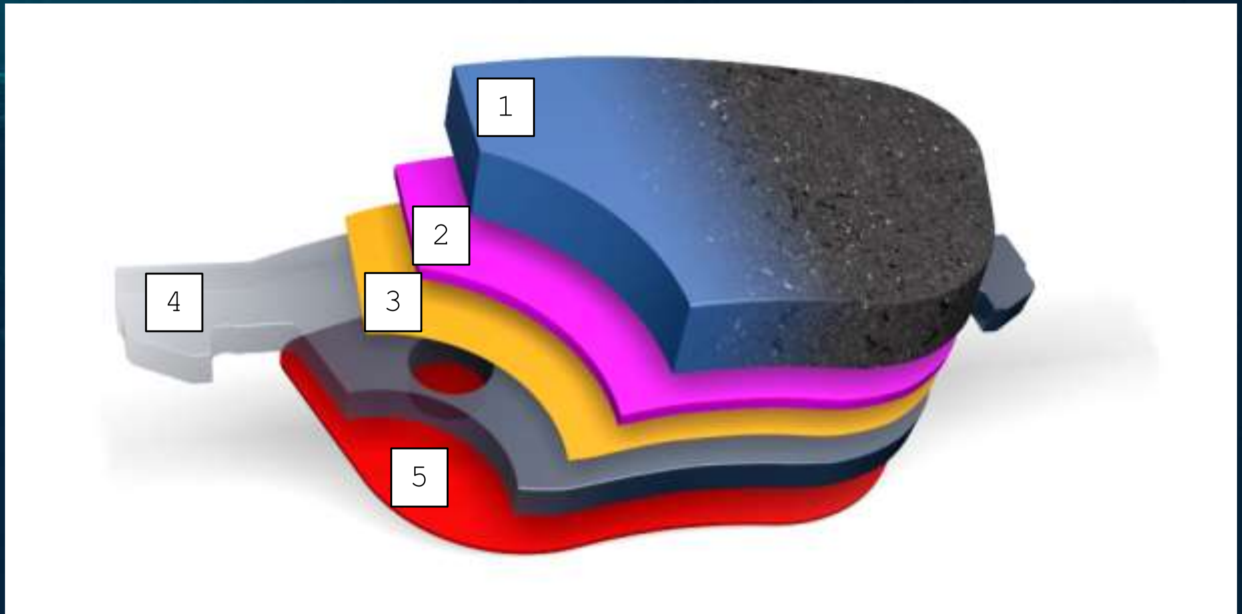
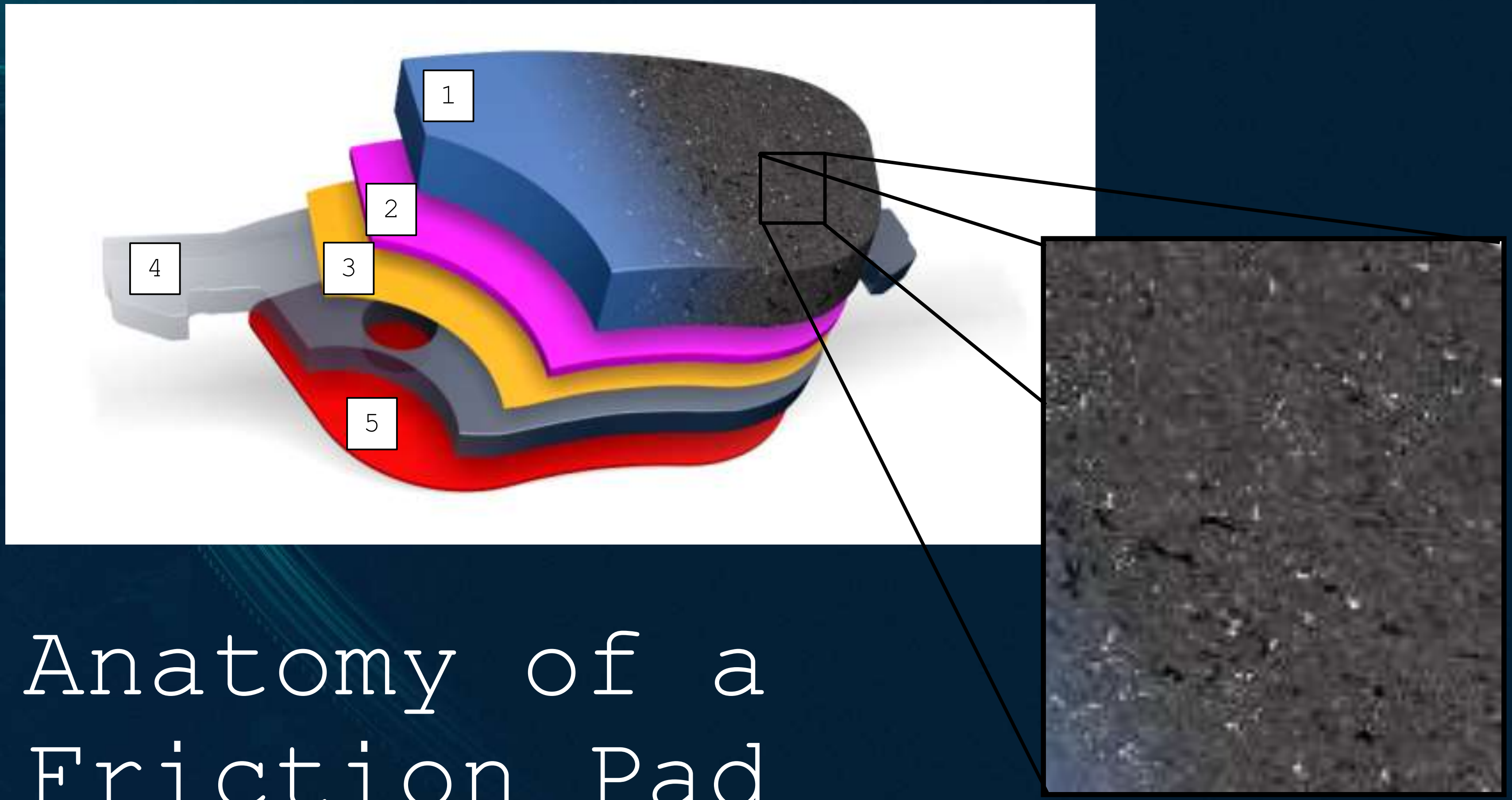
Pads description

02/12/2025



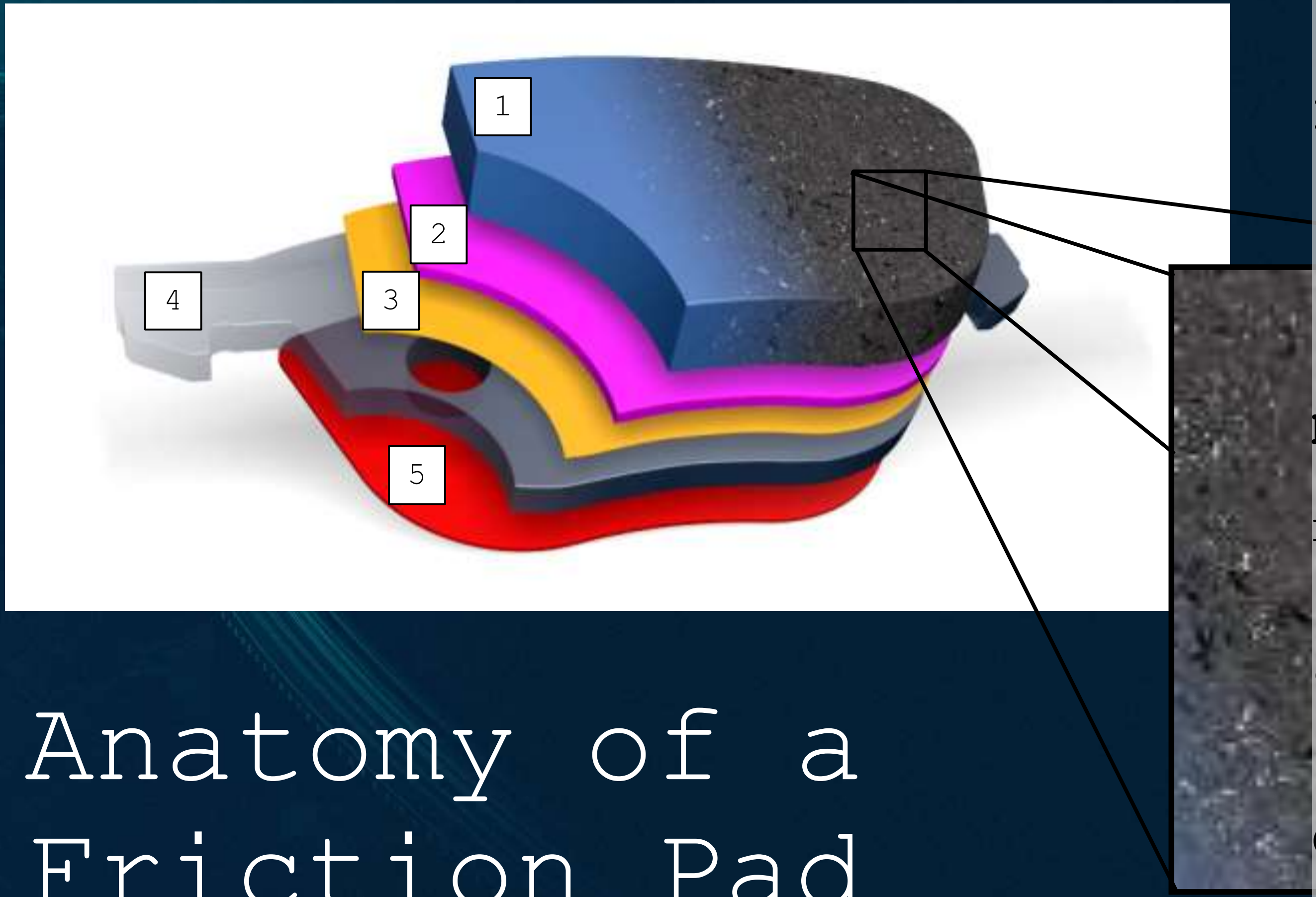
Anatomy of a Friction Pad

1. Friction Material
   - Contact to counter part
   - Contribute mostly the friction properties
2. Underlayer
   - Bonding
   - Compressibility
   - Thermal insulation
   - Noise reduction
3. Adhesive
   - Adhesion to backing plate
4. Backing Plate
   - Carrier for friction material
   - Distributes pressure from brake piston
5. NVH Shim
   - Noise reduction



Anatomy of a Friction Pad

What is a friction material made of?



Anatomy of a Friction Pad

Binder – typically phenolic resin used to bind the structure together

Friction Modifiers – raise, lower or stabilize friction level in addition to modifying wear characteristics (i.e., abrasives, lubricants)

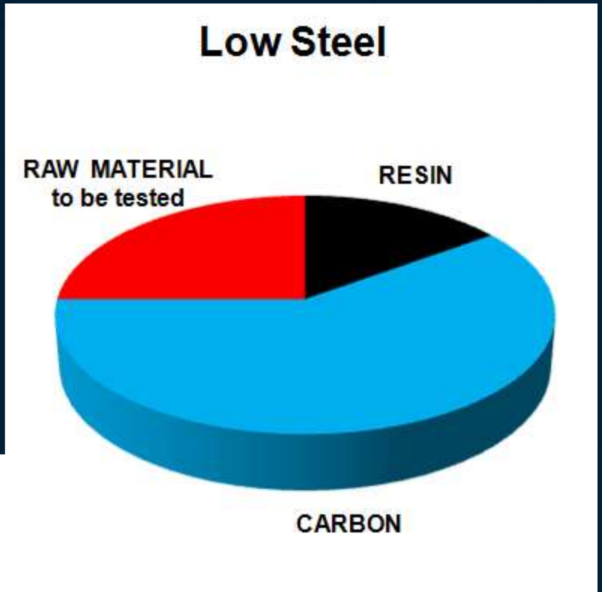
Metals – multi-functional constituents strengthen the material, increase thermal conductivity, increase the friction level and contribute to the deposition of "third body" layers (i.e., transfer film)

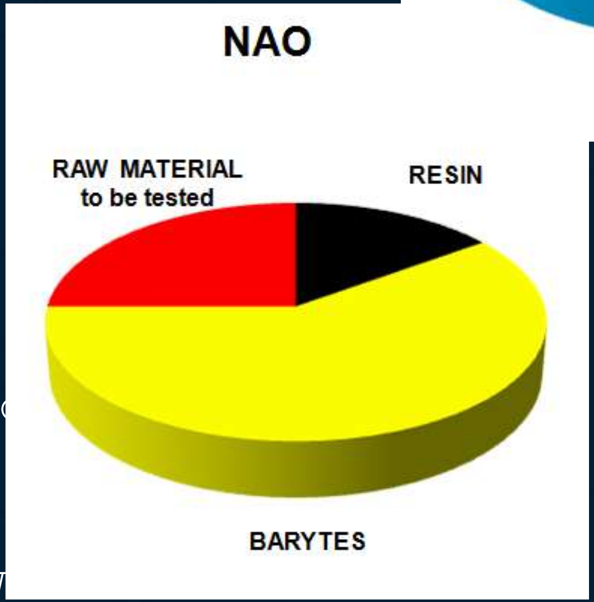
Organic / Inorganic Fibers – multi-functional constituents aid in the green strength of the friction material or providing reinforcement to the matrix

Fillers – constituents added to help control cost while minimizing

Raw Material Portfolio Development

- A standardized formulation representing the low steel back bone and the NAO back bone is used for the tribological fingerprinting
- A standardized coke is used as the back bone for the low steel formulation
- A standardized barytes is used as the back bone for NAO formulations
- The formulation is a defined limited raw material composition with a exaggerated amount of the raw material to investigate





> 1400 different raw materials are investigated in F-M database

Wear mechanism in friction

- Abrasive wear → cutting, ridging, ripping, grooving – harder surface rough
- Adhesive wear → material shearing, material transfer (film creation)
- Oxidative wear → creation of oxide layers on surface of friction components
- Ablative wear → thermal degradation of friction partners

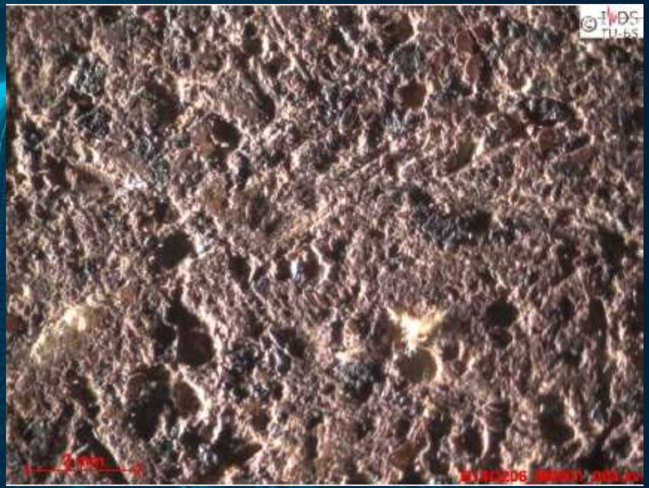
Friction is created by relative movement of two friction partners against each other under load

Movement creates wear particles → increase real contact area → increase friction

Tribology – friction & wear mechanism

- Friction is created by relative movement of two friction partners against each other under load
- Movement creates wear particles → increase real contact area → increase friction

- NAO



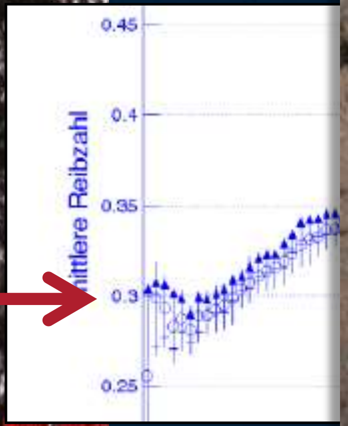
- Pad surface new
- Rough

- Pad surface used
- Smooth
- Closed film

Tribology – friction & wear mechanism

- Friction is created by relative movement of two friction partners against each other under load
- Movement creates wear particles → increase real contact area → increase friction

- Low Steel



- Pad surface new
- Rough
- LOW µ

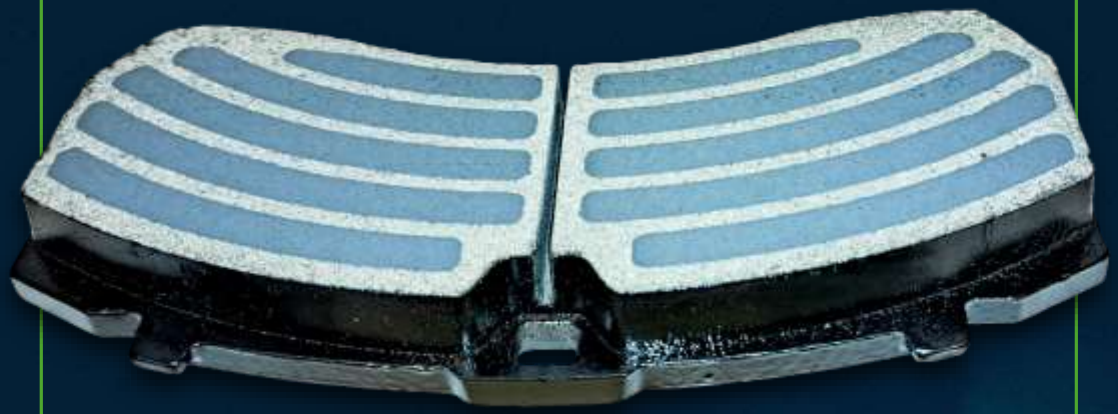
- Pad surface used
- Smooth
- Dust visible

- HIGH µ

Our journey to sustainability

Ongoing Research: Reducing CO_2 footprint via a paradigm shift in pad design & manufacturing concept.

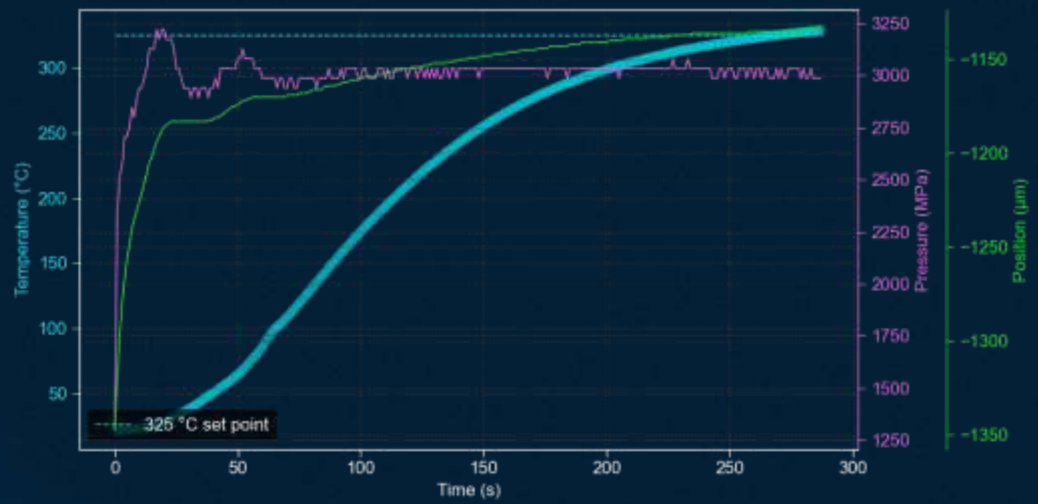
Inorganic Bond System



- Replacing the phenolic resins by an inorganic bond system
- Reduce CO_2 footprint of used materials
- Reduce Energy consumption during production process

Bond Design Verification 2025

Smart Press Technology



- Eliminate oven curing & scorching
- Control thickness change during ‘post cure’ by real-time pressure adjustment
- Control pressure and drive for constant thickness
- Potential to reduce K3 variations

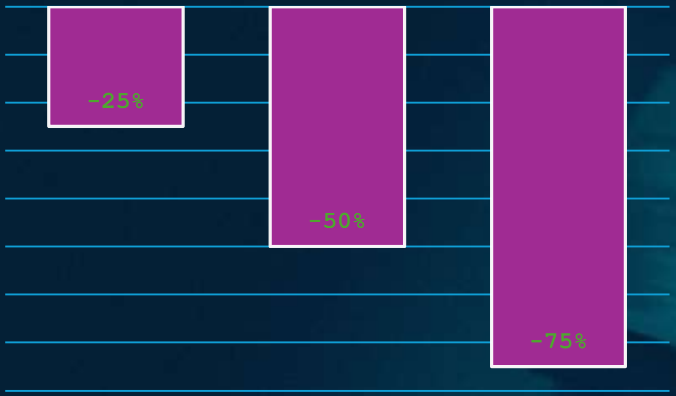
Product Verification Phase during 2025

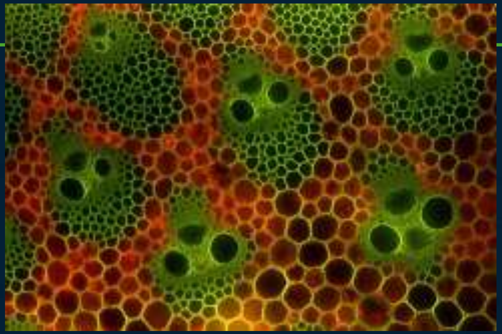
Our journey to sustainability

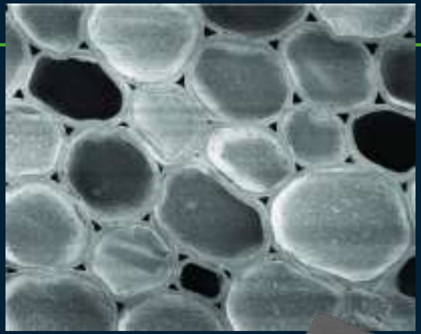
Ongoing Research: Innovative raw material selection from nature

Formulation

- Use of renewable materials
  - > Examples: Bamboo, coconut
  - > CO_2 reduction: Individually small > Combine
- Recycled raw materials
  - > Examples: Organic fibers, Fillers
- Secondary raw materials
  - > Examples: Graphite from electrode production scrap
- Naturally occurring minerals
- Use of materials from all 4 categories
  - > CO_2 reduction: Large (15-35% of friction)







Natural materials such as bamboo exhibit exceptional mechanical properties due to its hierarchical, structural features on different length scales.