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PERFORMANCE ANALYSIS FOR AN EXPERIMENTAL DIESEL ENGINE FUELED BY A MIXTURE OF RAPESSEED OIL AND DIESEL

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ABSTRACT

Due to the current international situation in terms of rising energy prices, biodiesel remains an extremely attractive fuel in terms of alternative fuels for agriculture sector. The advantages of using biodiesel by diesel engines can be explained both by the fact that it is produced from renewable sources with lower costs than conventional fuels and by the fact that biodiesel is comparable in terms of performance with conventional fuels. Besides the fact that it is obtained from green sources studies have shown that biodiesel has a number of advantages in terms of pollutant emissions. In this paper we will analyze the performances obtained by an experimental single-cylinder engine model AVL 5402.

INTRODUCTION

The purpose of these experimental tests was to highlight the impact of using oxygenated fuel obtained from renewable sources in a mixture with diesel for a compression ignition engine. For a more detailed analysis, the phenomena that take place in the engine cylinder analyzing the pressure curves and thermodynamic analysis were also followed.

Thus, it was possible to track the effect that the change of the proportion of biodiesel in the blend has on the combustion process and engine performance.

From the perspective of analyzing the variation of engine performance, it turned out that by increasing the quantity of biodiesel in the mixture, the mean effective pressure and thus the engine power and engine torque decreases with it. The decline in biodiesel engine performance is explained by the reduced calorific value of biodiesel. This implicitly determines higher fuel consumption per cycle, because a higher amount of fuel needs to be injected in order for the internal combustion engine to remain in the stable operating area. Thus, in order to maintain performance, a higher amount of fuel injected is needed. The oxygen content of the fuel increases locally. This favors the development of areas where self-ignition can occur. Another disadvantage of biodiesel is that biodiesel has a higher viscosity than diesel, which has a negative influence on the formation of the fuel jet, increasing the penetration of the jet.

MATERIAL AND METHOD

The Testecocel laboratory used for experimental research in this paper is divided into 4 main rooms. The first is the control room and is the area where the operator controls the parameters from the test room, from the technical room, and from the fuel room. The test room is fitted with the engine, dynamometer, sensors with data acquisition system, fuel injection control systems, oil and coolant control systems. The technical room is equipped with the atmospheric control equipment, the electrical cabinets, the flue gas exhaust system, the dynamometer control system, the compressed air system required for the test chamber installations, and the pollutant emission measurement systems. The internal combustion engine test cell consists of the dynamometer stand (fig. 1) to which the experimental engine and ancillary equipment are attached. The technical specifications of the experimental engine are given in Table 1.

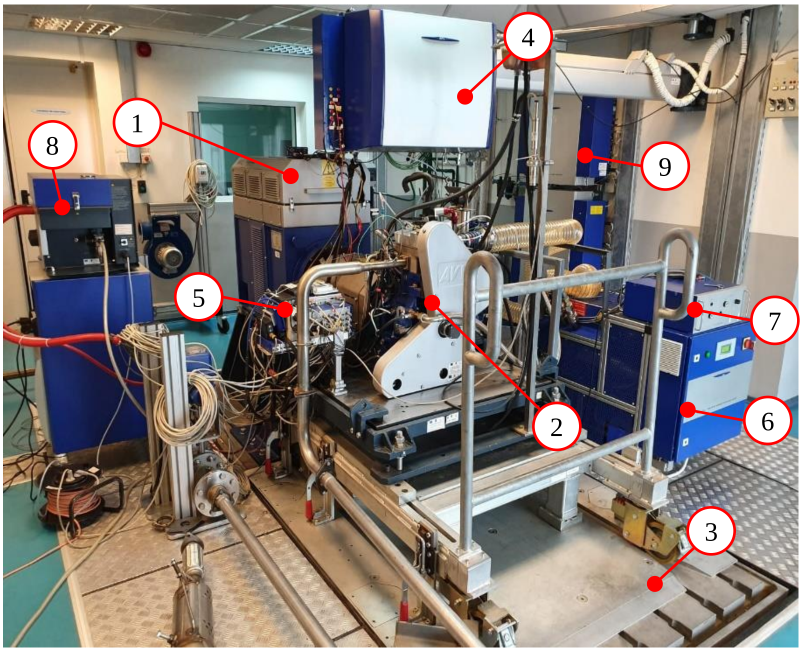

Figure 1. Internal combustion engine test cell
1 - DynoRoad 202 dynamometer, 2 - AVL 5402 experimental engine, 3 - hydraulic motherboard, 4 - BoomBox electrical connection box, 5 - electronic command and control equipment, 6 - engine water and oil cooling system, 7 - AVL Visioscope optical flash unit, 8 - exhaust gas opacity measuring equipment, 9 - equipment for measuring the mass flow of fuel

Table.1

Experimental engine technical data

Parameter	Value	M.U
Bore x Strole	90 x 85	[mm]
Displacement	542,5	[cm^3]
Compression ratio	17,1:1	[-]
Speed (maximum)	4200 (4500)	[1/min]
Maximum Power	aprox. 6 (16)	[kW]
Presiune maximă în cilindru	150	[bar]

The data exchange between the control panel and the rest of the control systems was done using CAN (Controller Area Network) communication. With the help of the PUMA Open application, all the systems that are integrated in the test cell were controlled. The fuel mixtures analyzed were D100 (Diesel with a concentration of 6.5%

Biodiesel), B20 (mixture of 20% biodiesel + 80% diesel) and B30 (mixture of 30% biodiesel + 80% diesel).

For each test case, the following were considered: operating point: speed; load; the percentage of biodiesel in the mixture; cylinder pressure (average over 101 consecutive cycles); exhaust gas temperature.

RESULTS AND DISCUSSIONS

Cylinder pressure variation curves have shown that the maximum cylinder pressure increases for mixed biodiesel cases. Thus, the increase in the percentage of biofuel led to higher values of the maximum pressure in the cylinder by 2.22% (B20), respectively 2.75% (B30) compared to the reference case (D100) (fig. 2).

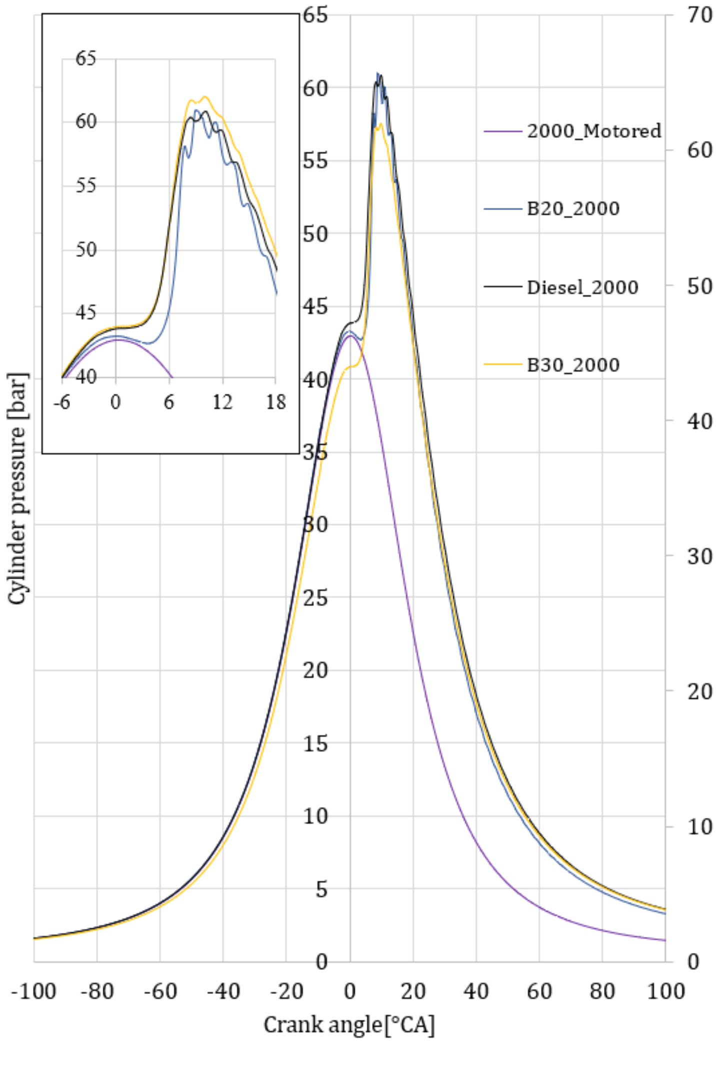

Figure 2. Cylinder pressure variation for the analyzed cases

The results obtained for the cylinder pressure are also confirmed by the specialized literature [Shehata, 2013].

The negative effect on the fuel jet spray also affects the formation of the mixture. The phenomenon is partially counterbalanced by the oxygen content of the fuel, but also by the reduction of the self-ignition delay due to a higher cetane number.

The experimental results showed a decrease in the mean effective pressure for all speeds when using biodiesel. For a more eloquent highlight of the effect of biodiesel on engine performance, the variation of the mean effective pressure for speeds of 1500, 2000 and 2500 1 / min was represented graphically (fig. 3).

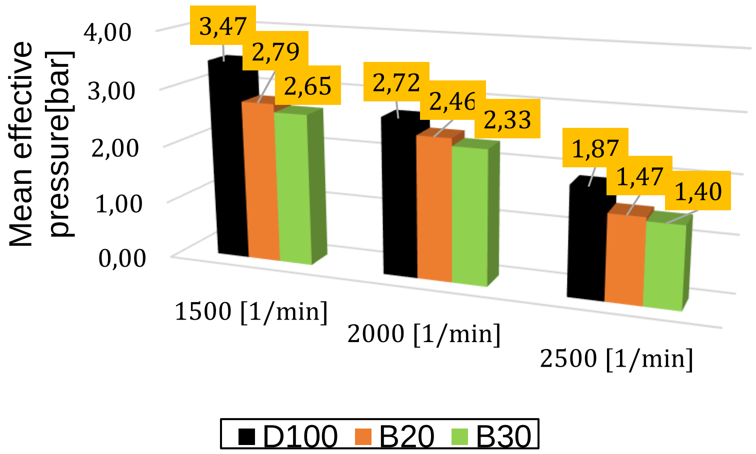

Figure 3. Mean effective pressure variation for cases: B20, B30 and D100.

Assuming that the injection pressure of the reference case (2000 1 / min) was chosen so as to make the most of the air available in the combustion chamber, this may lead to an increase in the amount of fuel that comes into contact. with the walls of the combustion chamber, which leads to the formation of the mixture in suboptimal conditions and an increase in the amount of unburned fuel. The mean effective pressure at 2000 1 / min for B20 and B30 mixtures was 9.56% lower and 14.34% lower than for Diesel. Engine torque decreased by 1.05 Nm for B20 and 1.58 Nm for B30 compared to D100 (fig.3 and fig. 4).

At first view, these results are not in line with the maximum pressure values in the cylinder, where the cases of biodiesel operation showed higher values. However, similar results have been obtained by other researchers [Shehata, 2013; Qi, et al., 2009].

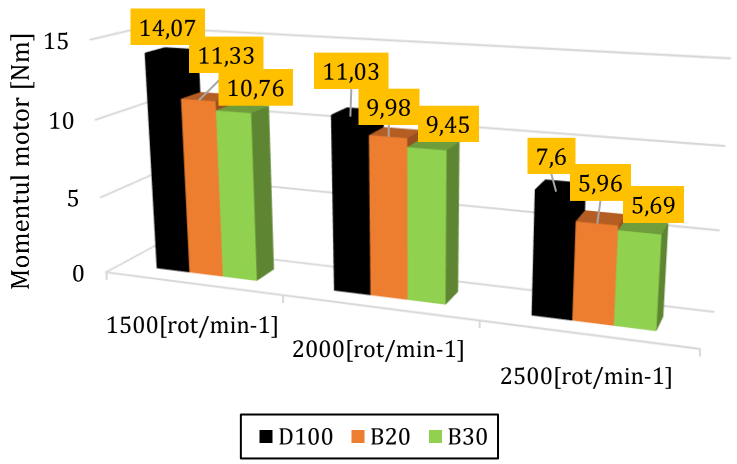

Figure 4. Engine torque variation for D100 cases; B20 and B30.

Due to the higher cetane number and a faster onset of injection (caused by a higher modulus of elasticity [Senatore, et al., 2000]), heat dissipation begins faster in the case of biodiesel (as can be seen in figure 5), and as a result, the pressure increase will manifest faster. Because, on the one hand, the self-ignition delay is shorter (less preformed mixture) and on the other hand the calorific value of diesel and biodiesel mixtures is lower than that of diesel, the maximum heat release rate will be smaller too. In contrast, due to the reduced load, the self-ignition delay of diesel increases, which leads to the formation of a larger amount of preformed mixture and thus to a higher rate of heat release. However, this is counterbalanced by a delayed combustion, which results in a lower maximum pressure. The experimental results are in agreement with the literature regarding the loss of performance for biodiesel compared to Diesel. [Shehata, 2013; Senatore, et al., 2000; Hansen, et al., 2006; Behçet, 2011; Keskin, et al., 2008]

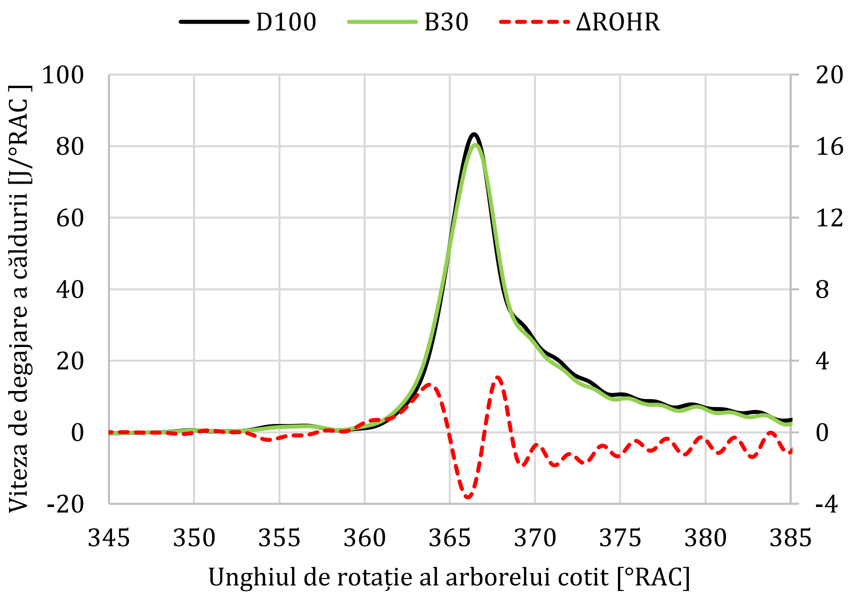

Figure 5. Rate of heat release for D100 and B30.

CONCLUSIONS

The analysis of the pressure curves in the cylinder after a run of 101 consecutive cycles revealed a slight increase in the maximum pressure in the cylinder for all cases of engine operation with a higher biodiesel content.

From the analysis of the data on the mean effective pressure it was observed that increasing the proportion of biodiesel obtained from rapeseed oil in the blend brings a decrease of performance.

For the case of 2000 of 1 / min the mean effective pressure, for the mixtures B20, B30 was 9.56% lower, respectively by 14.34% than for Diesel.

Engine torque decreased by 1.05 Nm for B20 and 1.58 Nm for B30 compared to Diesel.

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