

CONTROLLED EXPERIMENTS OF AFTERMARKET RETROFIT FUEL SAVER ON A TRUCK DIESEL ENGINE

N. LUNGU¹ V. SANDU²

Abstract: *The paper summarizes research works conducted on a heavy duty truck engine equipped with an aftermarket retrofit fuel saver. According to manufacturer claims, the device has an electrostatic effect, improving fuel economy and reducing exhaust gas emissions. The tests were performed on a dynamometric bench comparatively, "with" and "without" device mounted in the engine fuel supply line, keeping constant all the other variables. There were measured engine corrected power, torque, specific and hourly fuel consumption as well as smoke emission. The characteristics used were engine speed at total load and part load, in preliminary test and after 35 hours of running, approximately equivalent to 1100 miles of driving.*

Key words: *diesel engine, aftermarket fuel device, fuel economy.*

1. Introduction

In order to lower the price of the driving, consumers are searching for convenient alternative means to reduce fuel consumption and/or exhaust emissions. To this cheap product demand, the answer of the market was a bulk of aftermarket retrofit devices and fuel additives. Most of the fuel saving devices are magnets, fuel pill catalysts, platinum injectors, ignition enhancers, air bleed devices, turbulence generators, aerodynamic modifiers, electrostatic chargers or hydrogen generators. Typically, their advertisements sound very tempting, claiming to double fuel economy or to reduce exhaust emissions up to 90%. Even if this seems „too good to be true”, the purchasing of fuel saving gadgets is very popular. There

is a recommendation from U.S. Environmental Protection Agency-EPA [1] to avoid any changes to the vehicle engine, fuel, exhaust and emission systems which may cause higher emissions and fuel consumption, compromising manufacturer warranty and vehicle safety.

In the present study are presented engine dynamometric experiments which were carried out on a truck diesel engine to investigate the effectiveness of an aftermarket fuel device commercialized in Romania.

2. Description of the Fuel Saver

According to the manufacturer, the product is “a unique, proven and patented technology that significantly reduces emissions and effectively increases fuel

¹ Road Vehicle Institute, Braşov, Romania.

² Mechanical Engineering Dept., *Transilvania* University of Braşov.

economy which can be used on both gasoline and diesel-powered motors for car, trucks, boats, motorcycles and other applications” [3].

The aftermarket retrofit device was manufactured by the company PACE SETTERS, and according to product description [3] it is a very simple product (without any mobile parts) which produces electrostatic charging of the fuel. The layout and operation is represented in Figure 1 [4]. When the fuel passes through the product, the fuel molecules become polarized improving the combustion. The bar inside the “Vitalizer” product is made of five dissimilar metals (nickel, zinc, silver, copper and tin) and the tube is made of copper [4]. The fuel molecules are entrained in elongated ridges to promote dynamic fuel action, being electrically charged and easily dispersed when the fuel is injected into cylinders. The claims of the “Vitalizer” are better fuel combustion, with lower emissions, higher fuel economy and engine performances and lower maintenance.

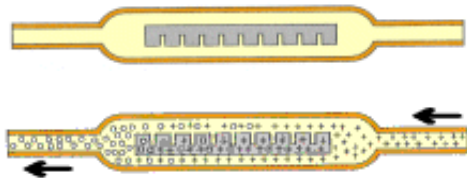


Fig. 1. Product layout and operation [4]

Also it provides quicker starting, removal of carbon deposits from combustion chamber, improved performance of the fuel injectors and cleaner exhaust system. In quantitative measures, the results will increase progressively during 1000 miles after the installation, with a 10-20% gain on rated power and 5-18% gain in fuel economy in urban driving and 9-18% in highway driving. The device evaluation was requested and financed by Romanian Ministry of Research [8].

3. Engine Test Procedure

In order to evaluate the claims of the device, a test program was established using the dynamometric test bench and a heavy duty truck engine. Two identical tests were performed with the device mounted on the engine fuel line and without it. The principle of the testing was to avoid any variations of the test conditions and measurements system. To be sure that any difference in data is not due to fuel, the engine was supplied from the same batch of fuel. The tests were performed in the same atmospheric pressure and temperature, almost constant. The instruments were calibrated and the readings were performed by the same operators to avoid reading errors. During test there were no changes to the equipment, no adjustments or component cleaning. The tested engine was manufactured at Roman Truck company, the engine codification being D2356HMV and serial number 2860, with the basic characteristics presented in Table 1 [9].

Engine technical data Table 1

Engine type	Diesel, 4 stroke, direct injection
Cylinder configuration	6-cylinder, in line
Bore x Stroke [mm]	123 x150
Displacement [l]	10.7
Compression ratio	18:1
Rated power [kW]	158
Rated speed [rpm]	2200
Max. torque [N·m]	720
Max. torque speed [rpm]	1400-1600

The engine was tested on the 300 kW eddy-current type dynamometric test bench (MEZ-VSETIN) at Road Vehicle Institute Braşov (INAR). The engine performance depends on atmospheric conditions and auxiliary equipment.

During the tests, the atmospheric pressure was 722 mm column Hg and ambient air temperature 16-18 °C [8]. The tests were performed according to Romanian engine testing standard [7], the measured values being corrected according to DIN 70020 [5].

The engine performance was corrected according to pressure and temperature with correction coefficient α , using the formula:

$$\alpha = \frac{760}{p} \cdot \sqrt{\frac{273+t}{273+20}}, \quad (1)$$

with p - atmospheric pressure expressed in mm column of Hg, t - atmospheric temperature in Celsius scale.

The measured values of effective power, torque and fuel consumption were corrected using the following formula, written for effective power:

$$P_{corr,ef} = \alpha \cdot P_{m,ef}, \quad (2)$$

with $P_{corr,ef}$ - corrected effective power and $P_{m,ef}$ - measured effective power.

During the testing the engine was equipped with:

- A type in-line injection pump;
- fuel correction device;
- no fan;
- no supplied alternator.

The "Vitalizer" was easily mounted on the fuel supply line at 5 cm upstream injection pump, using two removable double female adaptors. The active part of the device was protected with an industrial fuel hose resistant to petroleum products. The assembly was electrically isolated with exterior rubber hoses to avoid any electromagnetic disturbances.

Previously to the tests the engine was running 250 hours on the test bench, then the oil was changed and fuel and lubrication filters were replaced.

The engine was instrumented with temperature sensors (cooling liquid, oil and exhaust gas), pressure sensors (oil, air charge, exhaust gas) and flowmeters (air and fuel).

As cooling agent it was used distilled water from the cooling system of the test bench, the temperature being kept in the range of 75-80 °C.

For the engine operation it was used diesel fuel according to European in force standard and lubricant with viscosity class SAE W30.

As among the claims there were reductions of exhaust emissions, it was measured the smoke number with Bosch apparatus with the engine running under full-load and at steady speed, between 1000-2200 rpm. The measurement errors during the engine tests met the limits of the engine test standard [7].

The program of the test included the following phases:

A. Preliminary engine speed characteristics at total load (power, torque, hourly fuel consumption, specific fuel consumption, smoke emission) without and with fuel device.

B. Engine speed characteristics at total load (power, torque, hourly fuel consumption, specific fuel consumption, smoke emission) without and with fuel device, after 35 operation hours equivalent approximately to 1100 miles.

The B test was necessary due to the manufacturer assertion that the fuel device will reach its efficiency after a period of operation appreciated at 1000 miles.

4. Interpretation of Results

Engine speed characteristics at total load required the measurement of torque, speed and smoke and the calculation of power, hourly and specific fuel consumption.

For **phase A** the results of the triplicated tests are presented comparatively in

Figures 2-5 for the cases without “Vitalizer” and with “Vitalizer”.

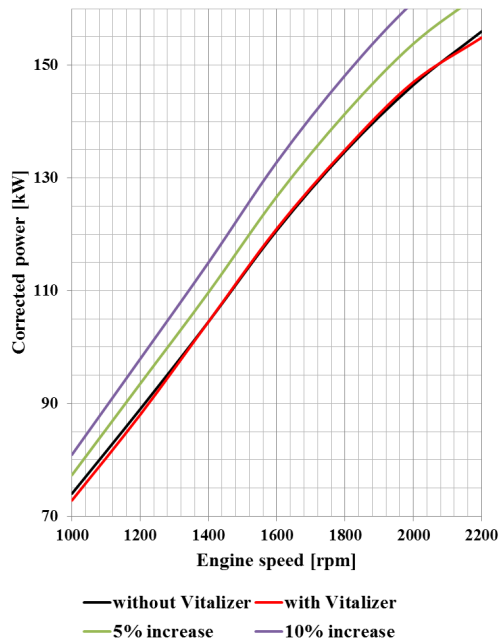


Fig. 2. Power versus speed at full load

The engine power is represented in Figure 2, showing insignificant variation of the rated power.

The claim of the manufacturer that fuel saver would increase the rated power with 5-10% would have been met if the red line had been situated between the lines of 5% and 10% increase.

The deviations between the two sets of data for power conducted to the coefficient of variation (defined as ratio of standard deviation to mean) of 2%.

The engine torque variation is shown in Figure 3; the operation with “Vitalizer” has lower values at lower speeds and small exceeding for the torques at higher speeds. The calculated coefficient of variation applied to deviation of torque data was 0.7%.

The measurements of the hourly fuel consumptions were performed on a two-hour period at the constant load of the dynamometric brake 500 N·m, at 1800 rpm.

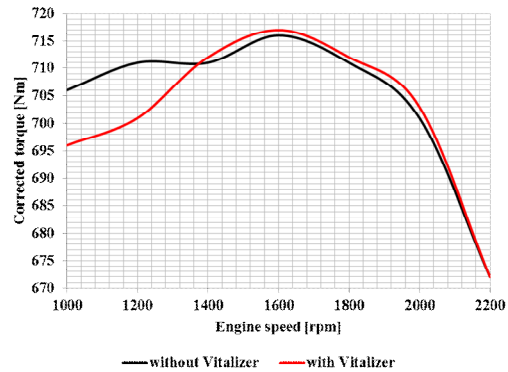


Fig. 3. Torque versus speed at full load

The results were 45.2 kg of fuel without “Vitalizer” and 45.5 kg of fuel with “Vitalizer”.

The profiles of the specific fuel consumptions plotted in Figure 4 did not reveal significant improvements, the coefficient of variation being similar to the torque measurement value, 0.7%.

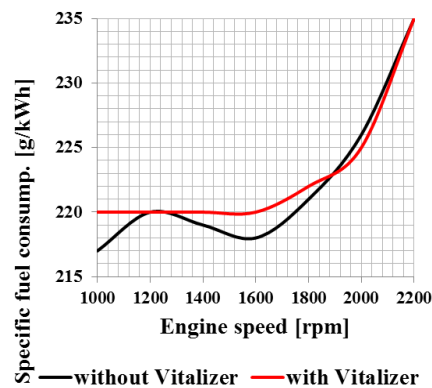


Fig. 4. Specific fuel consumption versus speed at full load

The image relevant for visible emissions is Figure 5 which represents engine smoke emissions. The green line indicates which are the limits imposed by ECE Regulation 24 [6], the European in force regulation. The maximum difference between cases with and without “Vitalizer” was minor, around 0.2 Bosch units, which lead to a coefficient of variation of 8%, mainly due to the reading errors of the apparatus.

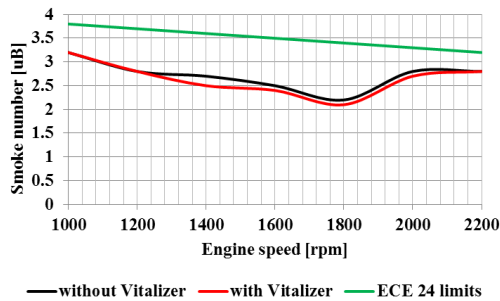


Fig. 5. *Smoke emission versus speed at full load*

For **phase B** the engine was operated 35 hours which is equivalent to 1100 miles, at the constant part load of the brake 500 N·m, at 1800 rpm. The profiles of the curves are practically the same with those presented in Figures 2-5, with coefficients of variation lower than 2%, the device having no positive effect after a long run. Also the measurements of the hourly fuel consumptions after 35 hours in the same operation mode indicated similar values, 45.2 kg of fuel without “Vitalizer” and 45.5 kg of fuel with “Vitalizer”.

For the interpretation of the fuel saver claims regarding fuel consumption from Chapter 2, it was assumed that highway driving mode is close to full load and high speed so the right side of Figure 4 could be used to check if the specific fuel consumption was lowered with 9-18%. The measured fuel specific consumption was 235 g/kWh, identical with and without “Vitalizer”, which should have been in the range 192-214 g/kWh to meet the claim.

Similarly, the urban driving which is typically characterized by low loads and low speeds, could be assumed to be close to a partial load of 500 N·m and 1400 rpm, for which the measured specific fuel consumption was 212 g/kWh, identical with and without “Vitalizer”, so no reduction even if the claim was of 5-18%.

Similar results were obtained by EPA [2] taking action whether the advertised

representations made with respect to the device are accurate; it was revealed that many aftermarket retrofit devices purport to improve fuel economy and/or reduce emissions in erroneous claims; most devices tested had a neutral or negative effect on engine performance.

The variation of 2-3 percent on the dynamometric bench is not unusual due to cycle variability, so unless there are several with and without repeats, an apparent improvement of this level is insignificant.

A reason for the popularity of selling among aftermarket retrofit devices could be the subjective nature of human kind; many people act upon their own perceptions and not upon scientific proof. The drivers cannot accurately measure the small variations of fuel consumption, performances or emissions of their vehicle, those parameters being very sensitive to driving style, weather and road condition, traffic congestion. As long as the buyers are not aware of the results of controlled experiments, their behavior will be strongly influenced by the advertising.

5. Conclusions

The fuel saver device, “Vitalizer”, has no statistically significant influence on fuel economy and visible emissions, contrary to the manufacturer claims, according to the test performed on the truck engine D2356HVM.

The differences between the engine power, torque and fuel consumption measurements were the same, under 2%, both in preliminary test and long run test, showing that the impact of the extended mileage accumulation is negligible.

This conclusion drawn from tests is necessarily of limited applicability, being quantitatively valid only for the tested engine.

Acknowledgements

The authors thank to research engineers Ilie Rău and Andrei Gal for useful support and discussions. The support of the Department of Engine Testing of Road Vehicle Institute Braşov is gratefully acknowledged.

References

1. <http://www3.epa.gov/otaq/consumer/420f11036.pdf>. Accessed: 06-09-2015.
2. <http://www3.epa.gov/otaq/consumer/devices/r99015.pdf>. Accessed: 06-09-2015.
3. <http://enviro-tech.tripod.com/id19.html>. Accessed: 06-09-2015.
4. <http://vitalizer.8m.com>. Accessed: 06-09-2015.
5. *** DIN 70020: *Automotive Engineering. Maximum Speed. Acceleration and Other Terms. Definitions and Tests*, Deutsches Institut für Normung, 1986.
6. *** ECE-R 24.03: *Uniform Provisions Concerning the Approval of the Compression Ignition Engines with Regard to the Visible Pollutant Emissions of the Engine*.
7. *** STAS 6635-87: *Internal Combustion Engines for Motor Vehicles. Rules and Methods for Bench Testing*.
8. *** *Tests with Fuel Catalyst for Improving 200-300HP Engine Performance*. Road Vehicle Institute INAR Braşov, contract 745C/8460/11.
9. *** D2356 HMV engine: *Romanian Standard of Product*, Road Vehicle Institute INAR Braşov.