Subject: Re: car weight to brake size/power?
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Ok, here goes on brakes and car weight, with formulae taken from Vanvalkenburg and from Puhn (his book on brakes):

Brakes can be rated in horsepower. HP = 0.00268 X weight of car in pounds X speed in MPH X decelleration in Gs.

For a 2,000 lb car at 100 mph and 1G decelleration this gives 536 hp. For a 3,000 lb car, 804 hp. I recall seeing an advertisement or the like for a Porsche which gave its braking power in horsepower

The energy a brake system must absorb can also be calculated:

Energy (in pounds per foot) = weight in pounds X (speed 1 squared - speed 2 squared) X 0.0335. Speed is in MPH.

For a 2000 lb car decellerating from 200 mph (don't we wish), to 50 mph, 2,512,500 lbs/ft of energy has to be lost.

A caveat - at higher speeds wind resistance plays a huge role per the authorities, contributing maybe one G of decellerative force at maybe 200 mph (which is why most of our cars won't go that fast anyway). However, for the discussion of "how big do my brakes have to be" for the speeds most of us are realistically likely to see on the track, it is probably safe to ignore this factor.

As all who have commented recognize, the ability of a braking system to dissipate all this energy, which presents itself as heat, is obviously critical. Think of pedals going mushy after a few laps, or runaway trucks in the mountains - the heat limit was exceeded. But how to figure that is not my present theme.

The maximum rate of decelleration for a proper brake system is going to be set by the tires and pavement, as this will provide the G term.

Having figured that, until the brakes and other system components are able to handle the heat (given whatever air ducting you can devise), having more pad area looks like it has to be good: absorbing or transferring heat over two square inches of pad looks like it has to be better than absorbing it over one square inch - lower heat per square inch. Still the same total amount of heat, though. If your one square inch pad will achieve the max decelleration your tires can bear, corner after corner, and not wear pad or rotor excessively (as you determine that factor), why do you need larger pads?

Here is another way of looking at this. The standard equation for "stopping force," which is in pounds per foot (or pounds per inch depending on how you want to measure - looks like it would work just as well in whatever units one wanted):

Force in lbs/ft = pedal force in lbs X system force ratio X coefficient of friction between pad and rotor X effective disk radius (in ft.) X 1/tire rolling radius (in feet also).

Pedal force is how hard your leg pushes against the pedal. It is in pounds.

The system force ratio is the result of combining the mechanical force multiplicaton of your brake pedal lever (simple lever calculation) with the hydraulic force multiplication derived from comparing master cylinder piston area to caliper cylinder area. If power brakes are involved, you have to factor that in also. You will note that this still gives you pounds delivered to the calipers.

The coefficient is also a dimensionless number (unless Puhn is playing tricks here), and depends only on the properties of the iron disk and the pad material.

The terms for effective disk radius and tire rolling radius account for the leverage effects. You can see from them a good feature of low aspect ratio tires - you can get the disk radius to be closer to the tire radius, which will make the brakes work better. This is where the "foot" or distance term comes from, and is why our force is in lbs/ft.

Now applying this in designing a brake system from scratch can get more complex, because you have weight transfer from rear to front based on CG height and wheel base length, and the force ratios typically are different in the front as opposed to the rear brakes, etc. I don't claim to have tried this.

But what leaps out of this formula is the fact that it says precisely nothing about brake pad size. How can this be? Won't a bigger pad brake harder than a smaller pad? The answer (based on the formula) is that it won't. Again, remember we are by definition talking of a "smaller" pad which is big enough to handle the heat. Here is how it works out, I think:

Imagine our 100 lb foot on the brake pedal gets multiplied 50 times at the one caliper which stops our car (and it is one-sided). That's 500 lbs of stopping force. A one square inch pad would press on the disk at 500 psi. A two square inch pad would press with 250 psi, etc. The unit forces will vary with pad size, but the total force remains constant. And, per the formula, the stopping power.

So, in at least "traditional" analysis (meaning we think we know what is what because the Puhns and Vanvalkenburgs said so), brake pad area literally is not a factor in the braking equation. This is consistent with "spot" brakes, which were (maybe still are) used on some small aircraft and drag race cars: vehicles which use the brakes once, with a very long cool down time between uses. A pilot friend told me that for commercial airliners they can or have to calculate how long they have to wait before they can take off again.

I guess I need to dig through my pile of Scientific Americans to see what new theories of friction have arisen. At one time it was believed that one G was the max which could be achieved by a tire, a belief which we all know can't be true in the real world because it is routinely exceeded. I'm not sure, though, how a theory which says that larger pad areas mean lower line pressures, which in turn mean less caliper flex, fits in. You need the same force (equivalent to a weight) to get the same stopping power, and that force, no matter how achieved, is what spreads the caliper, is it not?

As has also been pointed out, bigger is also heavier. The worst part of heavy is those big, large radius, rotors. Not only is is unsprung, it is also rotating weight, with a flywheel effect on top of its mere mass. Makes it harder to speed up, and harder to slow down. So the optimum setup has got to be a brake system which does the job with not too much to spare (sounds like about everything else in a race car, right?). At our (at least my) level of intensity, we are no more likely to have enduro brakes we swap for sprint brakes than we are to use qualifying engines. A nice margin makes for less weekend hassle.

So how does a guy decide what brakes to use? Word of mouth and the experience of others, plus succumbing from time to time to get something bigger, I think. My S/M caliper setup seemed to be doing the job on my 2,000 lb 911. As I improved its track times I saw a deal on a set of Bremteks (no longer made). They have been flawless, and I won't go larger (especially after lifting someone's uninstalled Big Reds) until I start to experience pedal problems. If I can squeeze another 50 HP out of my engine (possible in theory), maybe I'll find I am starting to get a mushy pedal. Sufficient unto the day is the evil thereof. But I'd be inclined to be looking for the smallest brake calipers guys with cars like the one I want to build (and who have reasonably competitive times) say work fine for them. Bearing in mind, as always in the complex racing game, the many variables.

Walt Fricke