TEST BENCH EVALUATION OF HEAVY VEHICLE SUPPLEMENTARY BRAKE SYSTEMS

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ABSTRACT – The paper is based on an experimental method regarding the determination of a diesel engine power loss using the motoring method in order to simulate the brake system efficiency. For the heavy duty commercial diesel engine, 1035-L6-DTI, manufactured at Roman Truck Company there were performed specific power loss tests on the engine dynamometric test-bench, changing the braking systems (bleeder engine brake and exhaust brake, individually and combined).As main conclusions of the paper are the following :The introduction of exhaust brake is a very effective braking method as the power loss with closed valve is in average with 97% higher than power loss with open valve in the same condition of normal operation (normal exhaust valve clearances).The introducing of bleeding brake by increasing the normal exhaust valve clearance to a higher, permanent value of aperture increased the power loss with an average of 8% because of increased negative work on the indicated diagram as the system is not isolated and the pressure in combustion chamber is lower.The combination of bleeding brake and exhaust brake is not recommended as power loss decreases in comparison with power loss with exhaust brake. The authors consider that the research work has important tehnical contributions to vehicle safety concerning the efficiency of braking systems applied to engines, bringing experimental results in the literature regarding the study of bleeder and exhaust brake systems.

INTRODUCTION

For heavy vehicles the conventional braking systems are friction –type which may fade when used intensively, so most of vehicles are fitted with a supplementary braking system which involves usually the interference with engine operation. Among the non friction braking systems two are most known and used [1]:

a. Engine brake – during compression stroke the exhaust valves are opened when the piston reached top dead center and not at the end of the power stroke so the air is compressed and exhausted before to move the piston. If the variation of valve timing is done during vehicle operation the energy from transmission is used to compress air resulting the retarding of the vehicle. So engine brake, known as compression release engine brake, modifies engine valve operation to use engine compression to slow down the vehicle speed. A simpler version of engine brake is bleeder brake which holds the exhaust valve open at a small, fixed distance during the entire engine cycle.

b. Exhaust brake- is a valve which controls the exhaust gas flow section, raising the exhaust gas pressure in the system and forcing the engine to work against a higher pressure, increasing the retarding the vehicle.

Literature [1, 2] mentions also the use of a combination of bleeder brake and exhaust brake to optimize retarding. The benefits of applying auxiliary non friction based braking systems are the increased vehicle safety with low extra weight and smaller wear of tires and service brake.

RESEARCH WOK OBJECTIVE AND FACILITIES

The paper continues previous research work made on commercial diesel engines D 2156 MTN 8R, 798 – 05, 392-L4-DTI and 1035-L6-DTI [3]. The purpose of the present work is to determine the mechanical power loss for a heavy duty commercial diesel engine and to evaluate the efficiency of two braking systems –engine brake and exhaust brake, individually and combined. The tested engine was 1035 - L6 – DTI, series 0001, equipped with a BOSCH type injection pump. Regarding engine codification, the first group of figures represents the engine displacement, cylinder configuration and number, namely – in line cylinders and 6 cylinders; group of letters DTI represents type of injection (Direct injection), type of supercharging (Turbocharged) and intake air temperature (Inter-cooled). The measurement of braking power was done using motoring method.

The motoring method consists in electrically drive of previosly heated engine without fuel supply and measurement of the resistant couple.

The main technical characteristics of the engine are power, torque and fuel consumption corrected according to requirements of engine performance standard ISO 1585 [4]. The tests were performed at the Road Vehicle Institute in Brasov (INAR) on a continuous current test bench type MEZ - VSETIN, DS 1146 - 4 kV of 300 kW power [5].

During testing, the engine was equipped as follows:

- Injection pump BOSCH PS 6P130A720RS7411, fixed injection timing of 0.5 ° RAC
- Speed regulator BOSCH, type RQ 275 / 1050 PA 12 74.
- Advance variator AB rep. 59111056009
- Injector 0832291035 and nozzle DLLA 138 / 186
- Turbocharger HIDROMECANICA tip H3 0225 A / A 17A2;
- No fan, no alternator and unloaded compressor;
- Simulated cooling of turbocharged air (continuous water radiator in bench tank);
- Exhaust system having as muffler type 89.15101.6001
- Normal clearance of exhaust valve is 0.35 mm,

The atmospheric conditions during testing were air temperature 12°C, atmospheric pressure 716 mm Hg and relative humidity 65 %.The cooling water temperature was kept in the range of 67 - 85°C and the engine has its own thermostat.The equipment used to measure engine data was as follows:

- dynamometric brake MEZ - VSETIN, for engine torque measurement and braking torque during motoring;
- fuel consumption meter ACG;
- electronic tachometer;
- U type manometer for measuring exhaust gas pressure (with exhaust system brake closed) and for measuring air super-cooling pressure;
- opacimeter for determination of Hartridge smoke units of the exhaust gas;
- barometer and electronic psychrometer;
- thermocouple Pt 100 for water temperature measurement.

TEST PROCEDURE

There were determined the following engine characteristics:

a. Speed characteristics at total load

b. Power loss with normal exhaust flow and open exhaust flow with normal exhaust valve clearance
c. Power loss with normal exhaust flow and open exhaust flow with permanent valve aperture of 0.3 mm
d. Power loss with closed exhaust flow with normal exhaust valve clearance
e. Power loss with closed exhaust flow with permanent exhaust valve aperture of 0.3 mm;
f. Power loss with closed exhaust flow with permanent exhaust valve aperture of 0.5 mm;
g. Power loss with closed exhaust flow with permanent exhaust valve aperture of 0.7 mm

The first characteristic „a" is the reference of performance of the engine, which the characteristic „b" correspond to engine power loss without any supplementary braking system. Characteristic „c" corresponds to a mild engine brake of bleeder type. Characteristic „d' correspond to a conventional exhaust brake and characteristics „e", „f" and „g" correspond to a combination of exhaust brake with engine brake of different grades of bleeding .

INTERPRETATION OF RESULTS

The results of the test procedure steps are described as follows:
a. For the first characteristic is represented Speed characteristics at total load, in fig.1.

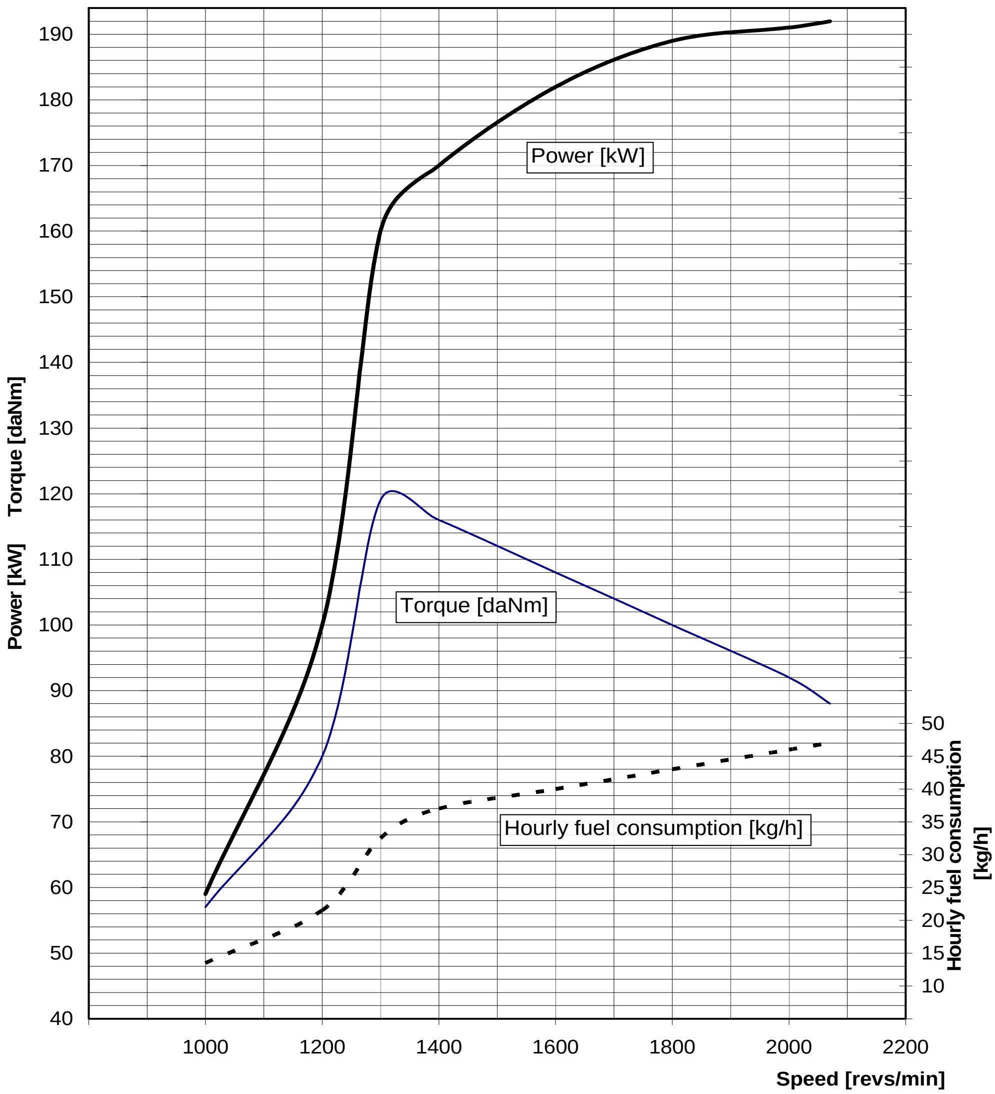

Fig.1 Engine characteristics versus speed

It illustrates the variation of effective torque Me, effective power Pe , hourly fuel consumption C and specific fuel consumption c. these characteristics represent the reference performance of the engine, meeting the requirements imposed by product standard.

b. Power loss with normal exhaust flow and open exhaust flow with normal exhaust valve clearance - In order to determine the power loss the engine was previously heated to recommended thermal operation -cooling temperature in the range of 67 - 85 °C.
   The engine was driven with zero fuel flow to the injection pump, being measured the resistant (driven) torques and exhaust gas pressures at the speed of: 1000; 1400; 1800; 2100; 2300 revs/min with normal clearance of the valves.

c. Power loss with normal exhaust flow and open exhaust flow with permanent valve aperture of 0.3 mm-the test was identical as test on point „b” just the aperture of exhaust valve was increased and maintained permanent open at the value of 0.3 mm. For test procedures of steps „b” and „c” there were measured power loss values and represented in figure 2.

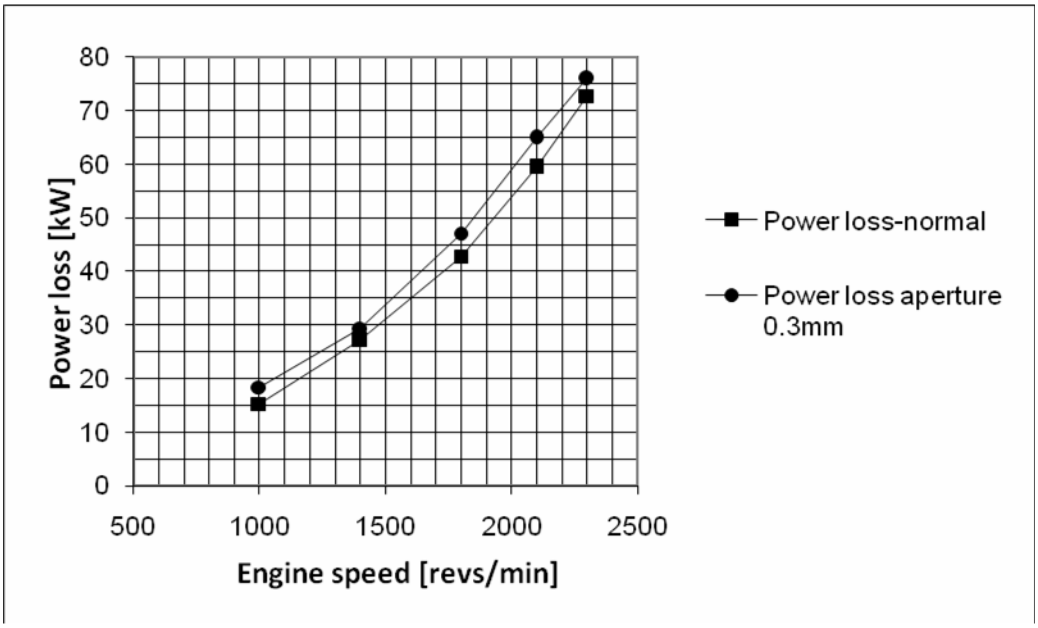

Figure 2. Power loss versus engine speed at normal exhaust and at bleeding exhaust valve aperture of 0.3mm.

d. Power loss with closed exhaust flow with normal exhaust valve clearance
   In the same engine test conditions measuring the same parameters it was determined the power loss when there was mounted on exhaust pipe an exhaust brake.

e. f, g. Power loss with closed exhaust flow with increased exhaust valve clearance (bleeding valve).

f.

   In the same engine test conditions measuring the same parameters it was determined the power loss when there was mounted on exhaust pipe an exhaust brake kept closed and the exhaust valves were regulated to a fixed, permanent aperture of 0.3 mm, 0.5 mm and 0.7 mm, respectively.

   These tests represent a combination of bleeding braking and exhaust braking. The results of tests „d”, „e” „f” and „g” were illustrated in figure 3.

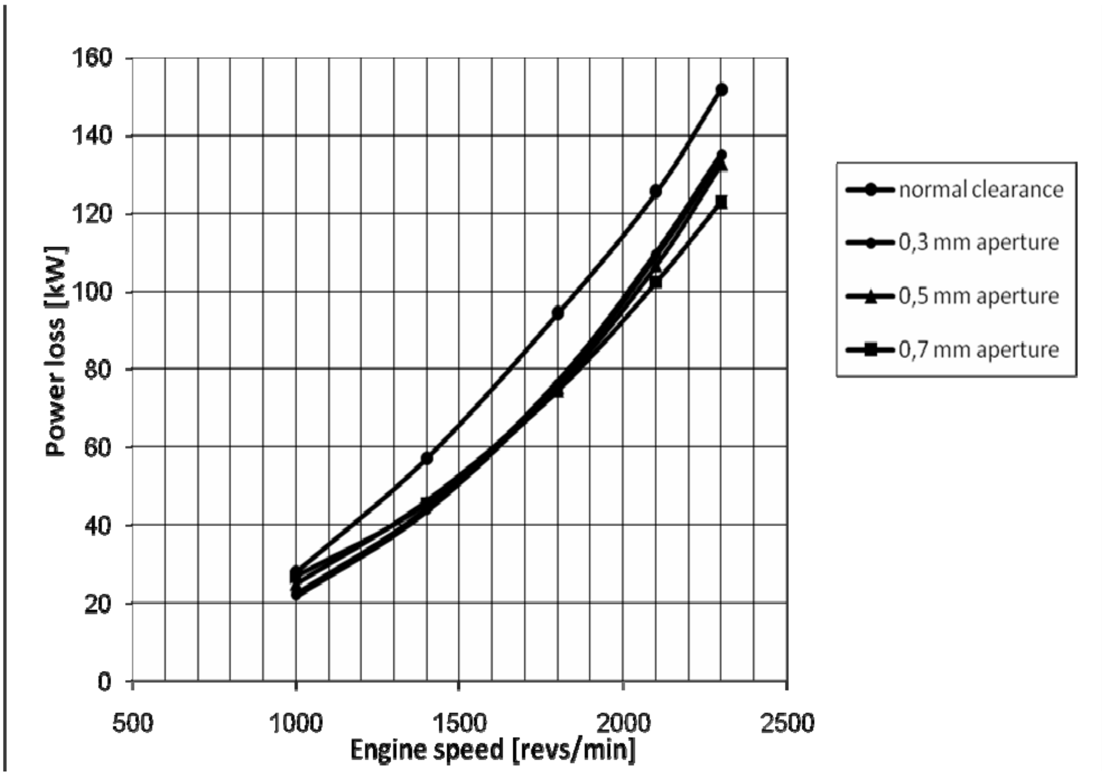

Figure 3.Effect of bleeding and exhaust braking

The simple comparison between bleeding and exhaust braking is done, considering power loss values from fig.2, entitled power loss normal, and fig.3 entitled normal clearance.
It can be noticed that values of the combination exhaust brake and bleeding brake are smaller than those of exhaust brake only, also the influence of the valve clearance is low, the highest clearance giving the smallest power loss.The values for 0.3 aperture and 0.5 aperture are overlapped.The exhaust pressure values measured are illustrated in figure 4.

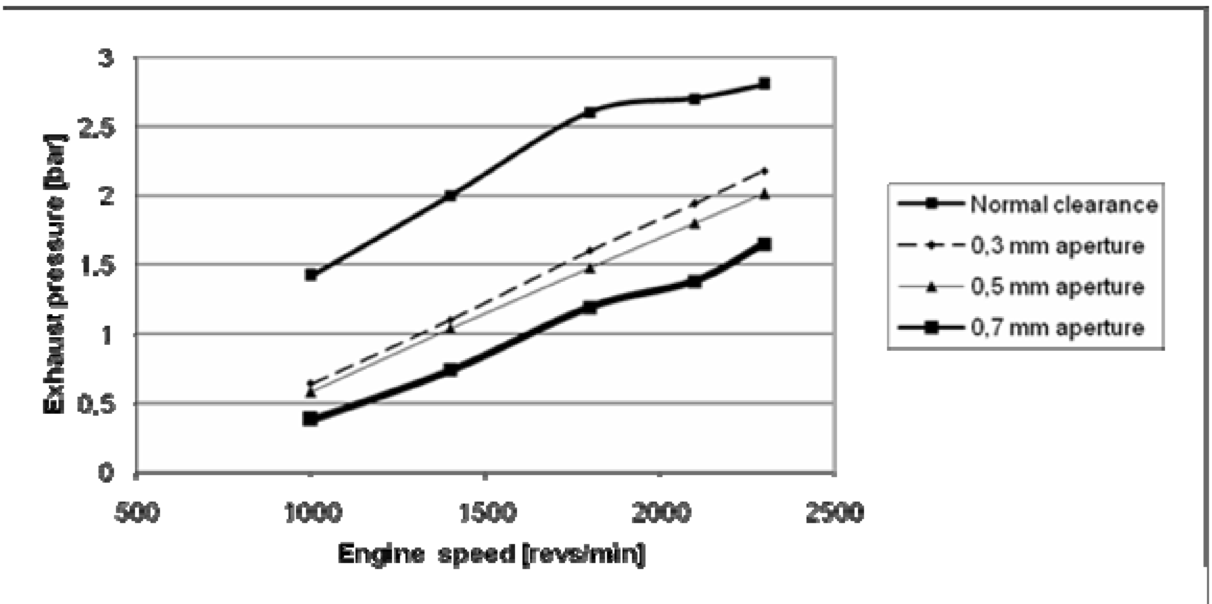

Figure 4. Exhaust pressure versus engine speed at different clearances

CONCLUSIONS

The test procedure lead to the following observations:

1. The engine performance met the producer requirements which allow the certitude that engine manufacture was accurate.
2. The introducing of bleeding brake by increasing the normal exhaust valve clearance to a higher, permanent value increased the power loss with (case „c" reported to case „b") an average of 8% for the first tested engine with aperture (0.3mm), as can be seen comparatively between powe loss values in figure 2.The explanation is given by increased negative work as the system is not isolated and the pressure in combustion chamber is lower.
3. The introduction of exhaust brake is a very effective braking method as the power loss with closed valve is in average with 98% higher (almost double) than power loss with open valve in the same condition of normal operation (normal exhaust valve clearances).
4. The combination of bleeding brake and exhaust brake is not recommended as power loss decreases in comparison with power loss with exhaust brake. The decrease of power is higher as aperture increases (for 0.7 mm aperture the power loss is with 20% lower in average than in situation with exhaust brake with normal clearance).

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