Experiences on chassis dynamometer measurements of heavy road vehicles

Summary of Research Activities at VTT
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Measurement and Monitoring of CO₂ Emissions from HDV’s

Varese, Italy      May 30, 2013
BACKGROUND

- In the early 00’s growing need to address fuel consumption and exhaust emissions of HDV’s
- A large number of measures were available, but no methodology to assess their performance
- No ”common grounds” for information from OEM’s

A novel way to measure performance of a complete HDV’s was necessary
ITEMS TO CONSIDER

**Maintenance**
- effect of maintenance on consumption
- vehicle/engine upgrades

**Driving & Use**
- duty cycles
- optimum driving style
- driver education
- motivation
- guidelines

**Fuel & Energy**
- fuel optimisation
- lubricants

**Specifications & characteristics**
- performance criteria
- specific consumption of vehicles
- values based on tonn/km

**Technology**
- driveline
- body & cargo space
- engine technology & auxiliaries
- driver assistance
- tyres
Chassis dyno vs. engine dyno (transient)

**ADVANTAGES**

- takes into account characteristics of a complete vehicle
- easier set-up of the test installation

**DISADVANTAGES**

- less accurate, if tyre/roller contact not normalised
- larger installation & test facility required
HD VEHICLE DYNAMOMETER FACILITY AT VTT

Max. power: ± 300 kW (range 54 - 110 km/h)
Max. traction: ± 20,000 N (range 0 - 54 km/h)
Inertia simulation: 2500 – 60,000 kg
Roller diameter: 2500 mm
Max. boggie load: 20,000 kg

Fast IGBT control enables transient operation
Texel V6 data acquisition system
Driver’s aid with different dynamic driving cycles
Discussing Research Methodology
ESSENTIAL ELEMENTS IN TEST METHODOLOGY

- Operating (duty) cycle & road characteristics
- Road-load model (air drag, rolling resistance etc.)
- Replicatory issues (tyres, cooling etc.)
DUTY CYCLE IMPOSED ON AN ENGINE MAP

- Real-world driving spreads more over the map than ETC!
TEST CYCLE @ DEPOT-TO-STORE URBAN DELIVERY

Delivery cycle, original onroad data, 420 hp / 22 t

Engine power kW

Road level m

Driving speed km/h

Time s
TEST CYCLE @ HIGHWAY

Highway cycle, original onroad data, 420 hp / 50 t

- Engine power kW
- Road level m
- Driving speed km/h

Time s

0 200 400 600 800 1000 1200

0 20 40 60 80 100 120 140 160

0 100 200 300 400 500 600 700 800

Engine power
Road level
Driving speed
TEST CYCLE @ FREEWAY

Freeway cycle, original onroad data, 420 hp / 50 t

Time s

Engine power kW
Driving speed km/h
Road gradient %

0 200 400 600 800 1000 1200

-2.5 -2 -1.5 -1 -0.5 0 0.5 1 1.5

-2.5 -2 -1.5 -1 -0.5 0 0.5 1 1.5

0 200 400 600 800 1000 1200

Engine power
Driving speed
Road gradient
• uphill/downhill driving visualisation to driver
Determination of the Road-Load Model
Determination of the Road-Load Model

- Coast-down test runs performed on a motorway straight, over 5 km of length
- Variable longitudinal geometry known with decent accuracy, and differential GPS is used to position the vehicle
- Sufficient normalization is achieved
Determination of the Road-Load Model

- Passing large vehicles create turbulence in the surrounding air
  >> results affected
- Must make several re-runs to compensate
- Slow-speed phase is also somewhat hazardous
Determination of the Road-Load Model

- Road surface "microgeometry" varies with season
- In April-May, the surface is very coarse after winter, increasing friction
- June and August, are the best, but July sometimes too "hot", because surface melts
Determination of the Road-Load Model

- Must use actual, physical ballast to test the effect of vehicle load
Determination of the Road-Load Model

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Jugs of water
Determination of the Road-Load Model

- Must use actual, physical ballast to test the effect of vehicle load

The "Big Sausage"
Determination of the Road-Load Model

- Must use actual, physical ballast to test the effect of vehicle load
- with water, dumping the ballast is easy!
Wind Correction

- Wind will distort results of a coast-down test, unless the direction is directly parallel to the road axis, when tests to both directions can be used to nullify the effect.

- Use of an anemometer, clear from the vehicle’s own wake, is preferred, and results into satisfactory correction, unless the wind is very intermittent or turbulent.
TYRE MAKES A SIGNIFICANT CONTRIBUTION

- Different tyre types and treads give different rolling resistance!
Tyre temperature

- Rolling properties of the tyre are affected by the tyre temperature
- At low running temperature, the resistance at slow speeds is abnormally high
- Must monitor and maintain always sufficient running temperature, when exercising coast-down runs
ONE SINGLE TYRE/TREAD TYPE CHOSEN
Pillars of the HDV chassis dynamometer method

- Light-duty vehicle chassis dynamometer emission measurements 70/220/EEC 91/441/EEC 98/69/EC
- HD engine emission measurements 96/1999/EC
- Accredited method for HD vehicle chassis dynamometer measurements
- Recommended Code of Practise HD vehicle chassis dynamometer measurements SAE J2711
- General safety instructions
Both full vehicle dynamometer as well as engine bench tests have accreditation according to EN ISO/IEC 17025
OTHER ELIGIBLE CANDIDATE METHODS

- On-road & on-board (PEMS)
- Computer simulations
Chassis dyno vs. on-road & on-board (PEMS)

ADVANTAGES

+ enables more accurate and complete emissions characterization, incl. PM size distribution
+ gives better repeatability & reproducibility
  >> higher accuracy

DISADVANTAGES

- more investments needed
- less flexible, must bring vehicle to the facility
On-road measurements (PEMS)

• Changing traffic situation
On-road measurements (PEMS)

• Changing weather conditions
On-road measurements (PEMS)

And even when the road is clear and the sky is blue...

• A lot of carry-on equipments are needed!
Chassis dyno vs. computer simulations

ADVANTAGES

+ enables quicker, more direct approach
+ results are usually “in the ballpark”

DISADVANTAGES

- more investments are needed
- less flexible, must produce vehicle before testing can be imposed >> not an early design choice tool
Challenges - Computer Simulations

- Must develop models for each vehicle type
- Must know the boundaries of the model
- Must be able to **calibrate** the models
PORTFOLIO OF ACTIVITIES

Trucks

Busses
VEHICLE EVALUATIONS - BUSES

Tested about 150 busses, From Euro 0 to EEV
VEHICLE EVALUATIONS - TRUCKS

Tested about 100 trucks, from Euro 0 to Euro VI
VEHICLE EVALUATIONS - SPECIALTY VEHICLES

After 2002, altogether more than 5000 individual test runs
HD VEHICLE CHASSIS DYNAMOMETER FACILITY

- Chassis-dyno facility for heavy-duty vehicles enables us to determine emissions and energy use from complete vehicles
- Multiple emissions measurement methods available, with good repeatability and accuracy
- The possibility to work with real-life duty-cycles opens up excellent possibilities to assess the influence of in-use conditions
- Running tests with complete vehicles is very cost-effective, especially if in-use vehicles are involved
The End

- Thank You for your Attention!
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