DIRT ON DYNOS

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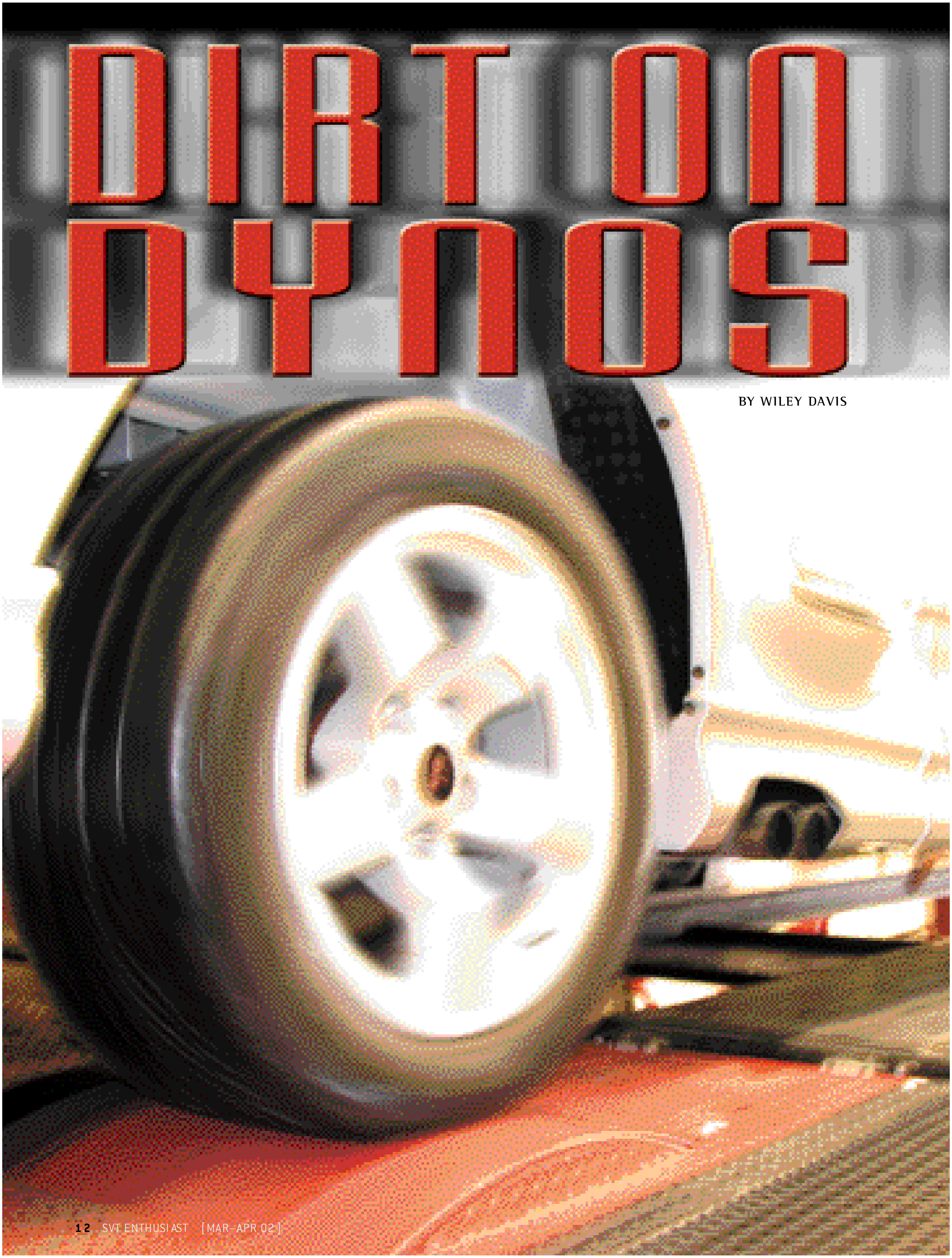

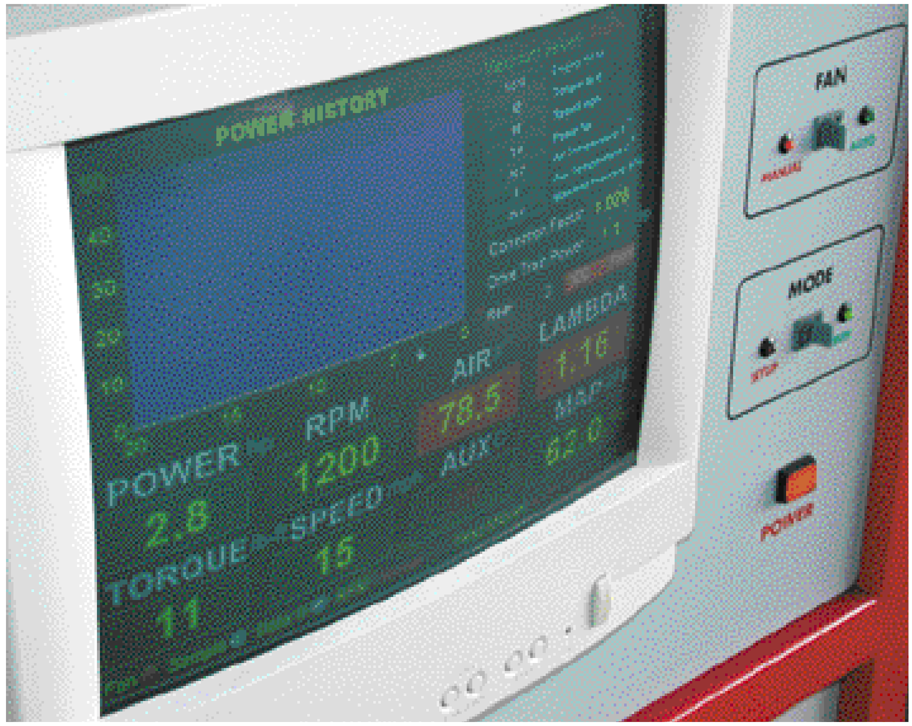

Today's dynos are computer-controlled affairs. All of the calculations, including corrections for atmospheric conditions, are calculated by the machine.

Power is addictive. One taste and the glory of raw acceleration can occupy a very large portion of your brain. No worries, you are not alone. There are others just like you out there who have dedicated their waking hours to the design and development of power-enhancing goodies that will make your life sweeter. They use many tools in their quest for performance but the chassis dynamometer has become the centerpiece in the battle for horsepower supremacy. It is common for enthusiasts to keep dyno graphs in their glove boxes, but before you accept the numbers as truth, it is wise to ask a few questions. Dynos, you see, can be manipulated to give results that aren't always accurate.

WHAT'S GOING ON?

Horsepower is a function of two things, torque and rpm. Using the formula (horsepower = torque x rpm/5252) a dyno can calculate the power level at varying engine speeds (It is interesting to note that, according to the preceding formula, torque and horsepower figures will always be identical at 5252 rpm). The chassis dyno is an effective tool for measuring power output at the wheels, taking into account the frictional losses inherent in the driveline. However, it must be noted that the chassis dyno has absolutely no way to measure these driveline losses. This is where the flywheel horsepower readings derived from chassis dynos fall into the realm of misleading conjecture.

WHAT'S NOT GOING ON?

A chassis dyno cannot calculate flywheel horsepower. (Some dyno software programs will attempt this by measuring the time it takes for the rollers to spin down while the car is in gear with the clutch disengaged.) This is called a "coast-down test" and is supposedly measuring "negative horsepower" and the results (a negative number) are subtracted from the wheel horsepower results to derive flywheel horsepower. There are several problems with this method that make it unsuitable for the intended purpose. First, this coast-down test cannot measure actual frictional losses. Frictional losses are proportional to the power being fed into the driveline. This means that losses increase as the power increases. A good reference is usually 15 percent (for manual transmission vehicles only. See sidebar). The coast-down test, however, does not reflect the power levels being fed into the driveline when wheel horsepower is being measured and therefore cannot accurately measure the amount of frictional loss. As far as the coast-down test is concerned you could have a 400hp SVT Cobra R or a 180hp SVT Focus, the losses will be the same. Obviously the coast-down test is not measuring actual power absorption.

There are a number of variables between the flywheel and the wheels that alter horsepower results. Small variances in tire pressure can significantly change the dyno results. Wheel alignment, transmission oil temperature, tire size and gear ratio all affect the results. It is very difficult to calculate the combined effect of so many variables, let alone do so consistently. The wheel horsepower measurements of a chassis dyno are reliable and consistent, but they are unable to accurately measure flywheel horsepower. As an engineer at Dynojet said, "Absolutely not. Our chassis dynamometer is not capable of measuring flywheel power."

AUTOMATIC TRANSMISSIONS

Automatic transmissions present a different set of circumstance for dyno measurement. First, the transmission must be capable of locking into a specific gear (i.e. 3rd) to get a proper reading. Automatic transmissions also suffer from increased frictional losses. This is why transmission coolers are necessary for high-horsepower applications. The energy being absorbed is turned into heat. Again, however, it is impossible to measure what this loss actually is using an inertial chassis dynamometer.

ATMOSPHERIC CORRECTION FACTORS AND THE MISCONCEPTION OF HORSEPOWER

If you haven't noticed by now, people like to brag about their performance. There is no getting around this. People also, however, recognize that many factors play into performance and that it is unfair to disregard these differences. This is why we have things like handicaps and point spreads. It is also one of the reasons dyno measurements have atmospheric correction factors. Correction factors (CFs) are used to make comparisons between dyno runs even though the atmospheric conditions are different. Because factors like air temperature, barometric pressure and humidity affect the amount of power an engine produces, it becomes necessary to adjust dyno measurements back to a baseline set of atmospheric conditions so that comparisons can be made. The actual mathematics involved are a complex and proprietary set of algorithms developed by the Society of Automotive Engineers (SAE) and are based on extensive laboratory testing. There are several standards but the SAE (J1349) standard enjoys widespread use here in the United States and is considered to be accurate and consistent. However, these CFs can only *estimate* what the baseline horsepower would be, they cannot actually *calculate* what it would be. The SAE standards were designed with an operational

Inertial chassis dynos like this one at GRC Performance in Mission Viejo, California, use simple principles to measure horsepower output. Essentially, the dyno is a large flywheel with a known mass and inertia. By measuring the time it takes for the car to accelerate this flywheel as well as corresponding engine rpm, the dyno can calculate torque and power.

A chassis dyno allows horsepower measurements to be made without having to remove the engine from the car. This is done by feeding torque into a set of rollers with the driven wheels. Chassis dynos are a precise and repeatable way to measure wheel horsepower.

WHAT IS HORSEPOWER?

It was James Watt who refined the steam engine design and turned it into a machine capable of doing work at a reasonably efficient rate. The most common applications of steam power in the early days were pumping water or lifting coal from mines. As far as coal is concerned it was horses who did most of this work before the coming of steam power.

Watt needed to be able to rate the power output of his steam engines in order to advertise them. He decided that the most sensible unit of power to compare them to was the rate at which a horse could do work. He tested the ability of a variety of horses to lift coal using a rope and pulley and eventually settled on the definition of a "Horsepower" as 33,000 foot pounds per minute — or 550 foot pounds per second. In fact the horses he tested could not keep up a steady work rate as high as this but being a conservative man he added 50 percent to the rate he measured in case other people had more powerful horses than he had tested.

So a horse walking at a comfortable speed of 5 feet per second would need to raise a weight of 110 pounds to do work at the rate of 1 Horsepower. Not so hard you might think — in fact a strong man can do that amount of work — but only in short bursts. A horse can easily do work at a faster rate than this but again not without rest. A steam engine, provided you keep it fueled, can run continuously. Watt's measurement was designed to take account of the fact that machines can run forever but animals or men need to stop and rest from time to time.

tolerance beyond which they will not be considered accurate. This limit is roughly +/- 7 percent. So on the dyno chart, applying CFs that are greater than 1.07 or less than 0.93, will result in measurements that are not considered valid. An educated reader of dyno charts will understand that it is wise to mistrust corrected horsepower figures from dyno runs made in drastically different atmospheric conditions.

Perhaps the most sinister of problems with chassis dyno numbers stems from operator dishonesty. This does happen, just ask Oscar Jackson of Jackson Racing in Westminster, California. "I had this one guy come in with a dyno chart for his car after he had his cam-gears adjusted. Sure enough, it showed a 15 horsepower increase just like he'd been promised. I looked at the chart, however, and noticed that the air temperature [used to determine the CF] jumped from 51 degrees on the first pass to 91 degrees on the final pass. Obviously something wasn't right but the guy didn't even notice."

Ambient air temperature will significantly affect the corrected horsepower measurement. The warmer the air the less dense it is, so a temperature measurement that is falsely high will cause the CFs to overcompensate, adding power that is not really there. It doesn't take much to, let's say, leave the temperature probe in the sun for a few minutes, or to take a measurement from the engine compartment where the air is hotter than ambient. Attention should be paid to the air temperature numbers. Make sure that there are no unexplainable changes in the temperature between runs. A little bit of skepticism never hurts.

Coolant temperature also plays a role. On the road, a considerable amount of airflow is keeping the radiators and intercoolers happy. Short of a wind tunnel, it is impossible to replicate this airflow and provide representative cooling to the vehicle on the dyno. As the temperatures increase, the power will decrease. All efforts should be made to keep coolant temperatures within operating norms.

WHAT'S IT GOOD FOR THEN?

So what is the chassis dyno good for then? If it can't determine flywheel horsepower and the measurements can be skewed to show any result, why do people bother with them? The answer is simple: They are very effective tuning tools. An inertial chassis dyno is an accurate and highly repeatable way to measure horsepower at the wheels. Just be sure to arm yourself with necessary knowledge beforehand.

Watch out for drastic horsepower increases that defy common sense. Make sure the chart lists wheel horsepower and not the questionable flywheel horsepower estimates. Some shops have claimed coast-down losses in the neighborhood of 25 percent. Claims like this should immediately raise red flags. Assume that a 200hp engine is being tested on the dyno. Coast-down losses are measured to be 25 percent. This translates into 50hp being lost in the driveline. There is no way that the driveline will be absorbing that much power. As a rough rule, expect losses to be in the neighborhood of 12-15 percent (manual transmission), though once again, this is only an estimate.

When making comparisons between runs made on different dynos, pay close attention to the variables. Were the CFs within the allowable range (1.07 – 0.93)? Correction factors are not valid at the extremes of temperature, humidity or pressure. Was the engine given enough time to cool between runs? Was the tire pressure the same? What gear were the runs performed in? What kind of fuel was used? All of these things will affect the measurements. The point is, there are many variables that come into play when making dyno measurements and they must be considered before jumping to any conclusions about actual performance gains or losses. It is time that people stopped accepting dyno numbers as gospel. Dynos are a tool. As such, they have the potential to not only provide real benefit, but to be misused. It is best to keep this in mind. Ask questions, learn as much as you can. If something doesn't sound right, probe until you get an answer that satisfies. It is not possible to get the most from a tool you don't understand. Knowledge is power.

WANT TO KNOW MORE?

www.howstuffworks.com/horsepower.htm
A great general reference site. Provides excellent animations and explanations of the physics behind all of this horsepower business.

www.pumaracing.com.co.uk
Provides a sharp-tongued critique of flywheel power measurement using chassis dynamometers. This site also contains a wealth of engine-building theory.

www.dynojet.com
Makers of the most popular inertial chassis dyno. An informative site with good schematics.

www.sae.org
The website for the Society of Automotive Engineers. The place for technically oriented people who want the nitty gritty to go.

EVERYBODY DYNOS

SVTOA Chapters – Did you know that having a Dyno Day is a great local event for your members? If you need more information on conducting a Dyno Day, please contact Joanne Schultz at SVTOA Headquarters at 866.377.8862 or joannes@svtoa.com.