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JRC Contribution to EVE IWG:
Hybrid System Power Determination

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28th Meeting of the GRPE Informal
Working Group on Electric Vehicles
and the Environment (EVE)

October 16th-18th, 2018, Ottawa (Canada)

European Commission

Activity Summary

- Hybrid System Power Determination Validation Program at JRC

  - Two OICA vehicles have been tested
  - N1 was tested on 11th-13th June 2018 in VeLA 8 JRC Lab
  - N2 was tested on 2nd-6th July 2018 in VeLA 8 JRC Lab
  - Post-processing of the results took place before summer
  - Results are under discussion
  - Possible updates/suggestions for the GTR drafting from the outcomes of the validation test program

JRC VeLA 8 – in Ispra (VA), Italy

- Electric and hybrid vehicles testing facility
- Energy efficiency and exhaust emissions measurements
- From Light- to Medium-Duty Vehicles
- Climatic chamber (-30/+50 ^{0}C)
- Chassis Dynamometer
    - Roller surface: metal sprayed
    - Full power 4WD 300 kW
    - Max. tractive force 7,000N up to 108km/h
    - Roller type single
    - 4WD
- Cooling Fan
    - Type: Vertical inlet
    - Outlet area: 0.4 (800mm x 500mm) m²
    - Axial windspeed fan with 90° bow and air inlet from the top
    - Bulk flow: 60000 m³/h
    - Distance from front of vehicle: moveable

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Vehicle N1

- Pre-testing exercise with “Golden engineering”
- Vehicle N1 is a petrol plug-in hybrid 4WD parallel TTR vehicle
- Rated engine power:235 kW @95rps
- Electric motor: 65 kW
- 8-speed gear automatic transmission
- 10.4 kWh Li-ion polymer battery

Vehicle N2

- Vehicle N2 is a petrol parallel 2WD hybrid vehicle
- Rated engine power:77kW@5700 rpm
- Electric motor: 32 kW
- DCT double-clutch gearbox 6-speed automatic transmission
- 1.56kWh Li-ion polymer battery

Data acquisition systems

- The **vehicle** N1 has been equipped with a **AC/DC current probe** (accuracy ±0.3%) for measuring the HV REESS current and with a special safety derivation box for **HV REESS voltage** measurement
- The **vehicle** N2 has been equipped with **three AC/DC current probes** (accuracy ±0.3%) for measuring the HV REESS current and the **12 Voltage service battery** and with a special safety derivation box for **HV REESS voltage** measurement. Voltage of the service battery was also measured
- Yokigawa **power analyser** was use to record the current and voltage data with acquisition frequency 20Hz as prescribed
- DC/DC converter current and voltage by CAN bus at 10 Hz
- **CANbus data** logging - continuously during all testing at 10 Hz
  Logging speed vehicle, engine speed, HV REESS current, HV REESS voltage, HV REESS SOC, HV REESS temperature, Accel. pedal %, breaking pedal (optional), intake manifold pressure, engine water temperature, engine oil temperature, ATF (automatic transmission fluid) temperatures, intake air temperature
- **Fuel flow rate** measured only for **vehicle N2**
- **Dynamometer data** logging – continuously during all testing at 10 Hz
  Logging time, inertia (simulated), dynamometer torque, dynamometer speed, calculated power, and calculated energy dyno, via the dyno controller.
- **Engine power** output curve from UN R85 results by OEM, corrected for altitude
- Torque meters or drive shaft sensors were **not** installed

Vehicle N1 – Test Summary

- Total of 8 tests plus additional tests for exploring different speeds and parameters
- Five repetitions at the same speed and full SoC of the REESS
- One test at low SoC of the HV REESS
- Additional tests changing the speed
- Both soak and conditioning phases recorded (also with power analyser) so as the recharging phases
- Temperatures (ICE oil, ATF, REESS) and SoC checked before starting the tests
- Both TP1 and TP2 tests and post-processing
- Being the first pre-testing and validation tests the main scope was to apply all the steps of the draft test procedure (from the installation up to the post-processing)

Test	REESS SoC
Hybrid Driving Mode	**Full REESS SoC**
Test0 - Power -	
Test1 - Power -	
Test2 - Power -	
Test3 - Power -	
Test4 - Power -	
Hybrid Driving Mode	**Medium REESS SoC**
Test5 - Power -	
Hybrid Driving Mode	
Test6 - Power -	
Hybrid Driving Mode	
Test7 - Power -	
Hybrid Driving Mode	**LOW REESS SoC**
Test8 - Power -	

Vehicle N2 – Test Summary

- Total of 11 tests with in almost all cases 4 repetitions in each test plus additional tests for exploring the speed at which the maximum power occurs.
- 101 km/h was chosen for the test repetitions at SoC of 60%
- Five repetitions with 4 peaks in each test were carried out for the selected speed
- Two tests with higher and lower speed to verify the peak
- One test at low SoC of the HV REESS same selected speed
- One test at full SoC of the HV REESS same selected speed
- Additional tests changing the driving mode to Sport mode
- Both soak and conditioning phases recorded (also with power analyser)
- Temperatures (ICE oil, ATF, REESS) and SoC checked before starting the tests
- Both TP1 and TP2 tests and post-processing
- The scope was to apply all the steps of the draft test procedure (from the installation up to the post-processing)

Test	Speed [km/h]	REESS SoC
Eco Driving Mode		
Test1 - Power -	101	**60%**
Test2 - Power -	101	
Test3 - Power -	101	
Test4 - Power -	101	
Test5 - Power -	101	
Eco Driving Mode		
Test6 - Power -	100,99,98,97	**60%**
Eco Driving Mode		
Test7 - Power -	102,103,04,105	**60%**
Eco Driving Mode		
Test8 - Power -	101	**FULL REESS**
Eco Driving Mode		
Test9 - Power -	101	**LOW REESS**
Eco Driving Mode		
Test10 - Power -	100	**50%**
Sport Driving Mode		
Test11 - Power -	100,101,99km,h	**70%**

Post-processing

- Both TP1 and TP2 methods have been applied to analyse the data
- 2 sec moving average window for peak power calculation over the 10 seconds at maximum acceleration
- Average values on the last 2 seconds (from 8th to 10th second) for the sustained power calculation
- Exploring also the sustained power value when considering the average value over the last 2 seconds before acceleration pedal release in the case in which the maximum acceleration was kept for more than 10 seconds
- REESS power from both CANbus and measurements by clamps
- ICE power corrected for altitude according to UN R85
- Fuel flow rate measured during tests of vehicle N2 and compared to UN R85 corrected values. **Commercial fuel used** instead of UN R85 fuel in both vehicles
- Data still under discussion

Validation testing observations

- To find the speed at which the maximum power occurs and related gear shift: acceleration from zero up to a maximum speed recording both power and gear shift by mean of the dyno controller was our solution
- Both TP1 and TP2 tests and post-processing were carried out. Difference in the two approaches with TP2 lower values possibly ascribed to the tire slippage. Order of magnitude of losses (dyno-wheel) in line with other presentations. Results under discussion
- No torque-meters or drive shaft sensors installed on the vehicle hence slippage correction has to be added to the results. Comparison between wheel speed and torque values from dyno and from CAN bus could support in this
- Low REESS SoC and High REESS SoC have an influence on the peak and sustained power calculated values
- Driving mode has an influence on the peak and sustained power calculated power

From ISO 20762 6.4

Data acquisition systems

- **TP2:**

  - The accuracy of this measurement device must fulfill the same requirements as for the shaft/wheel measurement devices: ± 6 Nm or ± 0.5 % of the maximum measured total torque, whichever is greater, for the whole vehicle, with a measurement frequency of at least 10 Hz.

  - If wheel torque and rotational speed measurement is provided by the chassis dynamometer, *the measured values for traction force and speed have to be transformed by calculation to the required values for torque and rotational speed at shaft/wheel, taking into account the specific data of the tires and the proportional vehicle weight at axle/wheel used during the test (e.g.: rolling friction losses, dynamic rolling radius).*

Thank you for the attention

Q&A

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