

**MADHAV INSTITUTE OF TECHNOLOGY & SCIENCE, GWALIOR (M.P.)**  
(A Govt. Added UGC Autonomous and NAAC Accredited Institute, Affiliated to R.G.P.V,  
Bhopal)



## **SKILL BASED REPORT**

### **HEAT AND MASS TRANSFER**

**TOPIC :-Thermal Conductivity of Brake Pads:  
Semi-Metallic vs Ceramic**

**SUBMITTED TO:-**

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## INTRODUCTION

The undeniable importance of braking power to the safe operation of an automobile has led to on-going research into the optimal properties of materials for modern braking systems.

In its simplest form, brakes work by first converting the kinetic energy of your vehicle's motion to heat and then dissipating that heat to the atmosphere. The major component of importance in modern braking systems are the **brake pads**. Brake pads were traditionally made from pure metals due to their high thermal conductivities resulting in their uncanny ability to resist thermal stress and dissipate generated heat. Unfortunately, metal-based components can carry a significant weight and in-turn lower overall efficiency. Today, most brake pads have since been replaced by semi-metallic, ceramic or organic based composites to overcome the drawbacks of pure metals. A brief overview of the various brake pad types can be seen in Table 1, below.

**Table 1: Brake Pad Types and Considerations**

Type	Consideration
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Semi-Metallic	<ul style="list-style-type: none"><li>- Very durable</li><li>- Excellent thermal properties</li><li>- Tend to be noisy</li></ul>
	<ul style="list-style-type: none"><li>- Can under-perform at low temperatures</li></ul>
Non-Asbestos Organic (NAO)	<ul style="list-style-type: none"><li>- Softer and create less noise than Semi-Metallic</li><li>- Not as durable</li><li>- Create significantly more dust</li></ul>
Low-Metallic NAO	<ul style="list-style-type: none"><li>- Less noisy than Semi-Metallic</li><li>- Great thermal properties</li><li>- More durable than NAO</li></ul>

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Ceramic

- Typically most expensive
- Extremely durable
- Great thermal properties
- Low noise
- Low dust

## Thermal Conductivity of Brake Pads: Semi-Metallic vs Ceramic

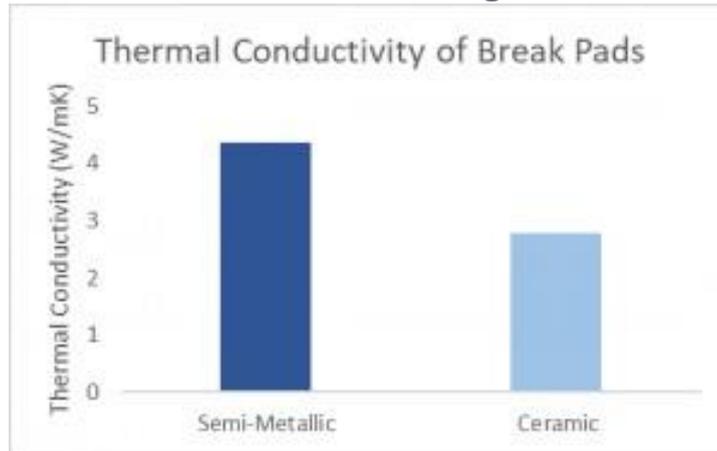
While there are many considerations to take into account (see above), ultimately stopping power can be most strongly related to thermal conductivity. To illustrate its ability to accurately and precisely test various brake pad materials, a C-Therm Trident Thermal Conductivity Analyzer was utilised with the Transient Plane Source (TPS) configuration operating in accordance to ISO 22007-2 to compare semi-metallic to ceramic brake pads (see Figure 1 & 2). Both sets of pads are base level units (<100\$), however it should be noted the ceramic pads were ~20% more expensive. For testing of these samples the reported results are the average of five tests.



**Figure 1: Semi-Metallic Brake Pad**



**Figure 2: Ceramic Brake Pad**



**Figure 3: Thermal Conductivity of Semi-Metallic and Ceramic Brake Pads**

As can be seen from figure 3 above, the semi-metallic pads resulted in thermal conductivity of 4.36 W/mK, whereas the ceramic pads were only about 2.79 W/mK (44% difference). Trident's TPS configuration was the optimal way to test these brake pads due to the hard and rigid nature of the samples. While not reported herein, it should be noted that C-Therm's TPS module also simultaneously collects and displays diffusivity data for applications where both are required. All testing had a precision of better than 1.7%.

## **SUMMARY**

The above results clearly demonstrate the superior thermal properties of semi-metallics over ceramics as well as coming in at a lower price point. Ultimately the higher thermal conductivity will result in an improved stopping performance as it can better dissipate the generated heat and lower the net thermal stress on the braking system.