Boleslav KADLECEK
Ladislav PEJSA
Martin PEXA

VIRTUAL VEHICLE-DRIVING CYCLE APPLICATION FOR MEASURING EMISSION AND FUEL CONSUMPTION ON HDVS

This proposed methodology is a simple, cost-effective and user friendly alternative to the ECE R83.03. It is suitable for basic measurements and vehicle diagnostic applications in service centers measurements. The methodology makes use of the quasi-static method. Measurements are carried out without the use of the Power Absorption Dynamometer. A narrow rotational frequency range is measured at a given time, and builds on gradually to successive measurements. Power is not transmitted through the driving wheels. For adhesion, it is not necessary to load the vehicle and the method can be suitably applied to HDV measuring. Test results are registered in grams of emission and fuel consumption per distance traveled in conformity with random loading of a defined driving cycle. The driving cycle is realized in a virtual way by measurements arrived at in the field of variables. Precision of the measurements depends on the sensor used and is comparable to the precision of the measurements made on chassis dynamometer.

Key words: HDV, service measurements, Power absorption dynamometer, fuel consumption, emission, economical and ecological running of vehicles

1. The principle of the quasi-static method

The suggested method for measuring running/operational properties of all vehicles in particular HDVs originates from the objectives of COST 346.10 "To develop an improved methodology for estimating pollutant emissions and fuel consumption from commercial road transport operated with HDV's in Europe". It also builds on the foundation lied by our contribution to COST 319, where we worked on "Quasi-static method of engine loading and its application in estimating fuel consumption and emission production" [1].

The quasi-static method affords the possibility of using the information technology in effectively taking advantage of the cheap acceleration measuring whilst maintaining the priorities of transient state measuring using a dynamometer.

The actual measuring proceeds as follows:

At a predetermined constant fuel feed/supply the combustion engine is braked using the vehicle brakes (steady analyzer of emissions) for 10 to 20 seconds. During this period the variable **z** (CO, CO_2, HC, NO_x) and variable **x** (frequency of revolutions) are measured. Then the engine is relieved and accelerated and during this period the variable **y** (engine torque) is measured. Mathematical computation of these variables, give rise to one point in the three dimensional-graph **z(x,y)**, as shown in fig. 1 It is important to note that the point for which the characteristics are measured is picked at random. All points for consideration are measured in the same manner and this result in a continuous three-dimensional graph.

It is then possible to realize a virtual test driving-cycle by a gradual mathematical loading of the vehicle in phases. This is done within the limits variables in **z(x,y)**. Transient conditions exist in each discreet working point. During this whole period of the virtual driving cycle the independent variable **z** is integrated. In the end emission is measured in grams with the corresponding fuel consumption for the traveled distance.

For a wider application there is need to consolidate and unify the measuring standard, the computation of. measurements and the presentation of results.

2. Discussion

The current urban driving cycle and rural driving cycle is suitable for official tests of cars and other light vehicles.

If we take into consideration that dynamometer use in ECR R83 is the source of mistakes (the need to simulate the air resistance and rotation of wheels), we can say that the virtual test cycle is not all that handicapped. There is of course the transitional problem at start changing gears.

If we further take into consideration that the virtual alternative to ECE R83 is much cheaper and cost-effective in application, there is no reason as to why it cannot be applied on wider scale in service stations. This would combine with and further verify the declared official test results carried out for standard verifications. Other diagnostic methodologies do not provide this possibility.

The virtual alternative seem to be most suitable in comparison to the CEE R49 (13-mode test) on chassis dynamometer. The practical difference between the two methods lies in the fact that the quasi-static method does not require precise predetermined fuel feed/supply and therefore, the z-axis (engine torque) cannot be set according to ECE R49. This can be computed and shifted mathematically in variable field.

We would like to ask why only alternative conditions to ECE R83 are being pursued, while there is the quasi-static method in offer.

The ECE R83 is a better method in evaluating engines and vehicle traction in comparison to ECE R49. The question which has remained unanswered is why the analog test method according to ECE R83 has not been applied to HDVs though it has had overwhelming support from stricter technical point of view.

The answer is simple. It has been due to economical reasons. As a result of this estimation of emission and fuel consumption is being done using the 13-mode test and not on the chassis dynamometer.

Apart from exorbitant costs handling and measuring some Lorries with various modifications like axes, prove to be laborious and cumbersome. This would call for complex construction of the test beds.

Even if the mentioned problem was solved using the multi-chassis dynamometers, another problem would arise. A lorry or a bus would need to be loaded to generate some adhesion force on the wheels to transfer the required power on to the rollers. This would give rise to many other problems like adjustments to the Vehicle test bed.

The above difficulties further support the application of the quasi-static method which does not require full realization of adhesive forces.

3. Proposal of a virtual test driving cycle for HDVs

In principle it seems vital to originate from the existing urban and rural driving cycles according to ECE R83. However, it is important to take the following different conditions into consideration.

According to ECE R83, during tests the acceleration is realized in exact predefined radial acceleration. This does not consider the ratio of engine power to the weight of the vehicle. This seems to be a compromise solution which does not give a true picture of the real world situations. The acceleration of cars depends on the capacity of the engine. Taking adhesion into consideration, there is deviation from torque and evolutions as prescribed by ECR R83. This shows the limitations of the application of ECE R83, resulting in pressure on the environment.

It is however a different matter when it comes to HDVs. Driver behavior is different here. The process is slow start off and gradual increase in acceleration. If the same trend of measuring used for cars was used here, it would lead to incorrect estimations of emissions and fuel consumption. Engine performance curves of new engines, worn out engines, and other modified engines differ and all these need to be registered in the tests.

The authors propose the following points for expert discussion on how to realize the virtual driving cycle for HDVs:

Quasi-statically measure the 10 to 15 discreet points of a vehicle on rollers. Mathematically work out the continuous field of points **z(x,y)**, where the dependent variable **z** (emission CO, CO_2, HC, NO_x) and the independent variable is **x** (frequency of revolutions) and **y** (engine torque). Example on figure 1.

The test driving cycles are according to ECE R83, with modification. The modification is that the acceleration phase of the vehicle is that of maximum simulation limited by engine power and wheel adhesion on the road [2].

The independent variable **z** is integrated. In the end emission is measured in grams for a given driving cycle with the corresponding fuel consumption for the traveled distance [3].

Conclusion

The quasi-static method [1] for measuring engines in connection with the virtual vehicle-driving cycle is suitable for the operational evaluation of engines. It can evaluate both changes in the engine and the traction part of the vehicle, and we see its use mainly on HDV, where the ECE R83 has not been effectively applied to date. It can significantly contribute to time saving, cost-effective and precise evaluation of technical conditions of Lorries, buses, tractors, constructional and other self-propelled machinery. The diagnostic signals acquired can then be used to decide on repair needs or weather the vehicle is operating economically without a negative impact on the environment.

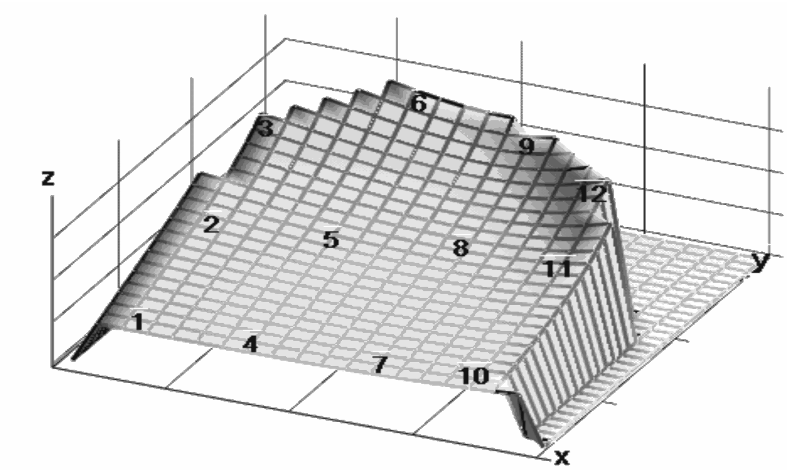

Fig.1. Example of quasi-statically measure

The application demand minimum investments and provides a possible economical and ecological effect in the whole system.

The proposed system needs to be perfected and verified. There is need to find ways of how to incorporate the outcome into the legislation. We target our efforts to support the „White Paper on Environmental Liability", issued in 2000 by the EU Committee at UNO. This provides as the possibility to build a technical base for regular checks of vehicles in real world operations with results being quantified in for instance annual emission production in kilograms. Corresponding reprisals could be imposed to offenders in accordance with what is quoted in White Book-„ He who pollutes must pay".

Quasi-statically measure the 10 to 15 discreet points of a vehicle on rollers. Mathematically work out the continuous field of points **z(x,y)**, where the dependent variable **z** (emission CO, CO_2, HC, NO_x) and the independent variable is **x** (frequency of revolutions) and **y** (engine torque).

References

[1] Otto K, Pejša L, Kadleček B.: *Quasistatic method of engine loading and its application in fuel consumption and emission measuring* (Report from solving of the partial project eu cost 319) January 1998 CZU Prague TF, 24 pgs.

[2] Pejša L, Kadleček B.: *Virtual vehicle-driving cycle for measuring emission and fuel consumption on hdvs*. Report for management committee of the project eu cost 346, 16.5 – 20.5.2001 Stockholm, Helsinki, 4 pgs.

[3] Pejša, L, Kadleček B.: *Measuring method on the free rollers for lorries tractors and special vehicles and its utilization at the emission, fuel consumption and engine technical state test*. Annual report of the project EU COST 346, 28 pgs. , Prague December 2001.

Ing. Boleslav KADLECEK, CSc,

Prof. Ing. Ladislav PEJSA, DrSc,

Ing. Martin PEXA

Czech University of Agriculture in Prague, Technical Faculty
Department for Quality and Dependability of Machines, Czech Republic
CZ-165 21 Prague 6 - Suchdol, Kamycka 258
Tel: + 420 2 2438 1111 Fax: +420 2 20921361
e-mail: Kadlecek@tf.czu.cz