Powertrain Performance vs. engine performance

White paper

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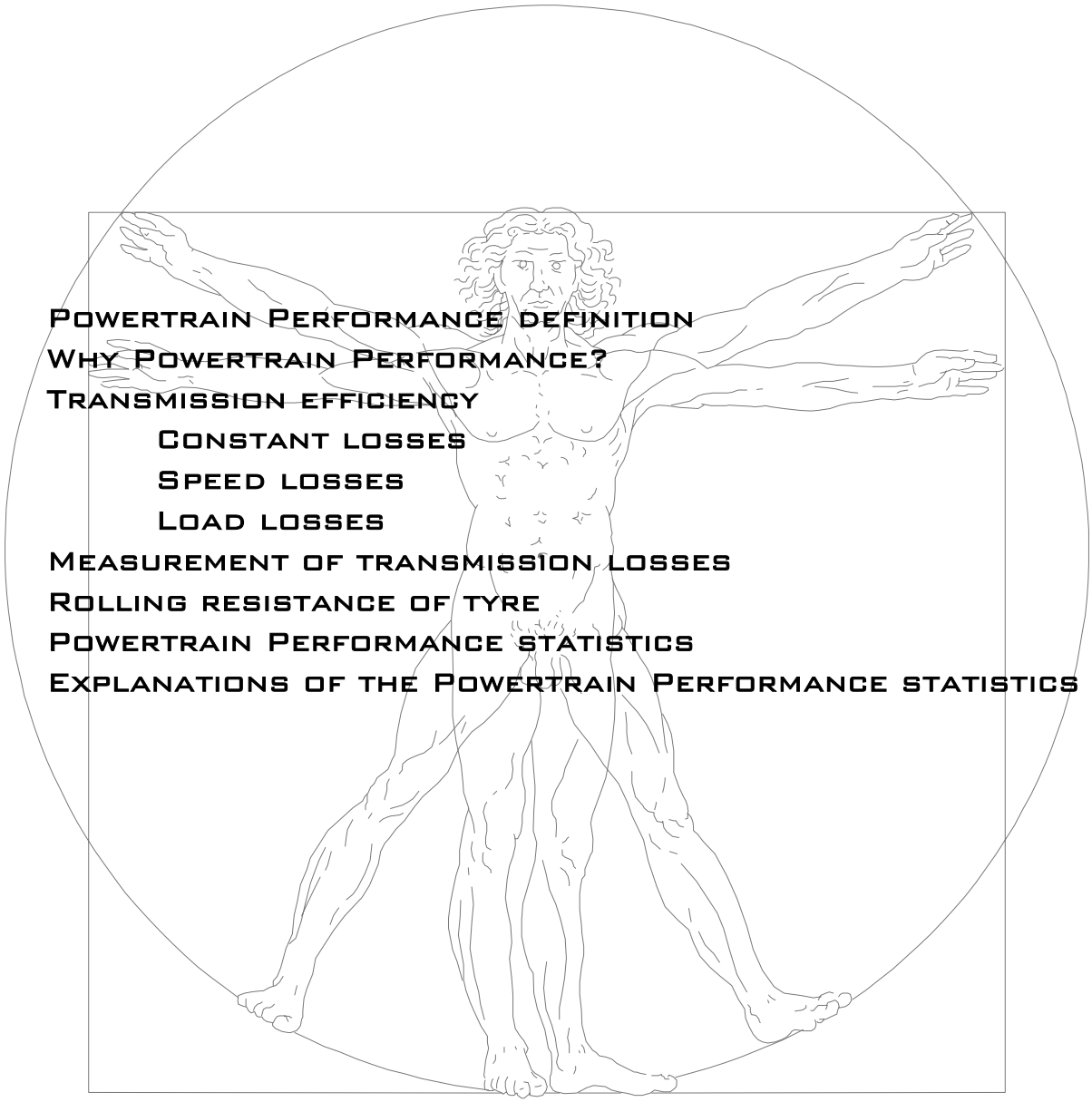

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Powertrain Performance vs. engine performance

Powertrain Performance Definition

Rototest Research Institute defines **Powertrain Performance** as the performance available to the wheels (measured at the wheel hubs). A simple description is the engine performance minus the drivetrain losses.

Why Powertrain Performance?

Engine Performance, declared by the automotive manufacturer, is related to a specific Test procedure where the engine is separately mounted and tested in an engine dynamometer. This has historically always been the way to do it and has the benefit of a controlled environment during the test. However, the modern cars of today have increased the integration of the whole powertrain to a degree where it has made it in practice impossible to test an engine separately.

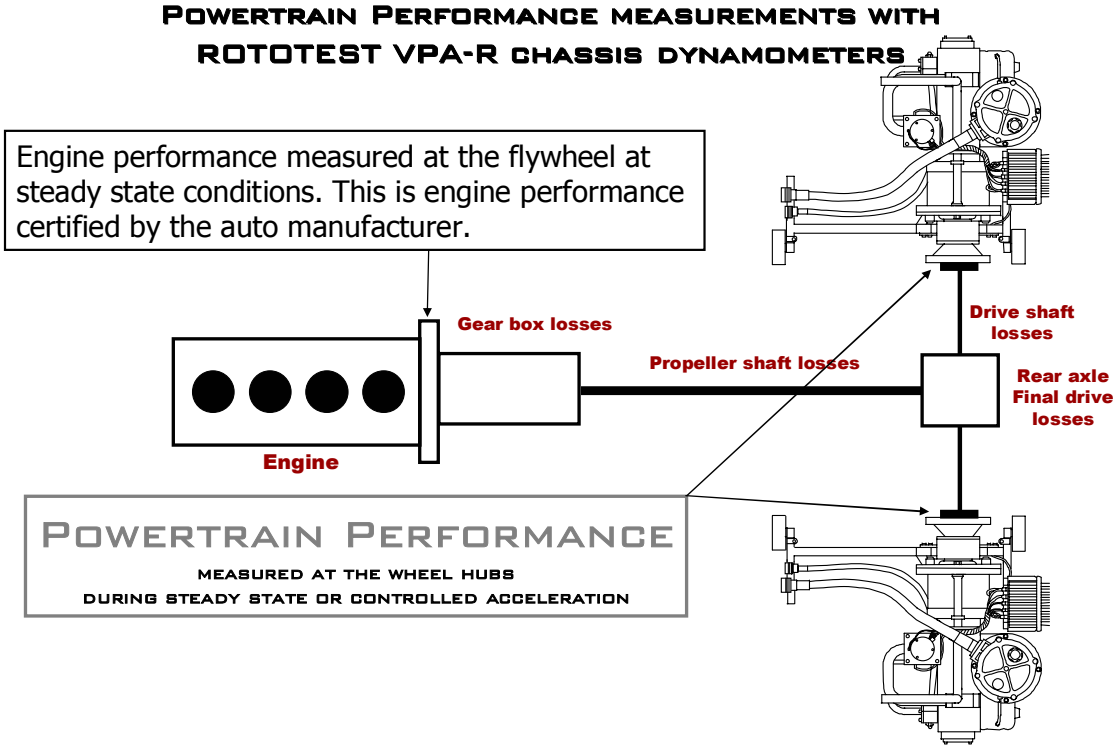
Powertrain Performance has the disadvantage of introducing variables, i.e. gearbox, final drive and drive shafts. However, the benefits are numerous:

- The engine is mounted in its true environment.
- The results are related to the available performance of the vehicle.
- It can be measured and verified, even on modern cars.

Powertrain Performance gives assessment power to the automotive consumer as well as relevant results.

Note!

How much of the **Powertrain Performance** that the wheel can transfer to the road is a very Complex issue, which includes the surface conditions as well as tyre behaviour. This means that it is a constantly changing variable.



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Transmission efficiency

The overall efficiency of a drive train transmission includes the sum of all losses derived from the transmission and can thus be defined as the ratio between the input performance and the output performance.

$$\eta_e = \frac{P_{Out}}{P_{In}}$$

In order to better distinguish among the different losses, a further distinction can be made:

- **Constant losses**
  These losses are neither dependent on the transmission's speed nor the load, i.e. they are constant. One example of elements causing constant losses is pre-loaded bearings. Due to the pre-loading, there is a constant friction force reacting to the rolling movement in the bearing. The pre-loading is in turn dependent on the temperature variations of the housing (gearbox, rear-axle, etc).

- **Speed losses**
  Speed losses increase with the transmission's speed and are, for example, caused by a windage effect on rotating parts. These losses are greatly influenced by the type and temperature of media (oil-air mix) in which the parts rotate .

- **Load losses**
  As load increases so do the load losses. Load losses are mainly friction losses from the transfer of force from one gear to another. The greater force applied the greater the loss.
  If loaded in the normal direction:
  The load losses are approx. 1.0 - 1.5% / pair of gears for normal gears.
  The load losses for a pair of hypoid gears are approx. 2%.

A result of the above is that although using the same input performance the output performance may differ between gears. This is due to the change in overall efficiency of the transmission. The overall efficiency is best described using an efficiency map for load and speed (much like an engine ignition map). The result is also dependent on temperature.

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Measurement of transmission losses

A common misunderstanding is the way of approximating the transmission losses of passenger vehicles when using "rolling road" type chassis dynamometers. The procedure includes tests where the transmission is driven backwards by the dynamometer with the gearbox in neutral or the clutch depressed. The amount of power required to drive the transmission is measured and then this measurement is used to describe the transmission losses during normal operations with the engine driving the transmission.

The benefit of the procedure is that it is relatively simple to perform but the **drawbacks are numerous**. Firstly, the use of a rolling road will introduce a number of difficulties to determine the actual performance with enough accuracy. This is mainly caused by the inferior transfer function between the tyre and the roller (please see table 1 for a list of factors that influence this transfer function) There are also in most cases measurement errors due to parasitic losses (bearing(s) and/or roller(s) transmission losses). Secondly, a driven transmission can only, in best case, simulate two of the three main types of transmission loss. Due to the fact that there is no load applied to the transmission the load losses are significantly underestimated. In addition, most modern transmissions have the gears optimised to bear the load on one side of the gear tooth meaning that the other side will have a different friction characteristic.

Table 1 - Example of factors that influence the friction and rolling resistance of a tyre

Relative movement (slip) **(no slip – no transfer)**
Rubber compound
Wheel load
Tyre design and tyre wear
Tyre air pressure
Tyre speed
Tyre diameter
Tractive force (wheel torque)

As with most measurements it is hard to take shortcuts without compromising the results. The ROTOTEST VPA-R chassis dynamometer has been recognised by the industry as having excellent accuracy and has been used in several projects to determine transmission efficiency. By the use of a known input power the overall transmission efficiency may be determined. The most accurate way of determining it is by continuously measuring the transmission input performance and at the same time measure the performance produced at the end of the drive-shafts. The procedure works on manual as well as automatic gearboxes. As an example, the percentage slip in the torque converter, compared to the rolling road procedure, can be described under different load conditions.

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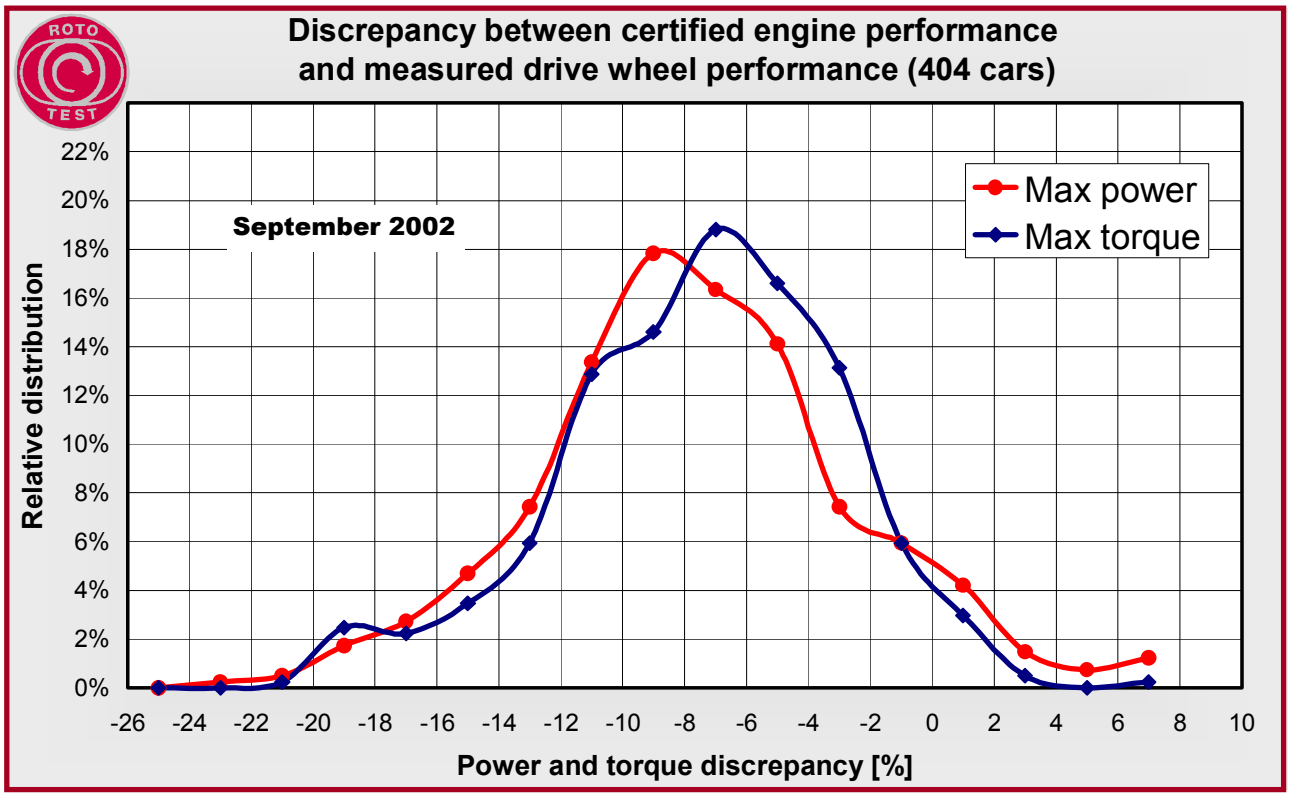
Powertrain Performance statistics

The graphs below describes the discrepancy between stated engine performance (steady state performance) and measured **Powertrain Performance** (steady state performance).

All types of different cars are represented, front wheel drive, rear wheel drive, four wheel drive, petrol and diesel engines, normal aspirated and turbo engines, manual and automatic transmissions.

The **Powertrain Performance** tests are performed between May 1993 and September 2000



Explanations of the Powertrain Performance statistics

The graph shows that the average torque discrepancy is 7% and the average power discrepancy is 9%.
Cars (engines) with more performance on the wheels than stated in the engines are a bonus for the car buyers. This phenomena can be due to market reasons and the difficulty to control engine performance within small limits. In the other end of the graph we find the discrepancies of more than 10-15% (depending on powertrain design) and there we have the bad transmissions and/or the engine performance cheaters.

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