LAP 22 - TIRE PRESSURE

On lap #1 we discussed tires and some of the technical terms used to describe how they perform. Additionally, we described the differences between the radial and bias ply tires used on race cars and how they affect driving style. What we didn't discuss was the most important variable in the tire equation, internal pressure. Your tires are the only means your car has to communicate with the road and the pressures inside them have a tremendous effect on their performance and the speed you'll run out on the track.

The weight of your car resting on the tires is a constant that we'll call "W." When out on the track, the only meaningful change in "W" is the slight reduction seen resulting from the burning of fuel (which we'll neglect for now). If you put your Mustang on 4 independent scales, one under each wheel, the sum of the individual measured weights will equal the total weight of the car. You will notice the weights at each wheel will be slightly different with the amount seen at the front tires generally larger than that seen at the rear. This is called sometimes called "front to rear bias." You may also note the left to right side weights will be different which is called "left to right bias." Some racers refer to these weights as "corner weights" because they refer to the four corners of the car and it's easier to think about in this manner. Engineers think in terms of loads or forces so the four corners of your Mustang exert an independent "load" or "force" to the pavement though each the four tires. We'll call these forces "F1, F2, F3 and F4" representing the force each tire exerts normal to the pavement. Therefore the weight of the car, "W," equals the sum of these forces so "W = F1 + F2 + F3 + F4."

Here is where tire pressure comes in to play. The force exerted by a given tire to support the weight of the car is a function of the pressure in the tire and the area of the tire touching the pavement. This area of the tire is called the "contact patch" because it's the portion that contacts the pavement and thus can transmit force. A pressure "P" is defined as a force "F" applied over an area "A" which can be written as "P = F / A." Solving the equation for "F" results in "F = P x A." This can be used to describe the local force at a given tire as "F1 = P1 x A1" where "F1, P1 & A1" represent the local force, pressure and contact area for tire #1. This makes sense because everyone knows the contact patch "A" gets smaller as "P" increases because "F" is a constant.

Here is a point to ponder. Consider having only 30psi (pounds per square inch) of pressure in all four tires of a Mustang weighing 3,000 lbs. What is the contact patch area? Simple, it's "A = F / P" or "A = 3000 / 30" or 100 square inches for the entire car. At each tire the area is approximately 1/4th that amount or 100 / 4 or 25 square inches which is a patch about 5" x 5" wide. Makes sense, right? As the pressure is reduced, let's say by 5 pounds down to 25 psi, the area of the contact patch must increase to "A = 3000/25" or 120 square inches or a patch area of about 5" x 6" wide at each tire. Many racers mistakenly believe they need to add air pressure to "stiffen" the sidewall of their tires while what they are really doing is simply reducing the contact patch area. It's also the reason you typically need more air pressure in the front tires to support the additional weight of the engine, it keeps the contact patch area the same from front to rear.

Of course, everything we've been describing only applies to a static situation with constant loads and forces, hardly describing a Mustang running a road course while shifting weight side to side and fore/aft during acceleration, braking, and cornering. The important thing to remember is that the total weight of the car never changes. Therefore, the sum of the weights at the four corners must equal the total weight of the car AT ALL TIMES. This means when the car rolls and pushes down hard on the outside tires the inside tires must see a corresponding reduction in load (or force). All this work generates tremendous heat and since air is a gas it expands when heated which increases the internal pressure in the tires. Why is this important? Because it changes the contact patch.

As the air pressure inside the tire increases due to heat generation, the contact patch gets smaller. In the pits, I commonly hear this dialogue. "What tire pressure do you run?" The response is given and then followed by another question, "Is that hot or cold?" That is a terrible question because the only tire pressure that matters is the "hot" pressure. The "cold" pressure means nothing to a racer because it is a function of the particular car, the setup, and the driver's style. What matters is the pressure seen out on the track. That is why you should be measuring your pressures as soon as you can after exiting the track. Yes, it's impossible to know the right pressure to begin with when the tires are cold but if you think about it you can make an educated guess. If your pressures are correct when exiting the track at the end of the day they'll be correct when you start the next. Try measuring pressures the day after things have cooled and you'll see a dramatic drop in pressure, ten pounds is not uncommon. Assuming you have no leaks and the ambient temperature is about the same, the correct starting pressure is already set for you because after the tires warm the air (gas) inside will expand and return to the same pressure you had on the previous day.

This is a reason most inexperienced drivers run too much pressure in their tires, constantly struggle to find grip, and ask everyone "what pressures are you running?" It's also the reason some racers use bleed-offs to control the way the tires respond to ..... oops, another speed secret almost got out.

See you next lap.

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