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Measurements made easy

A non-established solution to the measurement demands of new engine designs is not only more flexible – it is more cost-effective

WORDS: STEFAN EK

A typical 2WD setup of a Rototest Energy system

With shorter development cycles and more stringent budgets, the term 'cost-effectiveness' is becoming a mantra. How to do 'more with less' – the very essence of cost-effectiveness – is a challenge with which every development manager and engineer is struggling, regardless of whether the 'less' relates to time or resources. One way to help solve this problem is to use test equipment that is versatile, allows flexibility and increases productivity levels.

Swedish technology company Rototest has been manufacturing automotive test equipment for more than 20 years and specializes in hub-mounted chassis dynamometers. The traditional chassis dynamometer is of roller type, where the vehicle is driven on top of a roller that simulates a road surface. Rototest has employed a quite different approach with a design concept it refers to as a hub-mounted dynamometer. By removing the wheels and mounting a dynamometer on each wheel hub, the same road-like behavior can be simulated as with the roller-type dynamometer. But there is one main distinction: Rototest's hub-mounted solution enables verifiable and very high measurement accuracy by employing a fully calibrated and traceable measurement strategy.

Furthermore, the system is not limited to use for emission calibration during drive cycles; it can also double as an advanced test rig in powertrain testing. Until now, this type of testing would require dedicated and highly specialized test equipment. The secret to this versatility lies in Rototest's Unified Test Equipment Platform (UTEP). The platform is shared between Rototest's product lines and includes a self-adjusting, pivoting hub coupling with adjustments for tire contact point. The hub coupling and pivoting functionality allows the vehicle's suspension to be loaded in such a way that it does not infer additional stress and losses.

Improving efficiency

The tire rolling resistance, the aerodynamic drag and mass-related (acceleration and incline)

resistance are the major forces acting on a moving vehicle and therefore have an important influence on the amount of energy needed to motor the vehicle. Although minimizing these forces is a stated design target, these forces are difficult to reduce quickly and cost-effectively for a specific type and size of vehicle. The other option is to make the powertrain more efficient by individually identifying and reducing losses as much as possible.

This is one area of research that is becoming increasingly prioritized due to growing market demand for more energy-efficient vehicles. Powertrain efficiency studies can be conducted using highly specialized test rigs. The drawback with these test rigs is that as well as high initial costs, the setup time is also substantial. The setup time in Rototest's dynamometer is only a couple of minutes. As the measurement system has been designed specifically for dynamometer use, it achieves a high level of accuracy that enables the dynamometer to be well suited for traditional chassis dynamometer testing and previously dedicated test rig applications.

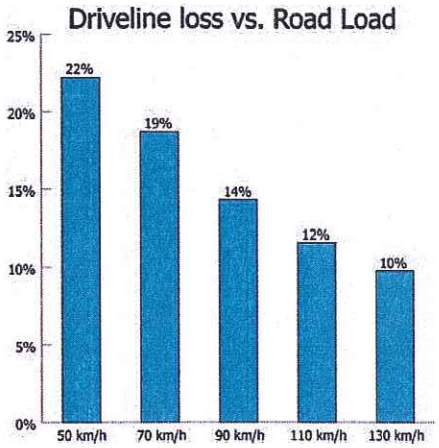

Figure 1: The driveline loss at idle load level compared with running resistance (road load)

Data study

To demonstrate the capabilities of the dynamometer in the powertrain field, Rototest asked automotive research organization RRI.se to conduct a short study using a Rototest Energy system. The objective of the study was to show how simple the procedure would be to measure the losses in a driveline at idle load. The study does not in any way claim to be comprehensive or take into account all aspects of driveline loss measurements.

The test vehicle was a five-door compact car equipped with a transverse manual gearbox. The test procedure in the study included three steps: test preparation, measurement and analysis.

Normal test preparation with the Rototest solution is so simple that it can be compared to changing a wheel. The car is lifted with a vehicle jack or hoist. The wheels are removed and replaced with appropriate adapters. The dynamometer units are bolted to the adapters and the vehicle is then lowered to be fully supported by the dynamometers. This solution allows for natural wheel load, suspension movement, and even steering movements of driving wheels while testing. In this particular case, the test preparation included an additional step in which the brake calipers were removed to eliminate any influence of brake pad drag.

Measurements were undertaken using a constant speed test mode with the dynamometer motoring the vehicle with the vehicle's gearbox in neutral. Test speed points of 30, 43, 56, 68 and 81mph (50, 70, 90, 110, and 130km/h) were measured, with the steering angle being set as straight forward. For each speed point, the torque required to keep the speed constant was measured. The wheel hub speeds were kept equal so that they did not influence the measurement due to additional differential losses.

In the last step of the study – the analysis – the results from the measurements were compared with the power required to overcome the aerodynamic drag and rolling resistance for the test vehicle to give a percentage value for each speed point. The result is shown in Figure 1, where it can clearly be seen that even the idle losses can be a substantial addition to the energy the engine must produce in order to travel at sub-motorway speeds. The complete test took less than two hours to perform, including test preparation, measurements and analysis.

The described sample study of driveline losses and powertrain efficiency is not the only area where the Rototest dynamometer system is applicable. Obvious fields are engine calibration and drive cycle related calibrations, as mentioned previously.

One field becoming increasingly popular is the NVH arena, where the hub-mounted solution's elimination of tire noise allows exhaust system development engineers a much greater resolution than has been previously possible using traditional technology. Another field where Rototest sees a natural application for its solution is the complex powertrains that are evolving using multiple power sources to propel the vehicle. This evolution is currently picking up speed and will require test equipment that enables flexibility and has built-in capacity to handle future powertrains of various types and designs.

Below left: The wheels are replaced by adapters, to which the Rototest dynamometers attach

Below: A 2WD Rototest Energy system includes two dynamometer units, one system control unit, and one main power unit. The system is fully re-generative and absorbed energy is fed back into the network grid