as compare to composite of Aluminium. For efficient Disc brake we should have to analysis the disc with different material after analysis take suitable material for Disc.3D model of Disc is create in Catia V5R20 The following materials are –

- Gray Cast Iron
- Structural Steel
- Aluminium Alloy
- Aluminium Metal Matrix Composite

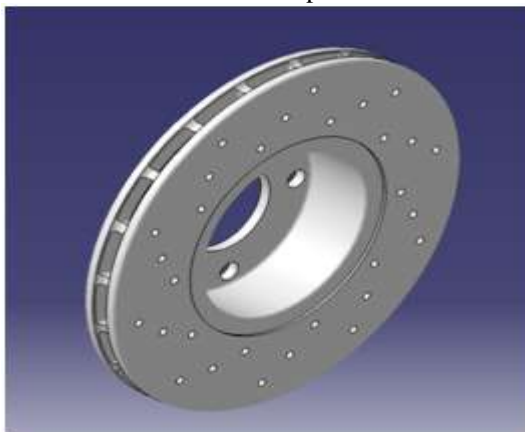


Figure 1: Isometric view of Disc

- Gray Cast Iron – It contains more than 95% Iron, 1.5-4.3 % carbon, 0.3-5% silicon and small amount of sulphur, manganese & phosphorus.
- Aluminium Alloy – It is have 85% of Aluminium, 4-5% silicon and other alloying elements are copper, magnesium, manganese, tin & zinc.
- Structural Steel – It is an alloy of Iron, Carbon and other. Carbon 0.23%, Manganese 1.60% Phosphorus 0.05%, Sulphur 0.05%, Silicon 0.05%.
- Aluminium Metal Matrix Composite – It is a Aluminium Oxide, which contains 95% Aluminium and rest part contains Ceramic, Graphite & semiconducting material.

### 2) Analysis of Disc

To perform transient thermal analysis, we should have to calculate the final temperature of the disc, for which we have to calculate total energy of vehicle,

If  $\Delta E$  is Total energy  
 U is initial velocity  
 V is final velocity  
 m is mass of vehicle

$$\text{So } \Delta E = \frac{1}{2} m \cdot (V^2 - U^2) \quad (1)$$

{to stop a vehicle the final velocity is zero}

If  $m = 1000 \text{ Kg}$   
 $U = 160 \text{ Km/Hr}$   
 $= 160 \times 1000 / 3600$   
 $= 44.44 \text{ m/s} \approx 45 \text{ m/s}$

$V = 0 \text{ m/s}$

$$\begin{aligned} \Delta E &= \frac{1}{2} \times 1000 \times (0 - 45^2) \\ &= 1012500 \text{ J} \\ &= 1012500000 \text{ g.m}^2/\text{s}^2 \end{aligned}$$

Now final temperature of disc-

$$\Delta E = m_d \times C \times (T_f - T_i) \quad (2)$$

Where-

$m_d$  - mass of disc (g)  
 C - Specific heat (g /Kg.k)  
 $T_f$  - Final temp. (°C)  
 $T_i$  - Initial temp (°C)

**i. Gray Cast Iron-**

$m_d = 9.22 \text{ Kg}$   
 $C = 447 \text{ g /Kg.k}$   
 $T_i = 22^\circ \text{C}$

From equation (2)

$$T_f = T_i + \frac{\Delta E}{m_d \times C}$$

$$= [1012500000 / 9220 \times 447 + 22]$$

$$= 268^\circ \text{C}$$

**ii. Structural Steel**

$m_d = 10 \text{ Kg/}$   
 $C = 434 \text{ g /Kg.k}$   
 $T_i = 22^\circ \text{C}$   
 $T_f = [1012500000 / 10000 \times 434] + 22$   
 $= 225^\circ \text{C}$

**iii. Aluminium Alloy**

$m_d = 3.551 \text{ Kg}$   
 $C = 875 \text{ g /Kg.k}$   
 $T_i = 22^\circ \text{C}$   
 $T_f = [1012500000 / 3551 \times 875] + 22$   
 $= 345^\circ \text{C}$

**iv. Aluminium Metal Matrix Composite -**

$m_d = 4.718 \text{ Kg}$   
 $C = 439 \text{ g / Kg.k}$   
 $T_i = 22^\circ \text{C}$   
 $T_f = [1012500000 / 4718 \times 439] + 22$   
 $= 490^\circ \text{C}$

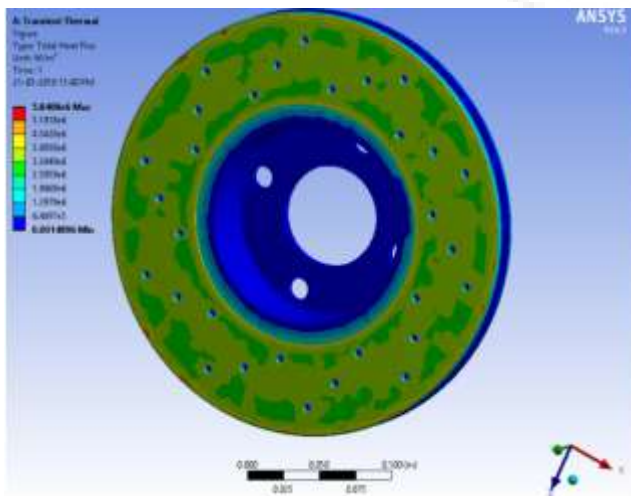
**3) Thermal Analysis:**

Ansys 14.0 software is used to calculate total Heat Flux, in which we take surrounding temperature  $22^\circ \text{C}$ .

**a) Gray Cast Iron**

**Table 1: Result of Gray Cast Iron**

Object Name	Total Heat Flux	Temperature
State	Solved	
<b>Results</b>		
Minimum	1.4896e-003 W/m <sup>2</sup>	19.084 °C
Maximum	5.8408e+006 W/m <sup>2</sup>	268. °C



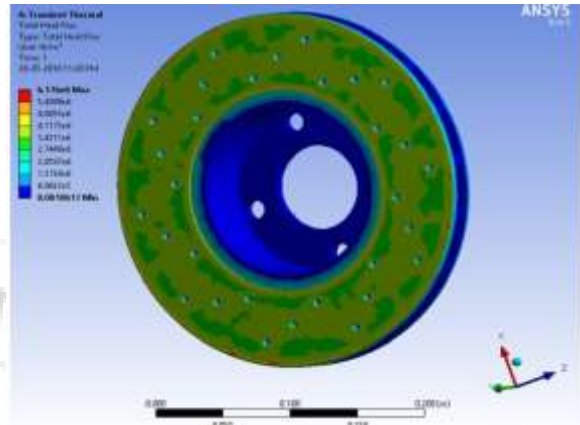
**Figure 2:** Transient Thermal Analysis of Disc using Gray Cast Iron material (Total Heat Flux)

Figure 2 Transient Thermal Analysis of Disc Using Gray Cast Iron material (Total Heat Flux)

**b) Structural Steel:**

**Table 2: Result of Structural Steel**

Object Name	Total Heat Flux	Temperature
State	Solved	
<b>Results</b>		
Minimum	1.0617e-003 W/m <sup>2</sup>	20.143 °C
Maximum	6.176e+006 W/m <sup>2</sup>	255. °C

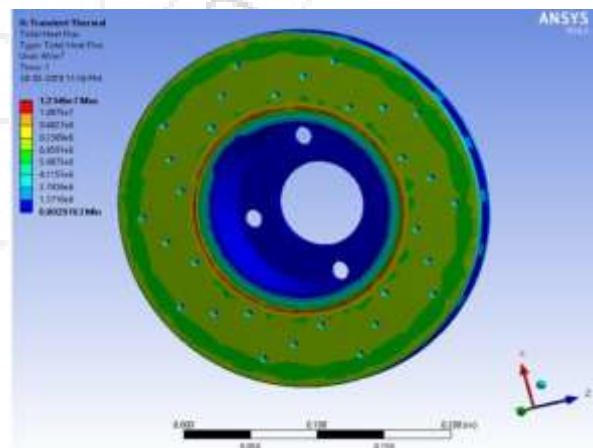


**Figure 3:** Transient Thermal Analysis of Disc Using Structural Steel (Total Heat Flux)

**c) Aluminium Alloy:**

**Table 3: Result of Aluminium Alloy**

Object Name	Total Heat Flux	Temperature
State	Solved	
<b>Results</b>		
Minimum	2.9763e-003 W/m <sup>2</sup>	22. °C
Maximum	1.2346e+007 W/m <sup>2</sup>	345. °C

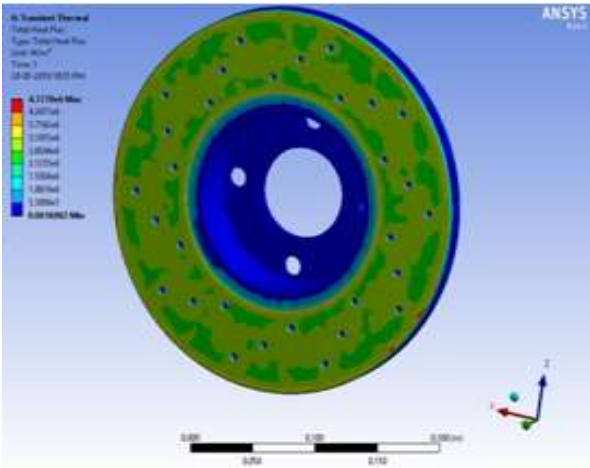


**Figure 4:** Transient Thermal Analysis of Disc Using Aluminium Alloy (Total Heat Flux)

**d) Aluminium Metal Matrix Composite**

**Table 4: Result of Aluminium Metal Matrix Composite**

Object Name	Total Heat Flux	Temperature
State	Solved	
<b>Results</b>		
Minimum	1.6902e-003 W/m <sup>2</sup>	12.526 °C
Maximum	4.7779e+006 W/m <sup>2</sup>	490. °C



**Figure 5:** Transient Thermal Analysis of Disc Using Aluminium Metal Matrix Composite (Total Heat Flux)

**Table 7:** Output Result of Aluminium Metal Matrix Composite material

	Max. Heat Flux(W/m <sup>2</sup> )	Min. Heat Flux (W/m <sup>2</sup> )
Ventilated Disc	4.77×10 <sup>6</sup>	1.69×10 <sup>-3</sup>
Solid Disc	5.123×10 <sup>6</sup>	1.11×10 <sup>-3</sup>

### 3. Conclusion

In the present Gray Cast Iron material Disc is mostly used , After analysis we found that the Aluminium Metal Matrix Composite material is better than Gray Cast Iron because it produce lower amount of heat flux and lower in weight & has good Yield strength and density properties ,it has been investigated. Ventilated Disc is more efficient as compare to solid, so that it is used instead of solid Disc, and also use of different material increases our resource of material.

### References

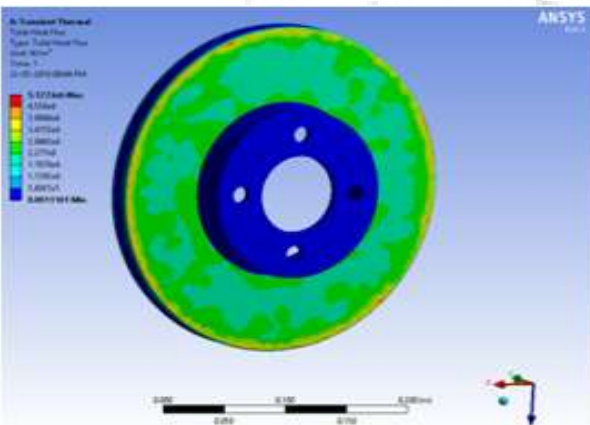
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### e) Analysis of Solid Disc using Aluminium Metal Matrix Composite material

Variation of Heat flux in solid disc

**Table 5:** Result of Solid Disc

Object Name	Total Heat Flux	Temperature
State	Solved	
<b>Results</b>		
Minimum	1.1101e-003 W/m <sup>2</sup>	5.2247 °C
Maximum	5.1233e+006 W/m <sup>2</sup>	490. °C



**Figure 6:** Transient Thermal Analysis of Solid Disc Using Aluminium Metal Matrix Composite (Total Heat Flux)

### 2. Final Result

Analysis shows that the Aluminium Metal Matrix Composite material produce lower amount of heat fluxes as compare to other. The Aluminium Metal Matrix Composite material is lighter than Gray cast iron and has good Yield strength and density properties. Ventilated Disc is more efficient and has lower Heat Flux as compare to solid Disc.

**Table 6:** Output Result of Ventilated Disc

S. No.	Material	Total Heat Flux (W/m <sup>2</sup> )	Weight (Kg)
1	Gray Cast Iron	5.84×10 <sup>6</sup>	9.22
2	Stainless Steel	6.176×10 <sup>6</sup>	10
3	Aluminium Alloy	12.34×10 <sup>6</sup>	3.551
4	Aluminium Metal Matrix Composite	4.77×10 <sup>6</sup>	4.718