SEVENTH MEETING OF THE GRPE INFORMAL GROUP ON HEAVY DUTY HYBRIDS (HDH)

Vienna, 12 to 14 October 2011

MINUTES OF THE MEETING

Venue: Austrian Federal Ministry for Transport, Innovation and Technology (bmvit), Vienna
Chairman: Petter Ăsman (European Commission)

1.- WELCOME AND INTRODUCTION

On behalf of bmvit, Mr. Tober welcomed the participants. The Chairman thanked bmvit for hosting the meeting at short notice and sitting in for Japan.

2.- ADOPTION OF THE DRAFT AGENDA

(Working paper HDH-07-02)

The draft agenda was adopted. It was agreed to cover agenda items 5 and 6 on 12/10 and the remaining agenda items on 13/10, if possible. 14/10 would be reserved for any additional items and a visit to IFA for interested participants.

3.- DRAFT MINUTES OF THE SIXTH MEETING

(Working paper HDH-06-09)

The draft minutes of the 6^{th} meeting were approved.

4.- CONTRIBUTIONS FROM CONTRACTING PARTIES ON HD HYBRID AND GHG ACTIVITIES

4.1 USA

(Working paper HDH-07-09)

Mr. Jackson presented the status of the US GHG (Greenhouse Gas) rule. The HD National Program was developed by EPA with support from industry, the State of California, and environmental stakeholders, and is a key component of EPA's response to a Presidential Memorandum issued in May 2010. The final rule was published at the beginning of August 2011 and becomes effective in 2014 followed by a second step in 2017. A second phase of regulations is planned for model years beyond 2018. For HD vehicles, the rule includes two sets of standards, one for the engine (in g/kWh), one for the whole vehicle (in g/ton-mile). The engine GHG emissions (CO_2, CH_4, N_2O) are measured over the FTP and SET test cycles (like for criteria pollutants), while the vehicle CO_2 emission is calculated by using the Greenhouse gas Emissions Model (GEM). The CO_2 standards for pickup trucks and vans are expressed in g/mile and detemined on the chassis dyno. The rule also includes flexibility provisions that allow using early credits. An implementation workshop will be held on 03 November 2011 in Ann Arbor. Questions may be submitted to EPA by 19 October 2011.

The second part of Mr.Jackson's presentation is covered under agenda item 7.

4.2 Other

None.

5.- ROAD MAP AND PROJECT PLANNING

(Working paper HDH-07-08)

The Chairman announced that a contract had been signed with TNO as a consultant to the Commission instead of TRL, as was previously indicated at the 6th meeting. The work program of TU Graz, which is also covered by this contract, remains unchanged.

The Secretary informed that the contract with TU Vienna had been signed, while the contract with Chalmers will be signed in the near future. Nevertheless, the work program at Chalmers has already been started. Also, the total budget of 265 k€ has not been changed.

Currently, the work program is slightly behind schedule. The roadmap on page 6 of working paper HDH-07-08 has been modified to reflect this delay. Termination of the research programs is now scheduled as follows:

- TU Vienna: 12/2011
- TU Graz: 04/2012
- Chalmers: 05/2012

Timing for WP.29 adoption is not affected, so far.

6.- PRESENTATIONS BY RESEARCH INSTITUTES

6.1 TU Vienna

(Working paper HDH-07-04)

Mr. Schneeweiss presented the work program of the Institute for Powertrains & Automotive Engineering (IFA) at the TU Vienna. After a general introduction, he first focused on the interface model. The major task of the interface is connecting the simulation model and the hardware ECU (see slide 10). The interface model is manufacturer specific and remains confidential, but must be disclosed to the approval authority. In case of multiple ECUs, the most important functions of less important control units could be implemented via the interface model of the HILS system, which is a kind of simplified software-in-the-loop.

The Japanese simulation model is realized with Simulink, a well established programming language, which is based on physical models and lookup tables (see slide 15). The most important model is the powertrain model (see slide 16). In Japan, five different powertrain models exist, but for a worldwide regulation more powertrain models would likely have to be developed. In order to solve this problem, IFA is proposing a component library. Components are physical entities (e.g. engine, motor-generator, battery, clutch, gearbox etc.) that are combined to result in a special powertrain topology. IFA also suggests to develop temperature models to take into account hybrid control strategies for optimized engine warm-up. Prof. Hausberger added that this would also be needed for the warm-up of any aftertreatment system. The Chairman recalled that the WHDC procedure includes a cold start and a hot start test, and this issue must be dealt with in a global regulation. It was agreed that this could finally result in two different engine cycles for cold start and hot start. The Chairman then raised the question where the models would be defined. It was general understanding that the gtr could only include some base models, like in Japan. Furthermore, it will not be possible to amend the gtr every time a new model is proposed by a manufacturer. The Secretary proposed an approach of defining in the gtr general guidelines of model construction on the basis of the component library proposed by IFA. With this approach, verification of the models becomes more important.

IFA then introduced an alternative to the Japanese vehicle based approach for consideration of the group. This alternative uses the premise that engine work of a conventional powertrain (on the WHTC) and of a hybrid powertrain (from HILS) should be comparable. The simulation would be done using the engine WHTC torque from WHTC speed input signal at the gearbox, as illustrated in slide 26. The approach is elaborated in more detail in working paper HDH-07-05rev by TU Graz.

IFA is proposing to do the model verification by comparing simulation results to actual measured data from test track driving using a random driving cycle. This is due to problems, which might occur in chassis dyno testing (correct recuperation, high cost).

IFA concluded that the Japanese component testing provisions could basically be used for a global regulation. Component testing strongly depends on the modeling depth and on the desired accuracy. Under this aspect, Mr. Jackson asked how the durability of the hybrid systems would be taken into account. This is currently not included in the Japanese regulation, but the Chairman emphasized that at least some aspects like durability of the storage system should be covered by the gtr.

Finally, Mr. Schneeweiss indicated that the final report would be issued by the end of 2011.

6.2 TU Graz

(Working paper HDH-07-05rev)
(Working paper HDH-07-10)

Prof. Hausberger (TU Graz) presented the work program of the Institute for Internal Combustion Engines and Thermodynamics (IVT) at the TU Graz. He started with a review of vehicle related data needed for the modelling approach. To this purpose he modelled the WHVC for a large variety of conventional HD vehicle categories. As a result, WHVC leads to similar engine loads as WHTC for all tested vehicles (see slide 8). Deviations against WHTC are rather low for criteria pollutants (NO_x ± 6 %, PM ± 25 %) and fuel consumption (± 2.5 %) for conventional engines (see slide 9). Influence of vehicle mass and air drag, simulated within ± 15 %, on NO_x and fuel consumption was also < 2.5 % (see slide 10).

In order to reduce testing burden, IVT is proposing a “WHTC-corresponding” power cycle at the wheel hub. This would allow a vehicle independent approach and an agreement of powerpack load between HILS and conventional engine tests. Negative driving power has to be adapted against WHTC to account for mechanical braking. This approach also allows to consider PTO and auxiliaries, which are not engaged in engine tests. But for this option, PTO and auxiliaries would have to be simulated in HILS. The approach replaces power demand simulated in the HILS simulator by WHTC power demand. Either P_{engine} or P_{drive} would be possible, but P_{drive} would be the better approach. The calculation of P_{drive} is shown in slide 14. Best interface for this replacement seems to be the driver model via relation gas pedal position and desired power, as shown in slide 26 of working paper HDH-07-04. The resulting cycle work (kWh) would then be the total system work and not just engine work, but Δ SOC must remain neutral over the cycle.

Japan has some concerns, but agreed to consider the approach. The Japanese understanding and response is given in working paper HDH-07-10. It was agreed to resume discussion at the 9th HDH meeting upon further information by TU Graz and Japan.

As regards PTO operation, it was agreed to use the US data for the time being.

As regards the WHVC weighting factors, IVT is proposing to use the PHEM model of IVT to simulate representative real world cycles and the WHVC for different vehicle categories. Weighting factors for WHVC sub-cycles would then be elaborated, which give similar cycle parameters as the representative real world cycles per HDV category. An example is shown in slide 20. The modelling would start with the three WHVC subcycles (urban, rural, motorway). The proposed method was agreed by the group.

6.3 Chalmers University of Technology

(Working paper HDH-07-06)

Prof. Fredriksson presented the work program of the Department of Signals and Systems (DSS) at Chalmers University of Technology, Göteborg. Though the contracts had not yet been signed, DSS had already started the work program. Prof. Fredriksson first gave an overview of energy storage principles (see slide 6) followed by an overview of hybrid topologies (see slides 7 to 9). The most promising solutions are considered to be the hydraulic pump/motor and accumulator, the pneumatic pump/motor and accumulator, the CVT and flywheel, and the motor/generator and flywheel.

Modelling of energy storage systems (flywheel, accumulator) and energy converters (hydraulic pump/motor, CVT) is similar to electric storage and converter models. Also, the pump/motor model can be simulated like the electric motor model (see slides 30 and 31). The result is a set of simulation models of non-electric powertrain components, which are suitable to be used in a HILS setup. As a first summary, non-electric hybrid powertrain topologies fit well into the same categories as for electric hybrid powertrains, and the mathematical models for flywheel, accumulator and pump/motor have similar model structures as in the Japanese regulation.

In general, information on modelling non-electric hybrids is scarce. Japan can not submit any input, but data might be available in the USA. Prof. Hausberger suggested to contact nonroad manufacturers, since they already use hydraulic hybrids in their equipment.

Next steps would be the development of the models, especially the CVT model, and proposals for component testing methods. Japan indicated that four months might be too short for the development of component testing methods.

6.4 Discussion and conclusions

The participants thanked the institutes for their excellent presentations. The major point of discussion was the IVT/IVA proposal of a “WHTC-corresponding” power cycle at the wheel hub. The alternative was welcomed by Mr. Andreae and Mr. Schulte, since it is less dependent on vehicle input data. Japan raised concern that simulation based on WHTC engine speed was not appropriate for series hybrids. The participants agreed that the approach is in any case more difficult for series hybrids. TU Graz was asked to look into this aspect more deeply by also consulting with vehicle manufacturers incl. Japanese manufacturers.

It was clear that in the ongoing first phase of the program only a dummy based validation would be possible, since no hybrid ECU would be available. Second phase validation would then include checking HILS against real vehicle testing, powerpack testing and SILS. The Secretary asked EMA to consider contributing to the validation program, especially with respect to powerpack testing. Mr. Jackson indicated that EPA and Environment Canada (EC) might be adding elements of the HDH program to their internal validation programs.

7.- ASSESSMENT OF POWERPACK TESTING

(Working paper HDH-07-09)

Mr. Jackson gave an overview of the hybrid test procedures in the US GHG rule. Hybrid testing falls under the advanced technology demonstration and consists of comparing a conventional vehicle with a hybrid vehicle. The results from the two vehicles will be used to determine an improvement factor. Testing will typically occur through either chassis testing or powerpack testing.

The pre-transmission hybrid control volume includes the combustion engine, the motor generator, the RESS and the HCM (hybrid control module). The combustion engine must meet the applicable emission limits. The hybrid system is defined as an engine system that includes features that recover and store energy during engine motoring operation and during braking unrelated to engine motoring. CO_2 emission is measured using the same procedures that apply for testing of non-hybrid engines. Mr. Andreae added that this approach minimizes certification afforts and matches with development practices. Evaluation is done by applying charge sustaining conditions laid down in SAE J 2711.

The post-transmission hybrid control volume in addition includes the transmission, vehicle related parameters and a driver model. The post-transmission powerpack test procedure simulates a chassis test with a post-transmission hybrid system. As with pre-transmission powerpack testing, the combustion engine must be criteria pollutants certified, and the CO_2 emission is measured using 55 mph constant speed, 65 mph constant speed, and a transient duty cycle. Validation from the rulemaking focused on comparison between powerpack and complete vehicle improvement factors. Additional validation testing using the powerpack and chassis dynamometer test facilities at EC is planned in the near future.

PTO testing can be applied to both post-transmission powerpack and chassis dyno testing. PTO testing is a procedure for quantifying the reduction in greenhouse gas emissions as a result of running power take-off (PTO) devices with a hybrid powertrain. The complete test for the hybrid vehicle is from a fully charged RESS to a depleted RESS and then back to a fully charged RESS.

8.- ASSESSMENT OF CHASSIS DYNO TESTING

(Working paper HDH-07-07)

In the absence of a representative from India, the secretary presented working paper HDH-07-07 by India. India proposes that the chassis dyno method can be used by Contracting Parties who have chassis dyno capabilities as an option to the HILS method.

The US GHG rule also includes complete hybrid vehicle certification on the chassis dyno. Coastdown testing to develop road load coefficients is performed consistent with the provisions of 40 CFR 1066. Coastdown requirements are largely based on SAE J1263 with some modifications. To correct fuel economy or emission results for net energy change of the RESS, the procedures specified for charge-sustaining operation in SAE J2711 are used.

Mr. Schulte indicated that chassis dyno testing of hybrid vehicles needed additional input compared to conventional vehicles, which is not a simple approach. Mr. Dekker confirmed that chassis dyno testing of hybrid vehicles is more complicated than for conventional vehicles. Mr. Jackson informed that SAE is updating the standard 2711. It was agreed to rely the assessment of chassis dyno testing on inputs from ongoing hybrid testing programs at different Contracting Parties.

9.- NEXT MEETINGS

The next HDH meetings will take place, as follows

- 8th HDH meeting: 17 January 2012, Geneva
- 9th HDH meeting: 21 to 23 March 2012, Tokyo

10.- SUMMARY AND CONCLUSIONS

Chairman and Secretary summarized the meeting as follows:

- The contributions of the institutes were very well received
- The project is delayed by 2 months but still within the overall timeline
- The very thorough technical discussions during the meeting significantly helped the participants in better understanding the complex issue of hybrid testing
- Based on first results, the Japanese HILS model seems to be a good baseline for a global technical regulation
- Based on first results, non-electric hybrid powertrain concepts seem to fit well into the same categories as for electric hybrid powertrains
- The proposal of TU Graz for the evaluation of WHVC weighting factors was agreed
- Discussion on chassis dyno and powerpack testing will continue on the basis of input from ongoing programs at the Contracting Parties
- The hospitality of Austria and the efforts of Mr. Tober in organizing the meeting were especially appreciated

11.- OTHER BUSINESS

None.

7th MEETING OF THE GRPE INFORMAL GROUP ON HEAVY DUTY HYBRIDS (HDH)

October 12 to 14, 2011, Vienna, Austria

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