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TECHNICAL WHITEPAPER:

Pad and Rotor Bed-In Theory, Definitions and Procedures

Removing the Mystery from Brake Pad Bed-In

In order for any brake system to work optimally, the rotors and pads must be properly bedded-in, period. This process can also be called break-in, conditioning, or burnishing, but whatever terminology you choose, getting the brakes properly bedded-in and keeping them that way is critical to the peak performance of the entire brake system.
However, understanding why the rotors and pads need to be bedded-in is just as important as the actual process. If one understands what is happening during the bed-in process, they can tailor the process to specific pads, rotors, and/or driving conditions. For this reason, we present this generic bed-in overview pertaining to all brake systems, but follow with links to application-specific bed-in procedures to fit most every set of circumstances.

What is brake pad “bed-in” anyway?

Simply stated, bed-in is the process of depositing an even layer of brake pad material, or transfer layer, on the rubbing surface of the rotor disc. That's it. End of discussion. Ok, not really, but although bed-in is quite basic in definition, achieving this condition in practice can be quite a challenge, and the ramifications of improper or incomplete bed-in can be quite a-a-n-n-o-o-y-y-i-i-n-n-g-g.

Abrasive friction and adherent friction

There are two basic types of brake pad friction mechanisms: abrasive friction and adherent friction. In general, all pads display a bit of each, with abrasive mechanisms dominating the lower temperature ranges while adherent mechanisms come more into play as pad temperature increases. Both mechanisms allow for friction or the conversion of Kinetic energy to Thermal energy, which is the function of a brake system, by the breaking of molecular bonds in vastly different ways.

The abrasive mechanism generates friction or energy conversion by the mechanical rubbing of the brake pad material directly on the rotor disc. In a crystalline sense, the weaker of the bonds in the two different materials is broken. This obviously results in mechanical wear of both the pad and the rotor. Consequently, both pads and rotors are replaced when they are physically worn to their limit and are too thin to endure further service.

The adherent mechanism is altogether different. In an adherent system, a thin layer of brake pad material actually transfers and sticks (adheres) on to the rotor face. The layer of pad material, once evenly established on the rotor, is what actually rubs on the brake pad. The bonds that are broken, for the conversion of Kinetic to Thermal energy, are formed instantaneously before being broken again. It is this brake pad-on-transferred brake pad material interaction on a molecular level that yields the conversion process.

With the adherent mechanism there is much reduced rotor wear as compared to abrasive mechanism, but it's not a free lunch – pads now become the primary wear element in the braking system. And even though rotors are not mechanically worn down with adherent systems, they still will need to be replaced on a regular basis due to cracking reaching a point of failure if they are exposed to intense, repetitive thermal cycling. This is why race teams throw out rotors that are actually as thick or thicker than when they were brand new. It's due to the an adherent brake pad transfer layer!

The all-important transfer layer

As stated above, the objective of the bed-in process is to deposit an even layer of brake pad material, or transfer layer, on the rubbing surface of the rotor disc. Note the emphasis on the word even, as uneven pad deposits on the rotor face are the number one, and almost exclusive cause of brake judder or vibration.

Let's say that again, just so there is no misunderstanding. Uneven pad deposits on the rotor face are the number one, and almost exclusive cause of brake judder or vibration.

It only takes a small amount of thickness variation, or TV, in the transfer layer (we're only talking a few ten thousandths of an inch here) to initiate brake vibration. While the impact of an uneven transfer layer is almost imperceptible at first, as the pad starts riding the high and low spots, more and more TV will be naturally generated until the vibration is much more evident. With prolonged exposure, the high spots can become hot spots and can actually change the metallurgy of the rotor in those areas, creating “hard” spots in the rotor face that are virtually impossible to remove.

Bedding fundamentals

In general, bed-in consists of heating a brake system to its adherent temperature to allow the formation of a transfer layer. The brake system is then allowed to cool without coming to rest, resulting in an even transfer layer deposition around the rotor circumference. This procedure is typically repeated two or three times in order to ensure that the entire rotor face is evenly covered with brake pad material. Sounds easy, right? Well, it can be if you have the proper information.

Because the adherent temperature range for brake pads varies widely (typically 100°F-600°F for street pads and 600°F-1400°F for race pads), each bed-in needs to be application-specific. One could try to generate a one-size-fits-all procedure, but too little heat during bed-in keeps the material from transferring to the rotor face while overheating the system can generate uneven pad deposits due to the material breaking down and splotching (that's a technical term) on to the rotor face.

In summary, the key to a successful bed-in is to bring the pads up to their adherent operating temperature in a controlled manner and keep them there long enough to start the pad material transfer process. Different brake system designs, pad types, and driving conditions require different procedures to successfully accomplish the bed-in. The recommended procedures below should provide you with the information you need to select the bed-in procedure appropriate for your application.

by Matt Weiss and James Walker, Jr. of scR motorsports, exclusively for StopTech

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Through scR motorsports, he has been actively serving as an industry advisor to Kettering University in the fields of brake system design and brake control systems. He also serves as a brake control system consultant for StopTech, a manufacturer of high-performance racing brake systems. In addition, Mr. Walker contributes regularly to several automotive publications focusing on brake system analysis, design, and modification for racing and other high-performance applications. He is a recipient of the SAE Forest R. McFarland Award for distinction in professional development/education. Mr. Walker has a B.S. in mechanical engineering from GMI Engineering & Management Institute.

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