Bulletin BPI 07-06

Subject: Friction technology

Vehicle Involved: All

Condition: The development, refinement, and implementation

Repair Procedure:
The purpose of brake lining/pads is to convert the kinetic energy of the vehicle in motion into heat energy. The purpose of the rotors is to dissipate that heat. Brake lining must be able to provide a stable, consistent friction level, with good wear characteristics, and low noise.

There are two types of methods used in brake friction technology: abrasive friction and adhesive friction.

1. Abrasive friction uses materials that are relatively hard. At a microscopic level, one surface will fracture the other and break off material. This type of friction material does not transfer a film from the friction to the rotor or drum. The drawbacks include poor wear characteristics, since one is abrading the other; and since the material is hard, it tends to vibrate in use causing noise.

2. Adhesive friction technology uses materials that will deform and rebound. Being somewhat elastic, the tendency for vibration and noise is reduced, and the wear characteristics are improved. This type transfers a film of friction material to the rotor or drum.

In the design of a friction material, the components to be used are chosen for the characteristics desired in the final product. While some elements will have the desired properties in their original state, others will be chosen for the altered properties exhibited in use. These physical and chemical changes occur during the heat and pressure of braking. Depending on the material or combination of materials, the changes that can occur are: melting, thermal decomposition, oxidation, reduction, and physio-chemical changes.

There are several fundamental elements in a friction material. These include: the bonding agent, fibers, fillers, friction modifiers, and specialty particles. The bonding agent is a thermal-set phenolic resin, which binds all of the other materials together. Organic and inorganic fibers are the reinforcing elements which lend strength to the mix. Fillers are neutral friction additives used for physical and thermal stability. Lubricants, (such as graphite), and abrasives are friction modifiers used to achieve the desired friction attributes. Ground rubber is

one of the specialty particles that can be used to fine-tune the desired properties of the final product.

When making a formula, all of the individual materials must be combined in exacting proportions. With some elements, even a few percentage point change in the amount will alter the characteristics of the final product. These materials vary greatly by weight, so the mass of each one must be determined. A lab instrument is used to measure the specific gravity of the compound. This will allow a specific volume to be determined, so then a weight percentage is calculated for each component of the formulation.

Special mixing machines are used to combine all of the specified materials. The mass of the material will determine the speed of the mixer and at what point in the process the material will be added.

Brake lining material is attached to a metal plate with the properly shaped molds of the brake pad puck. This mixed compound, in a very carefully measured quantity, is poured into the molds. Using a specialized oven-like press, the pad material is pressed and heated to a pre-determined temperature and pressure for an exact amount of time. These are then removed from the molds and allowed to cool. Application-specific grinding, chamfering, and slotting operations are then performed. They are now ready for testing purposes. Results are compiled and compared to the parameters that were expected to be met. The formula is tweaked for improvements and retested, or it is sent to the friction manufacturing facility.

R & D is a critical part of the development, testing, and auditing of premium friction materials. Our friction facility can test raw materials, develop and implement new formulations, and audit existing products. The center is equipped with lab equipment for assessing the compatibility of raw materials to specifications, a test lab to audit products from manufacturing and the field, and a dynamometer lab to test products for noise, durability, and compliance to industry and government standards. Manufacturing equipment is utilized on site that is identical to what is used at the friction plants, but on a smaller scale.

Vehicles are acquired to test products on streets and highways for real world trials, as well as controlled conditions on a nearby test track. These vehicles are instrumented for brake pressure and temperature and equipped with controls to deactivate ABS or individual brakes as needed for testing.

Arrays of dynamometers are available for testing of friction, rotors and drums. They can be configured to test for compliance to standards, such as D^3EA, computer-controlled repetitive noise tests, and heat-regulated durability tests. They can measure the amount of pressure required to obtain a specific torque value, as well as record trends in repeated tests.

Some of the elements that are tested for are fade, sensitivity, stability, and noise. Fade is when it takes an increasing amount of pressure to achieve a set amount of torque as the friction heats up. If the pressure required changes to whether the pad is cool or hot relates to the sensitivity of the material. Stability refers to how the friction level maintains over the range of temperatures and wear. Noise is always present in braking; the goal is to keep the frequency of the noise out of the range of human hearing.

Rotor pulsation is a problem that has been investigated at the center. Thickness variation greater than .0004-.0005" – that's **one-half of one thousandth of an inch** – will cause a noticeable pulsation. Hub run out will not necessarily cause pulsation, but over time will cause the rotor to wear unevenly and result in thickness variation.

The goal is to provide the best possible material for products that meet the performance requirements of modern vehicles.