wisdom & woe from the workshop

Horsepower & torque figures are often discussed, but rarely are they fully understood. Many of us are aware that horsepower and torque figures not only vary between different cars but also different dynamometers (a.k.a. dynos) - so this month we will be looking at some of the different methods of measuring horsepower and torque to try and get a better understanding of what it all means.

The definition of horsepower is well publicised, but it is still worth printing the formula here to remind us that horsepower is a function of torque and engine speed.

$$\text{Horsepower (bhp)} = \frac{\text{Torque (lbft)} \times \text{Engine Speed (rpm)}}{\text{5252 (Unit Constant)}}$$

Torque is the direct force that the engine applies to the drive-train, or the direct force that the wheels apply to the ground - we will look at the differences later. Horsepower is probably even more relevant to us, as this is a measurement of the work done by the engine or wheels in a given amount of time - this governs the rate of acceleration.

Car manufacturers usually always quote horsepower and torque figures at the engine's crank or flywheel - this is measured directly with the engine on an engine dynamometer. During testing some car manufacturers will use an engine that has been built to a better standard (e.g. blueprinted) and not fit various ancillaries (including alternator, power-steering pump, etc) to give higher publicised performance figures - TVRs of the 1990's are a prime example of this. Other car manufacturers will actually do the opposite and set the test engine up to give lower publicised performance figures - this is usually to adhere to certain regulations.

Unfortunately, there is not just one dynamometer measurement standard either - common standards currently used include DIN 70020, SAE J1349, ISO 1585 and more besides. Different standards will give slightly different horsepower and torque figures, so it can be seen that there is already considerable variation between different horsepower and torque figures, even when measured directly at the flywheel.

Chassis dynamometers (or rolling roads) measure torque at the wheels or hubs instead of at the engine's crank or flywheel. The engine rpm is still used to calculate 'wheel horsepower'. With a two-wheel drive TVR using a manual gearbox, the difference between the wheel speed and engine speed can be very easily calculated using the differential (final drive) ratio.

$$\text{Engine Speed (rpm)} = \frac{\text{Wheel Speed (rpm)} \times \text{Diff Ratio}}{\text{Gear Ratio}}$$

If run in a 1:1 gear (e.g.: 4th gear), as is correct & normal practice where possible, this simplifies the calculation even further:

$$\text{Engine Speed (rpm)} = \text{Wheel Speed (rpm)} \times \text{Diff Ratio}$$

The horsepower or torque figures measured at the wheels or hubs are always lower than the figures measured at the flywheel - this is due to transmission losses. Transmission losses vary between different vehicles and depend on a number of different factors, including number and type of differentials, type of gearbox and viscosities of oil used in the drive-train components.

$$\text{Flywheel Horsepower} = \text{Wheel Horsepower} + \text{Transmission Losses}$$

Thankfully, in practically all cases a TVR is rear-wheel drive with a manual gearbox - so this does simplify things a bit when comparing results between different TVRs. Obviously different manual gearboxes and different differentials will have slightly different transmission losses, but as they are the same basic design, these differences are relatively small.

There are a few commonly used methods for estimating transmission losses but, as described, they are just estimates - adding even more variability between different rolling road figures.

Many rolling road operators will apply a transmission correction factor, in the form of a simple percentage multiplier, to the wheel horsepower and torque figures in order to provide the customer with flywheel horsepower and torque figures.

Some rolling roads do attempt to calculate transmission losses by measuring the horsepower used during a 'coast-down' phase, but this is still not accurate as the losses are being measured with the gears within the differential and gearbox loaded on the opposite side to when the transmission is under maximum load in the forward direction. Interestingly, when we were using a local Dastek rolling road we consistently recorded coast-down losses of approx. 45bhp at peak horsepower on a wide range of TVRs with a range of different transmissions. This was regardless of actual engine output - in other words a TVR with 200bhp had virtually the same transmission losses as a TVR with 400bhp. This completely contradicts the idea that transmission losses are a simple percentage multiplier - if this is the case then the TVR with 400bhp will have double the transmission losses of the TVR with 200bhp.

Perhaps it is more likely that a large proportion of the transmission losses are essentially a fixed amount, with a small percentage variation to account for increased frictional losses with increased horsepower and engine speed.

The only way to truly know which method is correct would be through extensive testing. Despite numerous pages on the internet about dynos and transmission losses, such test information remarkably appears to be non-existent.

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In an ideal world we would test the engine on an engine dynamometer with all the ancillaries fitted (including complete intake & exhaust systems), and then test the car on a hub dynamometer (rather than a conventional rolling road) to measure the wheel horsepower without any variances due to the tyre pressure, traction or ratchet strap tension.
If done using the same measurement standard, this would give us the most accurate measurement of transmission losses across the entire rpm range.
We are currently in the process of designing an engine dyno to utilise one or two of our Dynapack hub dyno pods, so hopefully in the future this will allow us to obtain accurate transmission loss data for a wide range of TVRs.


TVR Griffith on Dynapack dyno


Dynapack hub connection

Another consideration when comparing any dyno results is the effect of various atmospheric variables - this includes intake air temperature, ambient air temperature, barometric pressure and relative humidity. The performance of the engine will vary according to these atmospheric variables so the dynamometer software will use various sensors to monitor these variables and calculate corrected horsepower and torque figures. The way in which the software calculates and corrects the effect of these atmospheric variables is dictated by the test measurement standard used (e.g.: DIN 70020, SAE J1349, etc). Unfortunately, even when using the same measurement standard the results can vary (or even be fiddled) by the location of the sensors - the location of the intake air temperature sensor in particular can cause a significant increase or decrease in calculated horsepower and torque.

So to summarise - chassis dynamometers are primarily useful for engine calibration (mapping), tuning and diagnostic purposes, not for comparing horsepower/torque figures between different dynos and cars. There are so many variables that we would be best to disregard flywheel horsepower altogether and look solely at wheel horsepower - this way we remove the largest variable of all.

If we still want to compare chassis dynamometer results and ensure that the data is as accurate as it is possible to be, then look for the following:

- **Ideally carry out all the runs on the same dyno**
- **Always use the wheel horsepower figures with no correction factor applied (not flywheel horsepower) - all rolling roads or hub dynos will have this data, as this is where the measurements are directly taken**
- **Ensure that the power runs were measured with the vehicle in a 1:1 gear where possible - this is 4th gear on practically all TVRs**
- **Establish which measurement standard the dyno operator is using (e.g.: DIN, SAE, etc)**
- **Check to see where the air temperature sensor was located and what this temperature was, either an average or as a range during the dyno run. Record this on your dyno sheet**
- **When using a conventional rolling road ensure that the tyre pressures are at the correct level and record the tyre pressure on your dyno sheet**
- **When using a rolling road with twin rollers make an observation regarding the ratchet strap tension.**

Ensure that the driving wheels are driving the rear trailing rollers as much as the front rollers.

This was a difficult article to write - dyno results are a contentious subject with a great deal of (mis)information already widely available, but we do hope that you found this article interesting and useful. If you have any particular questions that you would like us to answer, or technical articles you would like us to write, then either write to Sprint magazine or contact us at enquiries@lloydspecialistdevelopments.co.uk

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