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EFFECT OF TEMPERATURE AND EXCESS AIR RATIO ON COMBUSTION PROCESS OF MIXTURES OF ERUCIC RAPESEED

Adam KUPCZYK, Department of Production Management and Engineering, Warsaw University of Life Sciences – SGGW, Nowoursynowska str. 164, 02-787 Warszawa. Poland. adam_kupczyk@sggw.pl (*corresponding author*)
Karol TUCKI, Department of Organization and Production Engineering, Faculty of Production Engineering, Warsaw University of Life Sciences – SGGW, Nowoursynowska str. 164, 02-787 Warszawa. Poland. karol_tucki@sggw.pl

The paper presents results of investigations into diesel engine fuelled with high erucic acid rapeseed oil and its mixture with diesel, petrol and ethanol at different proportions. The study was performed in a chamber with constant volume depending on temperature and air pressure and the coefficient of excess air. The main purpose of performed tests was to determine the effect of various parameters on processes of spontaneous combustion and combustion of fuels. During the study basic parameters of combustion, e.g. auto-ignition delay, greatest pressure and contractual time were compared. Studies show that increased pressure injection improves combustion process for all test fuels, and injection pressure most strongly affect the combustion process of rapeseed oil and its mixtures with ethanol.

Keywords: combustion, erucic, excess air ratio, rapeseed, temperature

INTRODUCTION

As presently the concept of sustainable development is being developed and non-renewable raw materials for energy needs are becoming gradually depleted, it may be presumed that agriculture may contribute to reduction of CO_2 emission (Ashraful et. al, 2014). This sector is capable of supplying raw materials for the production of biofuels, in such a way implementing EU legal requirements. In the European Union among others rapeseed oil is used for the production of biodiesel (Czaban et. al, 2015; Osiak at. al, 2013). The usage of plant oil as engine fuel allows achieving numerous advantages, such as diversification of income and reduction of CO_2 emission. The chemical and physical properties of oils allow their usage in diesel engines (Buyukkaya et. al, 2014; Mahmudul et. al, 2017). Approximately 15% of those oils being used worldwide for energy needs are obtained from rapeseed, especially in Europe (Bełdycka-Bórawska et. al, 2015; Dyrektywa). Given the constantly growing area of cultivations to be used for energy-related needs, the emission caused by ILUC became a topic for talks pertaining among others to the future of conventional biofuels (of the first generation). For this reason the use of advanced biofuels obtained from waste and other remnants is being promoted (Jabłońska, 2014).

The objective of the studies was to perform a qualitative assessment of the impact exerted by temperature and the excess air coefficient in the chamber on the combustion process of petrol and ethanol.

The combustion process was studied for four air temperatures: 350°C, 425°C, 500°C and 575°C and for three air pressure values in the chamber: 0.5 MPa, 0.7 MPa and 0.9 MPa. The dose of fuel and injection pressure underwent changes – 65 MPa, 100 MPa, 135 MPa.

METHODOLOGY ADOPTED FOR ANALYSIS

The studies were carried out on a stand furnished with the following systems: fuel supply (Common Rail) with electronic control of multi-phase injection, control of injection time, process recording, air supply, measurement of combustion pressure in the chamber and additional assemblies (illuminators, vacuum pump). Study chambers enabled the visualisation of processes of injection and combustion, and also heating the agent within the temperature range of 400 – 700°C. The control system permitted changing the size of pilot dose and elementary dose in the initial phase of injection, the time interval between doses and pressure at injection start. In paper we examined the following fuels: diesel (ON100 %), erucic rapeseed oil (R100 %) and their mixtures with unleaded gas (U) (70 %R+ U30 %, 85 %R + 15 %U) and ethanol (70 %R+ E3 0%, 8 5%R + 1 5%E).

RESULTS

At a temperature of 350°C (Fig. 1) the combustion rate of a mixture of rapeseed oil with an addition of 15 % and 30% of U95 petrol was very low, much lower than that for diesel. At the highest air temperature of 575°C (Fig. 2) combustion progress of rapeseed oil and diesel is similar. Differences in maximum values of combustion pressure arise from a difference in calorific value. The addition of light fractions shortens the delay of self-ignition, but also tend to impair their further combustion.

The delay period of self-ignition for rapeseed oil and diesel at low temperatures differed considerably (Fig. 3). At high temperatures the differences were similar for both rapeseed oil and diesel with mixtures. If temperature grew, the quickest shortening of the self-ignition period took place of mixtures with petrol.

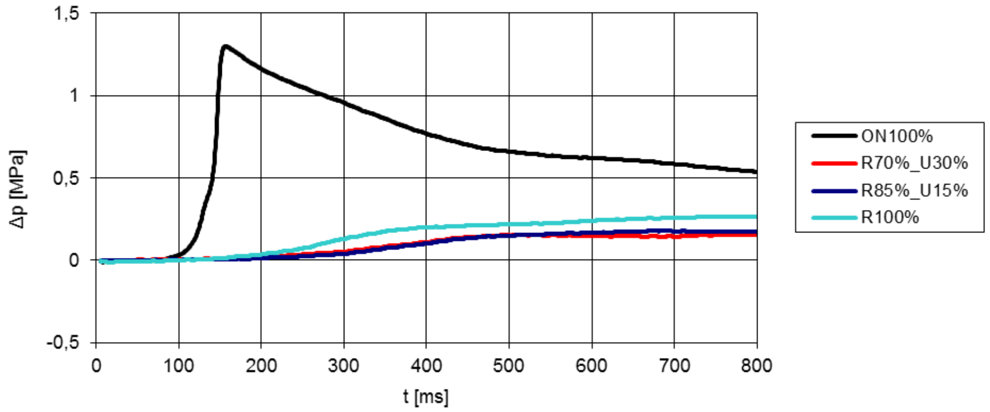

Figure 1. Increase in combustion pressure in the chamber; Initial temperature 350°C; Initial pressure 0.7 [MPa]; Injection pressure 100 [MPa]; λ=2.5

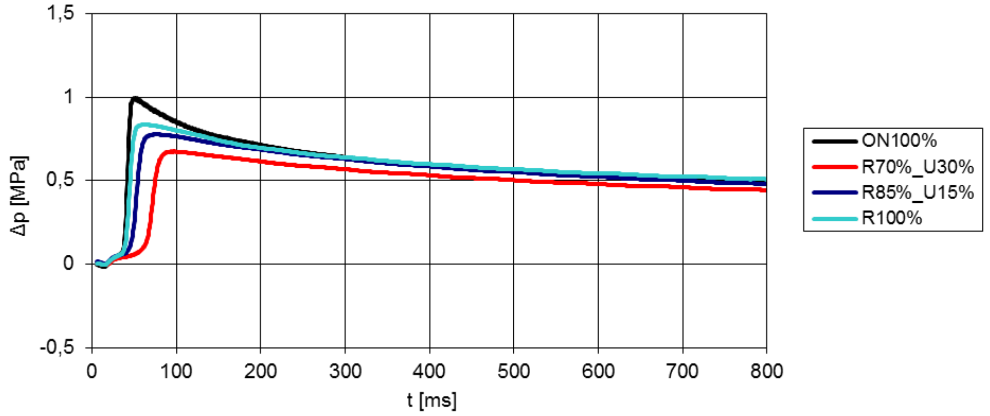

Figure 2. Increase in combustion pressure in the chamber; Initial temperature 575°C; Initial pressure 0.7 [MPa]; Injection pressure 100 [MPa]; λ=2.5

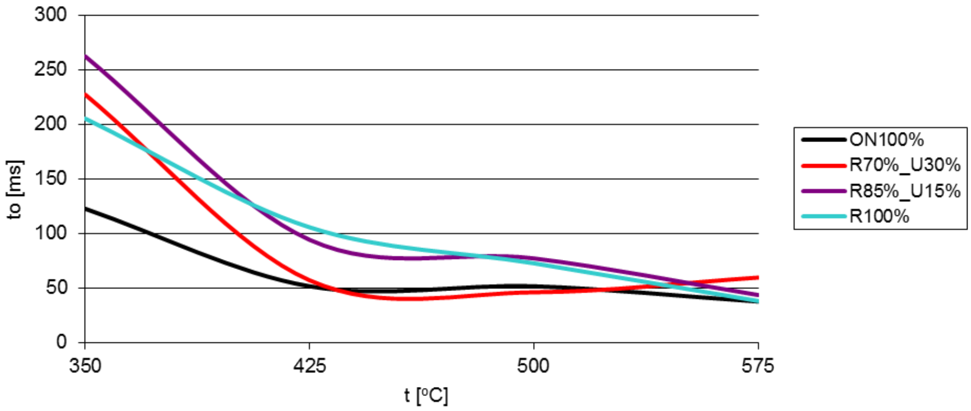

Figure 3. The impact of mixture of oil and gasoline on the auto-ignition delay time; Initial temperature 350°C; The initial pressure 0.7 [MPa]; Injection pressure 100 [MPa]; λ=2,5

Similarly as for combustion of a mixture of rapeseed oil with petrol. air temperature in the chamber also has a significant impact on the combustion process of a mixture of rapeseed oil with ethanol. At low temperatures (Fig. 4, Fig. 5) during the combustion of a mixtures of rapeseed oil with an addition of 15 and 30 % progressed very slowly as compared to diesel. Delay in self-ignition of a mixture with ethanol was bigger than with rapeseed oil, despite the additions of ethanol.

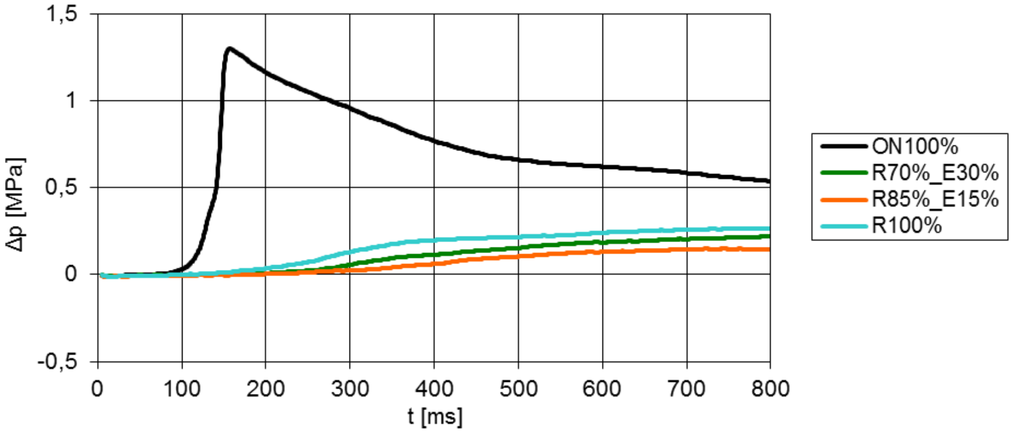

Figure 4. Increase the combustion pressure in the chamber; Initial temperature 350°C; The initial pressure 0.7 [MPa]; Injection pressure 100 [MPa]; λ=2,5

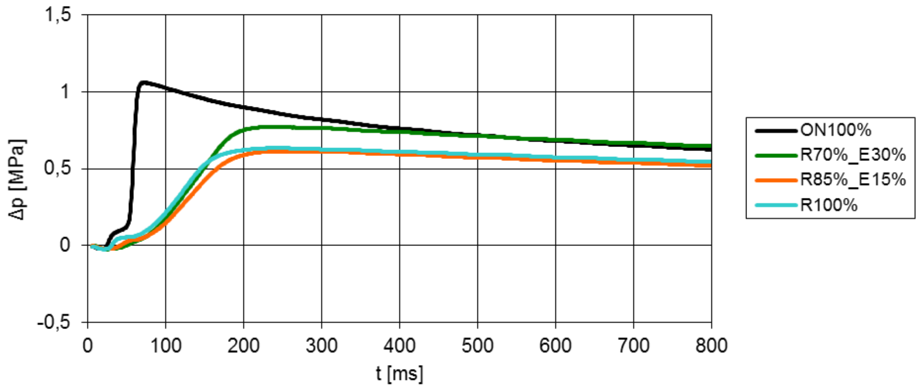

Figure 5. Increase the combustion pressure in the chamber; Initial temperature 500°C; The initial pressure 0.7 [MPa]; Injection pressure 100 [MPa]; λ=2,5

The conducted studies have shown that the combustion process of rapeseed oil and its mixtures with ethanol achieves parameters of the combustion process as for diesel only once the temperatures are high. The addition of ethanol has no significant impact on shortening the delay in self-ignition, beyond the scope of temperatures when the highest combustion pressure does not occur.

Currently the share of energy generated from biofuels made of cereals, other high-starch plants, plants used for sugar production and oil plants as well as plants cultivated for energy-related needs on agricultural areas as main cultivations, is to be limited to 7% of final energy use in the transport sector up to 2020. This implies a reduced importance of first generation fuels and a decrease in their share in transport, and concurrently intensified use of advanced biofuels.

CONCLUSIONS

The following conclusions have been drawn from the executed studies:

1. for all studied fuels the increase in injection pressure allows achieving an improvement in the combustion process;
2. injection pressure exerts the biggest influence on the combustion process of rapeseed oil and its mixtures with ethanol;
3. an increase in the air excess coefficient causes an impairment of the combustion progress;
4. an increased fuel injection pressure assures better combustion process progress;
5. combustion of a mixture of diesel with ethanol proved to be more advantageous as compared to a mixture of rapeseed oil with petrol;

6. the addition of ethanol and petrol caused a reduction of viscosity, density, evaporation temperatures of a mixture of those fuels as compared to rapeseed oil, with concurrent lowering of the propensity of those mixtures to auto-ignition.

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