



Dynos Explained

Authors: Stephen Dubovsky, Steve Weiner, Wil Ferch

From: Stephen Dubovsky <dubovsky@vt.edu>

Date: Fri, 05 Jan 2001

Since no one has responded, I'll input my \$0.02. I have worked on several, and designed one custom dyno for electric vehicle and fork truck motors for GE. Measuring REAL HP is easy. You go out and buy something called a torque transducer from someone like J. Himmelstein (www.himmelstein.com) that measures torque very accurately (0.1% error) and has a speed output (which can have errors of ~0% w/ an accurate clock to count pulses). You connect your motor to one side of the shaft (an electric motor in my case) and a big load motor (DC or AC) to the other side of the shaft. You run the big load motor as a generator and push all of the power you generate w/ the motor under test back to the power company;) We would set the load motor to regulate at a certain RPM (say 4000 rpm) and then set the test motor to apply torque. Torque x speed = hp. Simple. No fudge factors no differences. Motors tested this will will come out to within 1% even on different dynos. The differences come from improper alignment that causes a little shaft binding and therefore a little more bearing loss. One difference in a gas/electric motor is that the electric motor doesn't care about octane, clean filters, etc so it is more repeatable.

Dynos like the mustang chassis dyno use this same measurement principle but use a water brake or eddy current brake for the load. The errors come from the friction between the wheels and the drum and the bearings supporting the drum. Strap the car down harder, causes more force on the tires, causes more deformation, causes more rolling resistance. If the torque meter is calibrated and the drum bearings are well lubricated, then it will give a very repeatable and accurate measurement of HP generated. Why do readings jump so much then? Probably because the car's engine is not repeatable. Things like oil heating up, air temp, atmospheric pressure, and all those things cause the engine hp to jump around.

Dynos like the dynojet are inertia dynos. They use the $F=ma$ theory to calculate hp. They do not measure true static HP. The problem is that if you lighten a rotating mass in your vehicle like the wheels or flywheel, the dynojet will measure more HP whereas the mustang will not. Light wheels and flywheels do not make HP. Period! They DO affect your acceleration however, which is why some people like the dynojet's results. But it's not due to engine HP. Theoretically if the dynojet drum had nearly infinite mass so that it accelerated very slowly, it would measure hp accurately (since the forces to accelerate the rotating parts in your engine would approach zero).

What engineering geeks like me do is measure the real HP and then compute the rotating inertias of the wheels/flywheel to calculate what it's effect on the 0-60 time will be. We actually built entire models of the motor/gearbox/wheels/forktruck/load in Simulink/Matlab and could accurately model what adding inertia to the motor "crankshaft" or picking up a 6000lb load meant in acceleration. Interesting stuff, but its really just simple physics. (And only a top speed of ~12mph;)

Bottom line. It's easy to build a very accurate dyno. Its hard to build a car/system that produces exactly the same hp every time you hook it up when entirely too many important variables are changing. Sorry this whole msg is a big stream of consciousness, it's just the way I write. I also hope I didn't make any stupid mistakes when I was spewing all this out, so please correct me if you catch an error. Questions???? (I really hate to think what I'm getting into here;)

Stephen Dubovsky
83 911SC (that has never been on a dyno;)

Subject: Re: Dyno hype question
From: Steve Weiner <porsche@rennsportsystems.com>
Date: Sat, 06 Jan 2001 15:10:10 -0800
X-Message-Number: 55

Great thread,.....

Since we have had our own engine dyno for the past 25+ years, now added a Dynojet 248 and a new Mustang load-type chassis dyno lives less than 2 miles away, maybe I can offer some observations that might help.

First, having done this sort of thing for number of years, I can tell you that no two engine dyno's will display the same measurement, even with the standard SAE correction factors. Even water brake or eddy current models from the same manufacturers are not all exactly the same.

Chassis dyno's are either inertial (Dynojet) or load-type(Mustang) and use proprietary software to make the power measurements. In addition, the Mustang units will do both inertial AND load tests.

The relationship between rear wheel power and flywheel power isn't linear, due to all the variables. Tire temps, drum temperatures, gear oil temps, and engine temps, cylinder head temps, tire pressures that change during testing, slippage that occurs with inertial and load type dyno runs, are just a few factors that change so that even making 10 runs with the same car, back-to-back, can produce slightly different numbers.

For turbo cars, its damned difficult to keep charge-air tempswithin range and

therefore these are always the toughest and most inconsistent power runs. Cold Turbo engines produce lots more power than hot ones do and you can watch the power drop away as the engine and charge air temps rise.

We have taken a motor off the engine dyno, installed it in the car, then run the car on the Dynojet and then that Mustang unit for comparison. The loss through the transmission is not consistent due to some of the factors listed above and further, the Mustang and Dynojet 248 results are different, even in the same inertial modes! Differences in the size of the measuring drums, surface finish and software for power calculations would account for this. The Mustang always seems to display power figures about 15-20 HP lower than the Dynojet.

Now,.....what to believe, yes?

The truth is,..... you should believe which ever results you like. Dynamometers are devices for making torque measurements for comparison purposes, on site. This allows one to determine, among other things, what modifications produce results and where (RPM-wise), and what doesn't work. Normally, we'll make a whole series of runs and observe/record the changes and variances to ensure reliable, consistent information. This is all that matters. The absolute numbers are only relative. Porsche gearboxes have a loss range in the 12-18% range and that's rather wide. This is due to ring & pinion efficiencies, gear oil viscosity and temperatures, gear teeth pitch and bearing setup and drag. BTD,.....)

For bragging rights and advertising claims, that's a whole 'nuther subject,.....) Caveat Emptor!

Only the DynoJet seems to be the most consistent in their results, regardless of location. You can make comparisons for these machine's printouts from wherever they were made. I've not has enough experience with the Mustang units to see if they are similar, however those installations really vary more than the Dynojet 248's do.

No two engine dyno's will generate identical torque number seven with the same engine. Take those figures as a guideline and compare them against other engines from the same facility.

Hope I didn't confuse anyone or muddy the waters here but these issues are dynamic, not static,.....

--

Steve Weiner
Rennsport Systems

From: WFerch6687@aol.com

Date: Sun, 7 Jan 2001

Listers:

This recent thread about Dyno's reminds me that the list was engaged in a series of spirited discussions along these lines about a year ago...involving myself, Todd Serota, Joe Fabiani of Fabspeed fame, Stephen Dubrovny, and others. May want to check the archives, since I recall this being a very informative series of exchanges.

In a nutshell, the "inertial" devices like the DynoJet 248C, utilize the inertia of the mass of a rotating drum to gather info. Correct...this works, but is only good for Wide Open Throttle (WOT) applications. Or more correctly, at "one" throttle position. Engine part load characteristics (at other throttle openings) aren't captured with this sort of device, unless one goes through the extreme bother of doing a deliberate dyno run at one throttle position, and then another run at another throttle position, etc etc. This isn't practical since you would need at least a dozen runs to get a meaningful "map" of light-to-full throttle mapping. Based on the principle of operation, one can immediately see that with an inertial dyno, you can't "park" at a certain RPM, and map out part-to-full load characteristics. Think on how this works. It takes a certain amount of energy to get a massive roller spinning from rest, and once it reaches a specific rotational speed, it takes yet more hp (from the car's wheels) to spin it yet faster. If you should "stop" at a certain rotational speed, the inertia of the spinning drum will want to keep itself spinning, without any meaningful assistance from the car.

Once you think about how an inertial system works, this then makes sense. The eddy current, water "brake", and other devices like this (I believe the Mustang Dyno acts this way)...in contrast, can map out part throttle load characteristics. Although not entirely correct, think of this device working like this: once the device is turning, you can "lock in" on a rotational speed, and by "loading up" the spinning drum (in principle...putting larger and larger paddles in the water), you are loading up the device, but the device is configured to allow the RPM to stay the same. The results from a water brake device may then not be compatible with an inertial device. As an arcane side issue, I believe using a water brake device is the basis for the "brake" horsepower we read about all the time, as listed by various manufacturers.

By and large, one is advised to stick with a dyno "type", and simply compare before and after results. I noticed, too, that when I had Dyno runs on a 248C, you can choose the print out to be "Actual" hp (resulting from the actual atmospheric conditions of the test day)...or they can be standardized, or "corrected" to SAE, or other, standard conditions. Since I collect dyno runs for 3.2's...(my car and others)...it is amazing how comparable some of the runs are....for similarly modified cars....at different areas of the country, once the SAE correction factors are figured in. A run from Denver (high altitude)...once corrected to the "SAE" standard conditions of (I believe) sea level, 70 degF, 50% relative humidity, etc etc....gave

surprisingly comparable results to other cars tested near the East and West Coasts.

So we have two issues , here, really. The type of dyno used, and the basis of the print out. Certainly, factors like how much heat your own engine has warmed up to (first run , vs last run of a series)plays a part , too, so try to duplicate this aspect if small HP gains are being sought.

Regards,
Wil Ferch