EFFECT OF MODIFIED DIESEL FUEL ON ENGINE FUEL EFFICIENCY

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Abstract. For decades much more attention has been devoted to emissions from transport vehicles and to usage of various fuels and fuel blends for vehicle engine operation than to fuel consumption by this giving a chance for under-researched aftermarket products that allegedly reduce engine fuel consumption. The paper summarizes four fuel innovation product investigations commissioned to and carried out by the Department of Automotive Engineering of the Riga Technical University in a year scope. The innovative solutions offered by entrepreneurs contained a fossil diesel fuel treated by specific technology and three diesel fuel additives. The promoters of the products referred to pre-existing measurements showing 10 to 30 percent reduction of fuel consumption. Comparative experimental measurements using diesel fuel available in retail with and without usage of the proposed products have been done in laboratory conditions. The tests were performed on a stationary diesel generator RD2.0. Solid, repetitive results have been gained. The results did not confirm any significant positive effect of the products on engine brake specific fuel consumption. Factors affecting errors in this kind of product efficiency investigations for market promotion purposes and causes of positive effects from similar product applications in certain situations are discussed.

Keywords: diesel, fuel additives, engine efficiency.

Introduction

Engine fuel efficiency has always been an important factor for road transport vehicles. Nevertheless, with growing total pollution from transport vehicles emissions have become more important concern for governments, city residents, engine developers and researchers. Therefore, for decades both in legislation and correspondingly in research much more attention has been devoted to emissions from transport vehicles and to usage of various fuels and fuel blends for vehicle engine operation, by this giving a chance for manufacturers to offer on market under-researched products that allegedly reduce fuel consumption.

The paper summarizes four fuel innovation product investigations commissioned to and carried out by the Department of Automotive Engineering of the Riga Technical University in a year scope. The solutions offered by entrepreneurs contained three diesel fuel additives and a fossil diesel fuel treated by specific technology. The promoters of the products referred to pre-existing measurements showing 10 to 30 percent reduction of fuel consumption. The agreements with the product promoters did not allow publications about usability of their particular products; therefore, for the purpose of this paper the four separate product investigations are named Tests 1 to 4. Both, fundamental works [1-4] and individual studies [5; 6] recognize potential for fuel additives, but none evaluate fuel consumption gain comparable to acclaimed by the four product promoters and therefore it was considered unwise to expect results similar to the ones referred by the entrepreneurs. The goal of each individual product test was to test a hypothesis that the corresponding product gives any fuel economy results on a particular diesel engine.

The goal of writing this paper is to summarize the results from four separate unpublishable tests providing ground for discussions with potential similar fuel saving product promoters.

Materials and methods

All tests were performed on a stationary diesel generator RD2.0, utilizing a four cylinder, 16 kW, 2.0 liter, four stroke water cooled diesel engine with indirect fuel injection by an inline mechanical fuel injection pump and a three phase 400 V, 29 A generator, loaded by resistive, forced-air cooled up to 20 kW loading equipment.

Fuel consumption was measured by 50 ml volume type method for tests 1, 3 and 4, by mass type method for test 2, for both methods the time was measured manually using a mechanical timer. Rotation speed was controlled by a mechanical rpm governor of the diesel generator, checked and adjusted by an electronic non-contact tachometer DT-2234B. Engine exhaust was controlled by Bosch EAM 3.011 RTM 430 opacimeter, ambient air pressure, temperature and humidity were recorded.

Since all four tests were done according to contracts with a particular product supplier, the measurement methods slightly varied between the tests. Engine heating-up time for measurement start with each particular fuel was from 1 hour to 1.5 hours, reaching and stabilising the engine oil temperature between 80 and 85 ºC. For all tests the first measurements were carried out with unmodified diesel fuel. At each load and engine rotation speed three consecutive measurements have been made and since the results deviations were within 1 % limit, the average fuel consumption from the three measurements has been used for further calculations. The engine was run at each given load and speed for at least 10 minutes before starting the fuel consumption measurements. The procedures of switching from plain fuel A to modified fuel differed. Test 1 and test 3 required a run-up period 4 to 12.5 hours for the engine with modified or treated fuel B, one hour of the engine running with fuel B was used for tests 2 and 4 before the measurements were started.

Fuel for each test was delivered as per agreement with the corresponding contractor. For tests 1 and 2 fuel B (fuel A with additive) was prepared by the contractors. For test 4 mixing fuel A with additive was done according to manufacturer's instructions. Fuel B in test 3 was the same fuel A treated on-site by the device integrated into the fuel system. Fuel heating values have not been measured but according to low mass value of the additives, any significant differences in heating values between fuels A and B were not expected. For each fuel only fuel density and kinematic viscosity were measured, no other fuel characteristics were checked. The fuel characteristics normalized to equal temperature are shown in Figure 1.

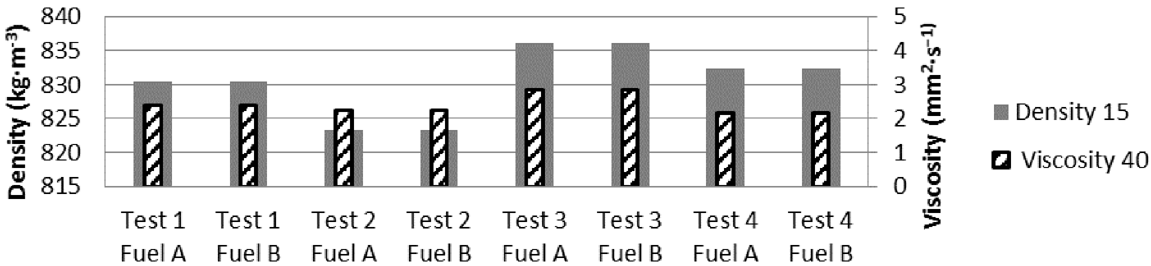

Fig. 1. **Fuel density and kinematic viscosity**

Result calculations and analysis were done using MS Excel. Since the fuel lower heating value is not known, influence of the applied measures on the engine efficiency will be assessed by means of brake specific fuel consumption (BSFCg). Index g for BSFC is used to show that the calculated BSFCg is a characteristic for the whole diesel generator unit since the measured power does not include power losses in the generator. Power used for BSFCg calculations is active electric power measured at the loading device. Calculations for each test were done separately after completion of each test while for the purpose of this paper all results from tests 1 to 4 and for each test results for untreated fuel A and modified fuel B are displayed together grouped according to different engine speeds 1100, 1300 and 1500 rpm. For each engine speed a polynomial trendline has been calculated and a division value for each fuel consumption figure by the corresponding trendline value at the given engine load and speed expressed as a percentage was calculated.

Results and discussion

Brake specific fuel consumption for all four tests for unmodified diesel fuel A and fuel with additives or treated fuel B at 1500 rpm are shown in Figure 2. A 6^{th} order polynomial trendline has been created for all data sets showing that no essential gain from fuel additives or fuel treatment can be noticed.

The generator efficiency map is not determined; therefore, engine fuel consumption at different speeds and different power cannot be directly compared. The conclusions about the efficiency of altered fuels can be done by comparing fuel consumption for fuels A and B at each engine rotation speed. Differences in engine load can be tolerated by means of the trendline. The trendline is basically a very well-known BSFC vs. BMEP function, since at constant speed brake power it is linearly dependent on BMEP.

Although BSFC vs. Power graphs are more common and easy recognisable, the variance between fuel tests cannot be well observed in Figure 2, therefore charts for 1100 rpm and 1300 rpm are omitted.

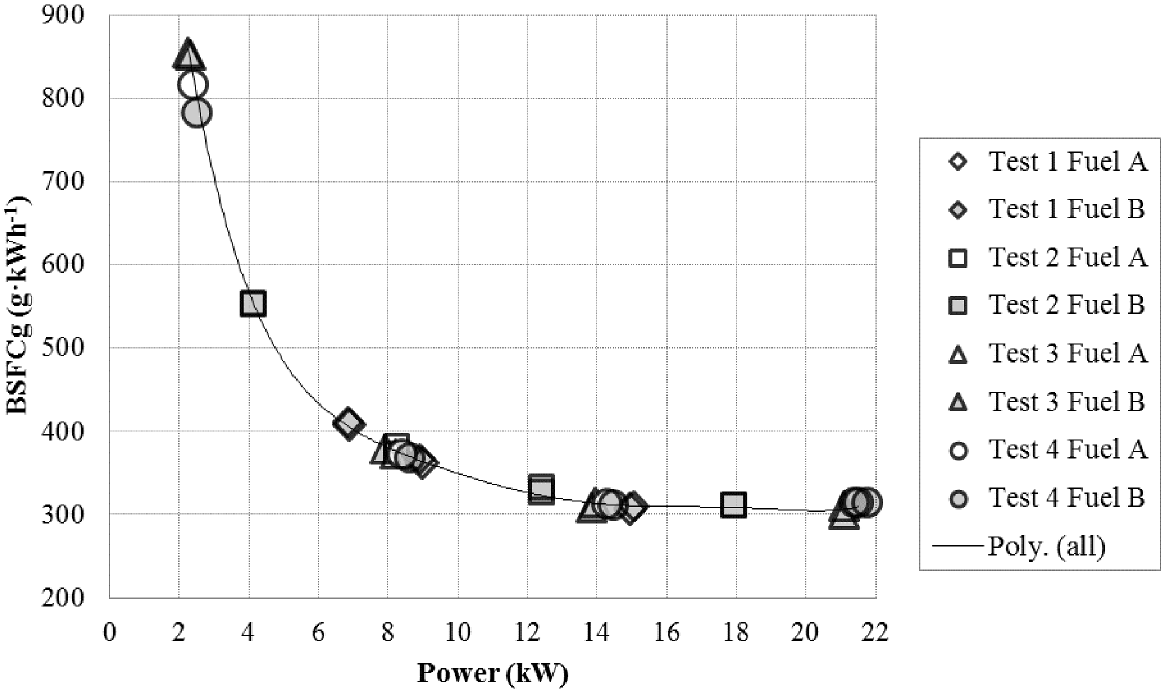

Fig. 2. **Brake specific fuel consumption for all four tests with and without fuel modification at 1500 rpm**

For better identification of the test results, charts showing relation of each fuel consumption measurement to a value calculated from the trendline expressed as a percentage for all three engine rotation speeds are given. The changes in BSFCg at 1500 rpm are shown in Figure 3. Open shapes correspond to untreated fuel A and filled shapes correspond to modified fuel B.

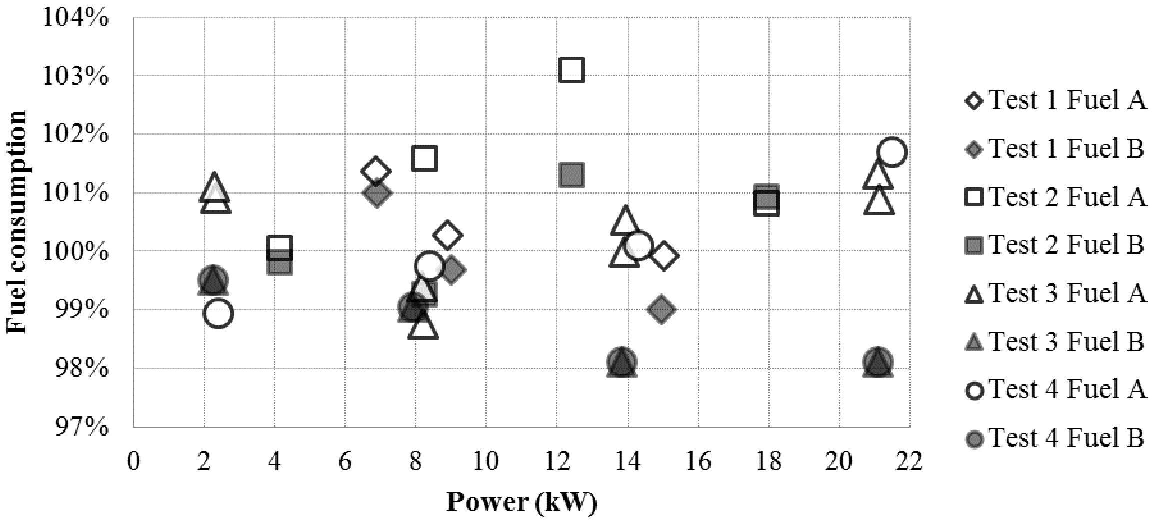

Fig. 3. **Changes in brake specific fuel consumption at 1500 rpm**

At 1500 rpm even visually a tendency for slightly lower fuel consumption using fuel B can be identified. For measurements at 1500 rpm fuel consumption for fuel B on average is 1.2 % below the value with fuel A. The same relates to measurements at 1300 rpm displayed in Figure 4 where the values for fuel B are on average 1.5 % below the values for fuel A.

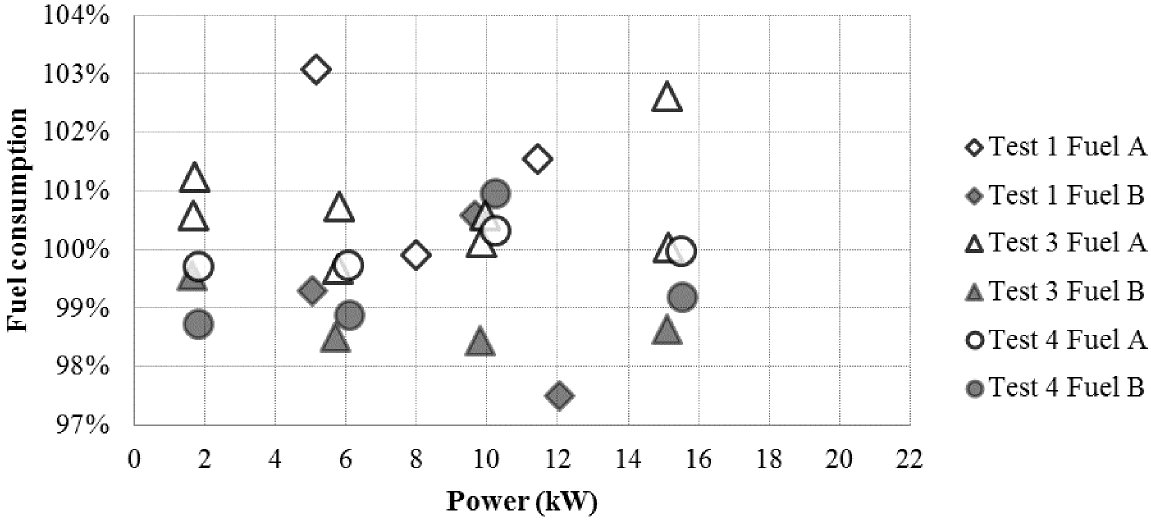

Fig. 4. **Changes in brake specific fuel consumption at 1300 rpm**

On the contrary, the measurements at 1100 rpm displayed in Figure 5 show the opposite pattern where fuel consumption for fuel B is on average 0.7 % above the values for fuel A. Calculating the average for all tests at all engine speeds and loads the fuel consumption for modified fuels B was found just 0.7 % below the consumption values for fuels A which is within the fuel consumption measurement error for the tests.

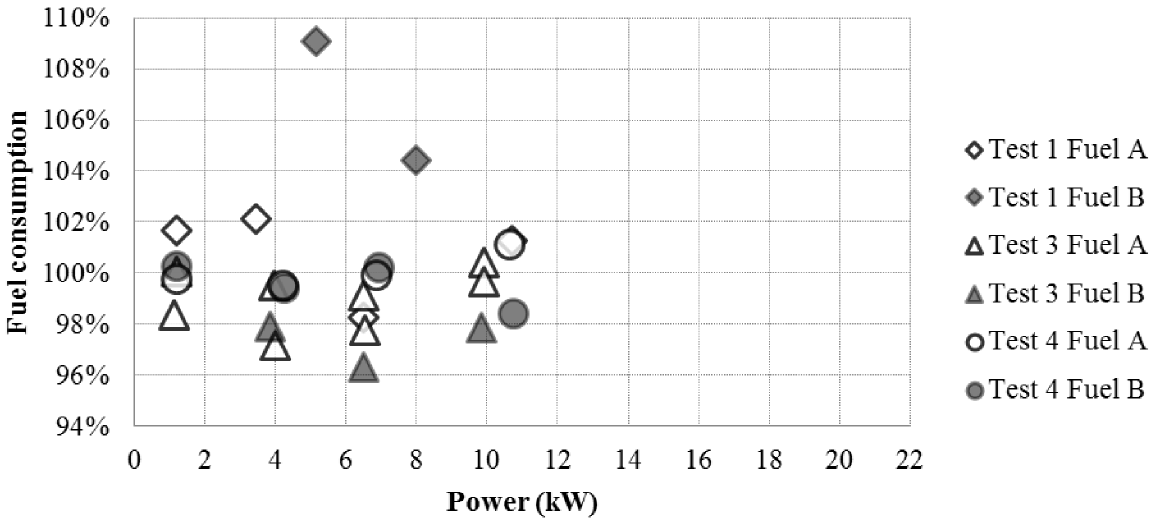

Fig. 5. **Changes in brake specific fuel consumption at 1100 rpm**

Comparison of all measurements made with unmodified fuel A at all engine speeds represented on charts by open shapes allow to evaluate both, the gained variance in fuel consumption for generic diesel fuel purchased at retail and precision of the tests both being within the same range of approximately 2 %. The measurement precision was far enough for the acclaimed fuel consumption savings of 10 to 30 % and the tests in all four cases rejected the assumption that the modified fuels would lead to essential fuel consumption cuts.

Nevertheless, the tests did not confirm and were not designed to confirm that the proposed fuel treatments do not have any positive effect at any given situation. Some fuel additives have cleaning effect and may be useful for cleaning both, the fuel system and the combustion chamber and may give positive effect for engines with contaminated fuel systems and having unburned product deposits in combustion chambers. Fuel additives may change ignition delay or enhance combustion and in combination with engine systems tuning may give some efficiency or NVH gain in comparison to the engine technical condition before the alterations. But the main gain from diesel fuel additives is pollutants reduction [7], not fuel savings. Promoters of fuel saving products should be more specific describing the applications and usefulness of each product.

The tests also did not investigate why the claimed and expected by the test contractors fuel consumption savings were so high and how the pre-existing measurements have been carried out. Purely fraud marketing cases were excluded both, because of commitment of the test contractors to the products and because of willingness to finance the tests. More realistic scenarios were poorly designed and executed experiments without paying proper attention to experiment design, preparation of experiments, heating-up all aggregates, taking into account the weather, traffic, driver training and other essential conditions for fuel consumption measurements.

Conclusions

The test results did not confirm any significant positive effect of the tested modified diesel fuels on engine efficiency improvement. Solid, repetitive results have been gained rejecting the high expectations of the test contractors from the tested diesel fuel modifiers. The tests did not confirm that the proposed modifiers have no positive effect at specific circumstances. Summarizing the results from the four individual tests would be applicable for future discussions with certain fuel saving product promoters.

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