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

Tokyo, 21 to 23 March 2012

MINUTES OF THE MEETING

Venue: Arcadia Ichigaya, 4-2-25 Kudan-Kita, Chiyoda-ku, Tokyo
Chairman: Petter Ăsman (Sweden)

1.- WELCOME AND INTRODUCTION

The Chairman welcomed the participants and thanked JASIC for the invitation and the organization of the meeting.

2.- ADOPTION OF THE DRAFT AGENDA
(Working paper HDH-09-02)

The draft agenda was adopted.

3.- DRAFT MINUTES OF THE EIGHTH MEETING
(Working paper HDH-08-06)

The draft minutes of the 8th meeting were approved.

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

4.1 EU Commission
(Working paper HDH-09-03)

Mr. Martinez presented the status quo on reducing CO_2 emissions from heavy duty vehicles in the European Union. The work program was launched following a political commitment to reduce CO_2 emissions by 80-95% below 1990 levels by 2050. According to an impact assessment, HDVs have a potential for a 40% improvement in energy efficiency by 2050. In Lot 1 of the work program, a HDV market survey in the EU was conducted. Lot 2 is intended to define the measurement procedure. The approaches explored so far are measurement on chassis dynamometer, measurement with PEMS and model simulation. The preferred option is component testing and model simulation with post-verification via measurement. With this approach, CO_2 is calculated from a steady state engine fuel consumption map corrected by a transient correction factor derived from WHTC. So far, elaboration of the test procedure made good progress, but further development is needed. The HDV CO_2 emissions strategy is tentatively planned to be adopted by the Commission by the first half of 2013. Mr. Martinez pointed out that the lead within the Commission for this dossier is with DG CLIMA. Information about the program may be found at
http://ec.europa.eu/clima/policies/transport/vehicles/heavy/studies_en.htm

4.2 ICCT
(Working paper HDH-09-04)

Mr. Sharpe presented an overview of certification procedures for advanced technology HDVs with special emphasis of evaluating test methods and opportunities for global alignment. Being a first time participant in the HDH group, he first introduced the ICCT. The ICCT (International Council on Clean Transportation) was founded in 2001 by leading air quality and transportation regulators and experts from around the world. The ICCT has offices in the USA, Europe and China, and its mission is to improve the environmental performance and efficiency of onroad vehicles, aircraft, and marine vessels.

The presentation is based on a report recently published. Motivations for the report were the increased activity worldwide for fuel efficiency/GHG regulatory development and the need for sound test procedures for HD hybrid systems and vehicles. The GTR No. 4 test procedure is considered as a potential first step towards harmonization of both criteria pollutant and GHG programs worldwide after 2020. Advantages and disadvantages of four test methods were evaluated: chassis dynamometer-based testing, engine dynamometer-based testing, powertrain dynamometer-based testing, and Hardware-in-the-Loop simulation and testing. Parameters for the evaluation were: consistency with existing engine test procedures, applicable powertrain configurations, robustness and resource requirements. It was concluded that no one method was clearly superior across all relevant parameters (see page 9 of the presentation).

As a summary, the ICCT considers the GRPE/HDH process as important for not only ensuring more equitable treatment of hybrid vehicles, but for also creating a stronger link between criteria pollutant and FE/GHG programs and for paving the way for global harmonization of test procedures. The functional equivalence of the WHTC and WHVC presents an excellent opportunity for creating this alignment between criteria pollutant and fuel efficiency/GHG programs, which is strongly supported by the ICCT.

5.- ROAD MAP AND PROJECT PLANNING
(Working paper HDH-09-10)

The secretary presented working paper HDH-09-10. In order to cope with the proposal of TU Vienna, agreed at the 8th HDH meeting, to conduct a validation phase 1 based on simulation of an ECU, the secretary proposed a modification of the road map, as shown on page 7. Validation phase 2 (real vehicle testing) would only start upon completion of validation phase 1. This would move GRPE adoption from June 2013 to January 2014. Consequently, timing for WP.29 adoption would be delayed until November 2014.

The modified roadmap was agreed by the HDH group.

6.- PRESENTATIONS BY RESEARCH INSTITUTES

6.1 TU Vienna
(Working papers HDH-09-13 and HDH-09-15)

Mr. Planer presented working paper HDH-09-13. He briefly summarized the results of the TU Vienna work package and indicated that the final report would be available, soon. Meanwhile, the final report has been published and circulated to the HDH group as working paper HDH-09-15. He then went on with the suggested validation phase 1 (pages 17 to 19). As already introduced at the 8th HDH meeting, validation phase 1 is intended to verify the

suggested changes of the research institutes to the Japanese HILS method. The proposal is based on the ECU as software in the loop as basis for further programming and software development. As task 1, a serial hybrid simulator would be developed, since the ECU is considered easier to implement. The simulator would cover both the WHVC and the WHDHC as input cycles for the simulation, and would be extended with a library for non-electric components, a library of new components, such as planetary gear box, power split, and with thermal models (exhaust gas aftertreatment components, coolant, lube oil, battery and electric motor). Task 2 would adapt the simulator to a parallel hybrid. As a result of tasks 1 and 2, task 3 would consist of amendments to the Japanese procedure with respect to the methods for component testing, test cycle definition and the simulation method. In task 4, an interface system would be defined to be used for real ECUs.

The participants principally agreed to the proposal. It was common understanding that starting with the serial hybrid would be most beneficial. JARI indicated that they had completed a serial hybrid model, which would be made available to TU Vienna for the validation study. JARI further informed that they already have a simple serial hybrid ECU and would support TU Vienna in developing the software ECU. OICA agreed to deliver input to task 1.4.

OICA offered to sponsor at least part of validation phase 1 depending on the total budget needed. The secretary asked the participants to consider contributing to the validation. In order to get a clearer picture, Mr. Planer was asked to submit a quote to the secretary by mid-April. Task 6 on page 19 (real vehicle testing) of working paper HDH-09-13 is not considered part of validation phase 1, but validation phase 2 and should therefore not be part of the quote. In order to meet the revised project plan the program should start no later than June 2012. Final approval of validation phase 1 will be on the agenda for the 10th HDH meeting.

Mr. Martinez indicated that EU COM would most likely take over the budget for validation phase 2. Intention would be to run this validation at JRC. OICA will check by the 11th HDH meeting (October 2012) which HDVs could be offered for this validation. It is expected to run at least one parallel and one serial hybrid.

6.2 TU Graz

(Working paper HDH-09-06)

Prof. Hausberger (TU Graz) presented working paper HDH-09-06. He started with a summary of the conclusions from the 8th HDH meeting.

On page 5, he gave an overview of the different options for the determination of the HILS engine cycle on the basis of a simple serial hybrid. Option A corresponds to the Japanese method by using the vehicle cycle WHVC and generic vehicle data as input signals. Option B1 uses system power and engine rpm at the wheel hub as input signals while option B2 uses system power and engine rpm at the shaft as input signals. Both options are based on the engine cycle WHTC resulting in the World Heavy Duty Hybrid Cycle (WHDHC). Option B1 had already been presented in detail at the 8th meeting. Prof. Hausberger expressed some preference for option B2.

When using the WHDHC approach, it is required to normalize the negative (braking) power. First, it was concluded that there is a good correlation between negative power and engine rated power (page 9). This was confirmed by Mr. Andreae. However, negative power is influenced by the vehicle category, which requires a correction factor (shown on page 11). The complete normalization procedure is outlined on page 12.

Pages 14 to 18 show the comparison between the WHVC and WHDHC approach for a conventional powertrain. Three different vehicle categories of the Japanese regulation (T4, T6 and T7) were evaluated each with different power packs (240 kW, 3 different shapes of full load curve). The WHVC approach leads to engine loads and speed/load distributions that are quite different from the WHTC approach. Contrary to the WHTC approach, high powered vehicles virtually do not have high engine loads in a power pack cycle resulting from WHVC. Options B1 (wheel hub cycle) and B2 (shaft cycle) are comparable, whereby option B2 seems to be the simpler method that also matches the WHTC for conventional engines. The advantages and disadvantages of the three options are summarized on page 19. A yet unresolved issue is the definition of the full load power curve for a hybrid powertrain.

As regards the evaluation of WHVC weighting factors, Prof. Hausberger reported that the definition of vehicle classes and CO_2 test cycles within the EU CO_2 program has not yet been finalized. Therefore, the evaluation is currently limited to city buses, as already presented at the 8th meeting and shown again on page 33. The final report will only include these results and the calculation method. The results with the other vehicle classes and cycles will be delivered to the HDH group later without additional cost.

The simulation of an air conditioning system of a city bus with respect to PTO load is shown on pages 36 to 41. It is concluded that influence of this PTO load on brake specific criteria pollutant emissions is low and should therefore not be added. PTO loads may be included in the CO_2 test procedures. For a detailed AC simulation, an additional component “electric consumer” would have to be established within the HILS method. For other PTOs, “hydraulic consumer” and “mechanic consumer” might be added, accordingly.

Apart from the final evaluation of WHVC weighting factors, the program is on schedule.

Japan asked for clarification on the CO_2 mandate. Harmonized CO_2 test procedures for conventional vehicles should be first discussed at GRPE level. The Chairman responded that CO_2 is within the mandate for hybrids, and that need to be taken into account when establishing general CO_2 test procedures within GRPE, in the future.

6.3 Chalmers University of Technology
(Working paper HDH-09-07)

The secretary presented the work program of the Department of Signals and Systems (DSS) at Chalmers University of Technology, Göteborg, since Prof. Fredriksson could not attend the meeting.

He reported that non-electric hybrid powertrain topologies fit well into the same categories as for electric hybrid powertrains. In general, non-electric hybrids can be divided into serial, parallel and split powertrain topologies. The most promising concepts are CVT and flywheel, motor/generator and flywheel and hydraulic (or pneumatic) pump/motor and accumulator. An example of component modeling is shown on page 10.

So far, component parameters have been defined for flywheel, accumulator pump/motor and CVT. Also, the hypothesis that no major modifications to the HILS method are needed has been verified. MATLAB/Simulink implementation, standardization of variable names and system modeling for a parallel hydraulic hybrid are ongoing. The work program is on schedule.

One of the major problems is getting data for the modeling from equipment suppliers. EPA will try to supply such data from hydraulic hybrids to Chalmers. Mr. Osaki commented that

verification of a non-electric hybrid not only needs component testing, but also complete HILS validation. The secretary responded this would be done during validation step 1.

6.4 Comments by OICA

(Working paper HDH-09-08)

Mr. Berg presented working paper HDH-09-08. He indicated that the extended HILS approach proposed by TU Vienna as a possible alternative would require new test equipment connected to the engine dyno. Overall, benefits would be low, and higher accuracy would better be achieved by powerpack testing.

As regards the WHDHC proposed by TU Graz, WHTC has artifacts, like gear shift torque interrupts that may not be present in a hybrid vehicle with a non-conventional gearbox. In addition, the WHTC is based on assumptions that may not be valid for e.g. a serial hybrid. But also the WHVC would create some problems, since it defines no slopes thus being less representative for highway applications. Artifacts from conventional gearbox shifting are visible in the vehicle speed profile and would require a smoothing of the speed trace. OICA is in favor of investigating both the WHVC based approach (option 1) and the WHTC based approach (option 2).

6.5 Position Japan

(Working papers HDH-09-11 and HDH-09-12)

Mr. Osaki first presented working paper HDH-09-11, which suggests a solution for the WHDHC other than the TU Graz approach. The proposal basically consists of applying a torque reduction factor to the WHTC. If the hybrid system does not work, i.e. no electric motor work is applied, the engine driving cycle would be the same as the WHTC. In cycle sections where the hybrid system is active, i.e. the electric motor works, the hybrid effect on the engine driving cycle can be reflected according to the respective hybrid system efficiency. The torque reduction rate would be calculated based on the WHVC on a flat road by obtaining the operating ratio of the engine to the total system in chronological order by HILS simulation (see page 9). Examples of the modified WHTC are shown on pages 11 to 14. Mr. Osaki pointed out that this approach is not applicable to serial hybrids.

He also made a proposal on how to consider cold start. A hybrid cold start algorithm could be realized in HILS by putting the water temperature profile of a cold start event of the vehicle or engine into the interface model and send them to the hybrid ECU in the cold start HILS simulated run.

The Japanese position is summarized on page 1 of working paper HDH-09-12. The extended HILS approach proposed by TU Vienna is not considered appropriate for certification because of the expected huge investment for the facilities and the complexity of the system. The WHDHC approach proposed by TU Graz is considered reasonable, however, it does not use the vehicle basis and consequently does not properly reflect the difference between vehicle specifications. A comparison of the different approaches is shown on page 2.

In the discussion that followed Mr. Kawai indicated that the WHTC is generally not appropriate as basis for serial hybrids. It is common understanding of the group that the total powerpack system needs to be considered for emissions evaluation, not only the ICE. In general, a vehicle independent approach would be favorable, if it reflects the real world behavior of an HDV. The final method should also be suitable to give input needed by the various CO_2 programs. Japan agreed that the WHTC could be the basis for criteria pollutants, but not for CO_2.

7.- ASSESSMENT OF POWERPACK TESTING

(Working paper HDH-09-09)

Mr. Andreae presented working paper HDH-09-09. He gave an overview of the powerpack test procedures within the EPA GHG rule. The key challenge for a vehicle independent hybrid certification is the torque curve definition for the hybrid, since the torque curve may depend on the energy storage system state. Examples of torque curve mapping are shown on pages 6 to 8. The major challenge for the future GHG rule is the alignment of vehicle and engine test cycles. EPA rulemaking is therefore facing many of the same challenges as have been raised in the HDH group. A vehicle independent hybrid certification option is seen as the most practical solution for the HD market.

8.- ASSESSMENT OF CHASSIS DYNO TESTING

(Working paper HDH-09-05)

Mr. Schulte presented working paper HDH-09-05 on the experience with chassis dyno testing in the context of the EU CO_2 work program. The presentation mainly focuses on energy recuperation in real world operation vs. chassis dyno operation for an articulated city bus. In case of parallel activation of the mechanical and electrical (recuperation) brake system, brake forces of the axle(s) not in operation/rotation on the chassis dyno may be „over“ recuperated by the axles in operation/rotation, which would give a positive effect to the final test result. This might require additional testing of the mechanical brake forces of the HDV. The recuperation correction is shown on pages 6 to 9. Other issues with chassis dyno testing are the necessity of coast-down measurements, which are often not possible, the cooling of power electronics, converter and energy storage, and additional measurement systems for electrical values in a high-voltage environment. Japan indicated that measurement of current is sufficient, since battery voltage normally does not change very much.

9.- NEXT MEETINGS

The next HDH meetings will take place, as follows

- 10th HDH meeting: 05 June 2012, Geneva
- 11th HDH meeting: 10 to 12 October 2012, Ottawa
- 12th HDH meeting: January 2013, Geneva

10.- SUMMARY AND CONCLUSIONS

Chairman and secretary summarized the meeting as follows:

- The contributions of the participants were very well received
- The revised roadmap and project planning were agreed
- TU Vienna will prepare a quote for the first validation study using software based simulation
- The first validation study will cover both the original HILS approach (based on WHVC) and the wheel power approach proposed by TU Graz (based on WHTC) for electric and non-electric hybrids
- It is general understanding that a vehicle independent approach is the most favorable solution provided the results largely match real world operation
- The extended HILS approach will no longer be considered
- OICA offered to submit part of the budget for validation phase 1

- Discussion on chassis dyno and powerpack testing will continue on the basis of input from ongoing programs at the Contracting Parties
- The hospitality of JASIC and the excellent organization of the meeting were especially appreciated

11.- OTHER BUSINESS

None.

12.- VISIT TO JARI

The participants would like to extend their appreciation to Mr. Morita for organizing the trip to JARI and for his competent demonstration of the HILS method as well as for the lab tour. The HILS demo provided to the participants an invaluable insight into the method.

9th MEETING OF THE GRPE INFORMAL GROUP ON HEAVY DUTY HYBRIDS (HDH)

March 21 to 23, 2012, Tokyo, Japan

ATTENDANCE LIST

NAME	COMPANY/ ASSOCIATION	COUNTRY	E-MAIL	PHONE	SIGNATURE
Äsman, Petter	Trafikverket Chair	Sweden	petter.asman@trafikverket.se	+46 725305 998	
Stein, Jürgen	Daimler/OICA Secretary	Germany	hj.stein@daimler.com	+49 711 1723295	
Martinez, Bernardo	EU Commission	Spain	bernardo.martinez@ec.europa.eu	+32 2 296 69 69	
Hensel, Michael	FPT/OICA	Switzerland	michael.hensel@fptpowertrain.com	+41 71 4477330	
Öhlund, Per	Transport Agency	Sweden	per.ohlund@transportstyrelsen.se	+46 ~~243-758 30~~ 1049 55667	
Schulte, Leif-Erik	TÜV Nord	Germany	lschulte@tuev-nord.de	+49 201 825 4129	
Dekker, Henk	TNO	Netherlands	henk.j.dekker@tno.nl	+31 888 668 387	
Rijnders, André	RDW	Netherlands	arijnders@rdw.nl	+31 79 3458196	
Hygrell, Michael	Volvo/OICA	Sweden	michael.hygrell@volvo.com	+46 31 3223113	
Morita, Kenji	JASIC	Japan			
Kawai, Terunao	NTSEL	Japan	kawai@ntsel.go.jp		
Osaki, Nobuya	Fuso/JASIC	Japan	nobuya.osaki@daimler.com	+81 44 331 4776	
Berg, Henrik	Scania/OICA	Sweden	henrik.berg@scania.com	+46 8 553 89403	

NAME	COMPANY/ ASSOCIATION	COUNTRY	E-MAIL	PHONE	SIGNATURE
Sharpe, Ben	ICCT	USA	ben@theicct.org	+1 415 202 5746	
Fechter, Andrea	UBA	Germany	andrea.fechter@uba.de	+49 340 2103 6508	
Sanchez, James	EPA	USA	sanchez.james@epa.gov	+1 734 214 4439	
Deschatelets, Julie	Env. Canada	Canada	julie.deschatelets@ec.gc.ca	819-956-4968	
Andreae, Morgan	Cummins/EMA	USA	morgan.andreae@cummins.com	+1 812-377-9651	
Hausberger, Stefan	TU Graz	Austria	Hausberger@ivt.tugraz.at	+43 316 873-7714	
Planer, Michael	TU Vienna	Austria	Michael.Planer@ifa.tuwien.ac.at	+43-1-58801-31538	
Toba, Yuki	JASIC	Japan	toba@jasic.org	+81 3 5216 7241	
Narusawa, Kazuyuki	NTSEL	Japan	narusawa@ntsel.go.jp	+81-422-41-3218	
Noburori OKUI	NTSEL	Japan	n-okui@ntsel.go.jp	+81-422-41-3843	
Atsuto KAJIWARA	MLIT	Japan	kajiwara-a2v9@mlit.go.jp	+81-3-5253-8604	
Seiichi YAMAGUCHI	HINO	Japan	seiichi.yamaguchi@hino.co.jp	+81-42-586-4475	
Kunihiko Hikiri	UD Trucks	Japan	kunihiko.hikiri@volvo.com	+81-48-781-3463	