HIGH-PERFORMANCE BRAKE SYSTEMS

DESIGN, SELECTION AND INSTALLATION

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Front Cover:
There is more to upgrading your brake system than just shopping for the best looking parts. While aesthetics certainly are important, consideration must also be given to system-level performance. Picking the right parts is usually more complicated than physically bolting them on–they have to work together. (Randall Shafer)

Title Page:
During track use, rotors are squeezed with thousands of pounds of clamp force, twisted by thousands of foot-pounds of torque, and heated to over 1,200 degrees F. Heavy cars with large engines such as these only make the demands that much more intense. (Wayne Flynn/pdxsports.com)

Back Cover, Top:
Designing a hot rod brake system from scratch may seem intimidating at first, but the fundamental concepts of gain and balance still apply. What really differentiates these brake systems are unique design and operating requirements that may require different compromises than would be appropriate for an all-out racecar. (Randall Shafer)

Middle:
Because experience is the best teacher, the final four chapters of this book are dedicated to sharing our years of upgrade know-how with you. Whether you are upsizing your front rotors for track use or converting your muscle car from rear drum brakes to rear disc brakes, grab your wrenches and head out to the garage with us. Just be sure to wear your safety glasses! (Randall Shafer)

Bottom:
Motorsports can place extreme demands on your brake system, and if your hardware is not up to the task, performance can suffer dramatically. A solid understanding of brake system fundamentals greatly increases your likelihood of ending up in the winner's circle on race day. (Wayne Flynn/pdxsports.com)

CHAPTER 10

Brake Rotors

There's nothing that screams high-performance more than an oversized brake rotor sitting behind an open-spoke wheel wrapped in the widest rubber possible. No self-respecting automotive enthusiast would be satisfied with a 10-inch rotor tucked inside an 18-inch wheel. Bigger is always better, right?

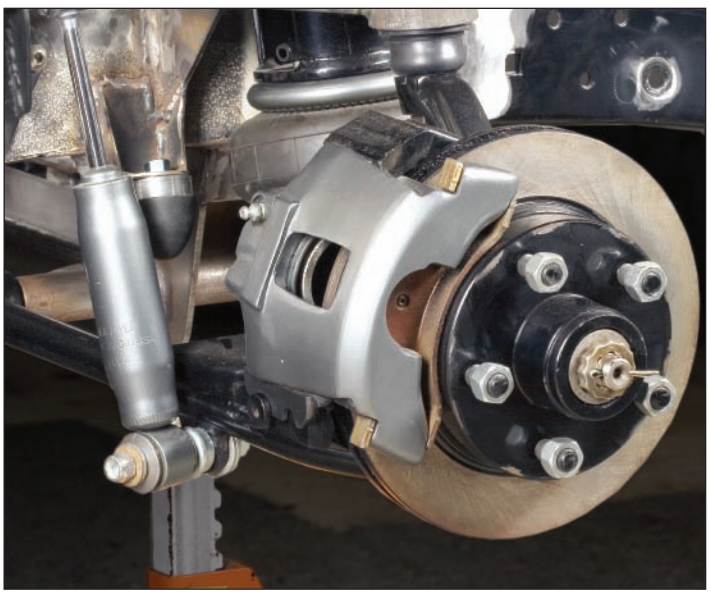
Well, yes and no. There's much more to selecting the proper brake rotor than finding one that fits. Certainly the big-brake touring-car look is desirable, but selecting the wrong rotor can actually compromise overall brake system performance. It's time to find out what it takes to get the best of both worlds.

A Rotor Refresher

Although discussed separately to this point, the rotor actually performs two functions in the brake system. First, the rotor acts as the primary heat sink during the conversion of kinetic energy to thermal energy. This is where a majority of the vehicle's kinetic energy ends up during a typical braking event, and back in Chapter 1 you learned to estimate the temperature rise of the rotors by using the following equation:

Rise in temperature (degrees F)
= kinetic energy (ft-lb) ÷
weight of the brakes (lb) ÷
77.8 (assuming cast iron)

The rotor's second function was covered in Chapter 3—it is also responsible for converting the brake pad friction force into wheel torque. Because the brake pad friction force occurs at a fixed distance from the center of the spinning



Although rotors are available in a variety of different shapes, sizes, and materials, they all share a common purpose—they must first absorb then dissipate a vehicle's kinetic energy during braking. While this rotor may be horribly undersized for a road racing application, it may fit the bill perfectly for a boulevard cruiser. (Randall Shafer)

During track use, rotors are squeezed with thousands of pounds of clamp force, twisted by thousands of foot-pounds of torque, and heated to over 1,200 degrees F. Heavy cars with large engines such as these only make the demands that much more intense. (Wayne Flynn/pdxsports.com)

rotor, the resulting wheel torque was calculated as follows:

Wheel torque (ft-lb) =
brake pad friction force (lb) x
[rotor effective radius (in)
÷ 12 (a conversion factor)]

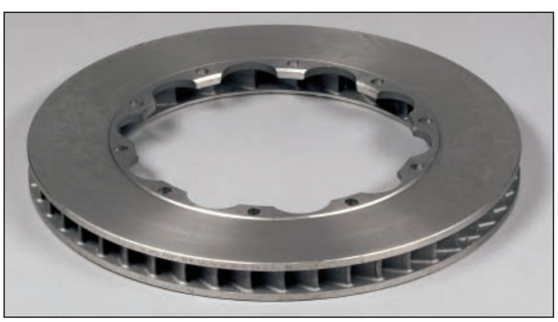
Although these tasks are quite different in nature, heat absorption and torque generation occur simultaneously. In a competitive environment, the rotor is continuously compressed with thousands of pounds of caliper clamp force, generating thousands of foot-pounds of wheel torque, all while sustaining operating temperatures well over 1,000 degrees F, lap after lap after lap. It's not easy being a rotor!

Rotor Terminology

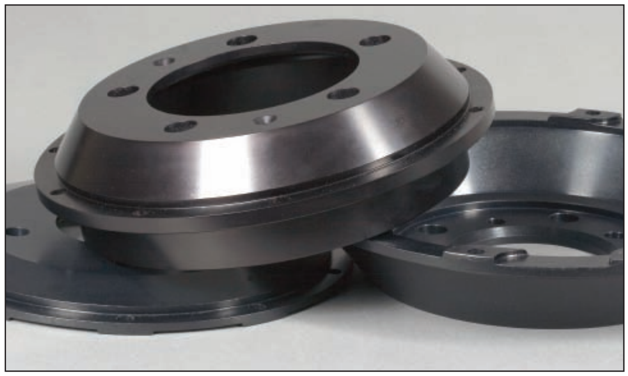
Like other parts of the brake system already discussed, a typical rotor can be broken down into several discrete components. Therefore, before going any further, it's once again necessary define the terminology.

Friction Disc

The *friction disc* is essentially the working component of the brake rotor. It's responsible for providing a mating friction surface for the brake pads, as well as supplying the thermal mass necessary for thermal energy absorption. Consequently, the friction disc experiences the highest operating temperatures of any brake system component.



The friction disc is where all the action takes place. Because of its ideal mechanical properties and reasonable cost, gray cast iron is the predominant material of choice for nearly every friction disc today. The hazy film shown covering this friction disc is a coating to prevent corrosion before installation. (Randall Shafer/StopTech)



The rotor hat couples the friction disc to the wheel hub. In many production vehicle applications, it's integral to the friction disc, but in high-performance applications, it may be a separate component. The hats shown here are machined from billet aluminum in order to reduce rotating inertia. (Randall Shafer/StopTech)

Friction discs are usually made from cast iron due to its inherent strength, energy absorption characteristics, and temperature robustness. Other materials can be used in select racing applications (more to come on this topic later in this chapter), but when comparing cost to performance, cast iron simply can't be beat.

Rotor Hat

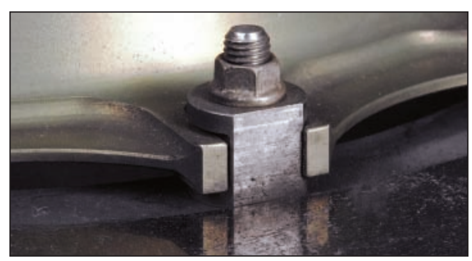
The rotor *hat*, also known as the *mounting bell*, serves to locate and attach the friction disc to the vehicle's wheel hub or spindle. In doing so, the torque generated in the friction disc is transferred by the hat to the hub, through the wheel, and ultimately to the tire contact patch.

The rotor hat can either be integral to the friction disc, or it can be a separate component assembled to the friction disc. In either case, the hat also provides the primary mechanical heat transfer path from the friction disc to other vehicle components at the wheel end.

In the quest to further reduce rotating inertia, it's possible to use rotor hats made from exotic alloys. The hat shown above (already attached to a friction disc) was machined from a magnesium alloy. While cost prohibitive, it provides the lightest rotor assembly possible. (Randall Shafer)

Integral rotor hats are made from the same material as the friction disc—cast iron in most cases. Discrete rotor hats can be made from a variety of materials, with aluminum alloys being the most common due to their low weight and relatively modest cost. In more exotic applications magnesium alloys can be employed, but these are beyond the budget of most automotive enthusiasts.

Two-piece rotors allow for relative movement between the friction disc and hat at temperature. Specialized fasteners are used to provide this freedom while simultaneously transmitting thousands of foot-pounds of brake torque. (Randall Shafer/StopTech)



Since most rotor hat mounting methods allow for some unrestricted axial motion, they may rattle around when cold. Although not present on the racing rotor shown, anti-rattle springs are typically employed on street applications. (Randall Shafer)