Composites in Automotive Applications: Review on brake pads and discs

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Composites in Automotive Applications: Review on brake pads and discs

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Brake system

2 types of brakes
a) the drum/shoe brakes
b) the disc/pad brakes

Design requirements
- exceptional frictional properties
- low wear rate
- high thermal conductivity
- resistance to environmental conditions
- increased durability
- low weight, noise production and cost

Brake pads

- Complex structure

- Composite material of 4 main components:
  a. **binder**: holds the components together
  b. **structural materials**: provide strength
     metal, glass, Kevlar, carbon, ceramic or natural fibres
  c. **fillers**
  d. **additives**: abrasives and lubricants

Brake pad materials

- Metallic pads
  metallic matrix reinforced with steel, copper or other metals

*high strength*
*high thermal conductivity*

great wear damage
increased squeal noise
vulnerable to corrosion

Brake pad materials

- Semi-metallic pads
  combination of metals and organic materials

  - Good friction properties
  - High thermal conductivity

  - Significant wear damage
  - Increased squeal noise
  - Vulnerable to corrosion

Brake pad materials

- Non-asbestos organic or Ceramic pads
  organic matrix reinforced with aramid, Kevlar, glass or ceramic fibres

  *high strength*
  *high thermal resistance*
  *high wear resistance*
  *lightweight*
  *low level of noise*

- Quite brittle
- Increased wear in high temperatures

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Brake pad materials

- **Carbon-carbon pads**
  - similar to ceramics **but** with superior properties

  - high friction properties
  - high thermal resistance
  - high wear resistance
  - lightweight

  - not efficient at low temperatures
  - high cost (material & manufacture)

Brake pad materials

- Eco-friendly materials
  - Use of natural fibres such as sisal, flax, hemp kenaf, jute, coconut shell, banana peels or palm kernel fibres as reinforcement
  - High mechanical properties
  - Stable friction
  - High wear resistance
  - Lightweight
  - Low environmental impact
  - Low cost
  - Tend to agglomerate at mixing
  - Wear from environmental conditions

Brake discs

Characteristics

- high friction properties
- low wear rate
- high thermal capacity to prevent distortion or cracking

- Cast iron
  + high strength
  + high thermal conductivity
  + high wear resistance
  + low cost
  - heavy weight

# Brake discs

| Al-metal matrix composites | + high strength  
|                          | + high thermal conductivity  
|                          | + high wear resistance  
|                          | + lightweight  
|                          | + high rate of heat dissipation  
| Ti-metal matrix composites | + resistance to corrosion  
|                          | - low wear resistance  
|                          | - low load capacity $\Rightarrow$ surface modification  
| Ceramic composites | + high friction properties  
|                          | + high thermal properties  
|                          | + lightweight  
|                          | + perform at high temperatures  
|                          | - brittle  
| Carbon-carbon composites | + thermal conductivity  
|                          | + lightweight  
|                          | - high cost  

Conclusions

Composites are widely used in the automotive brake system

- ceramic composites are the most commonly used brake pads
- carbon-carbon pads exhibit superior properties but their cost is currently very high
- eco-friendly materials in brake pads seems promising, though there are still issues that need to be addressed (i.e. wear from environmental conditions)
- metal matrix, ceramic matrix and carbon-carbon composites are mainly used in brake discs
- carbon-carbon discs are very expensive, used only in sports cars

The combination of the material of the pads and that of the disc is critical to achieve the desirable performance of the system.
Thank You!