ECONTECHMOD. AN INTERNATIONAL QUARTERLY JOURNAL – 2018, Vol. 07, No. 4, 49 – 52

Influence of Perkins 1104D-44TA motor powered with SME supply on the CO, NO_x, THC and O_2 emissions

G. Wcisło[1,2], D. Kurczyński[3], P. Łagowski[3], B. Pracuch[2], A. Leśniak[4], V. Tomyuk[5]

[1]Faculty of Production Engineering and Power Technologies. University of Agriculture in Krakow, Poland
Phone. 0048 513-157-977, e-mail: grzegorz.wcislo@ur.krakow.pl

[2] Malopolskie Centre for Renewable Energy Sources "BioEnergia", Poland
gwcislo@bioenergia.com.pl

[3] Kielce University of Technology
Department of Automotive Vehicles and Transportation, Poland
Phone: 0048 41 3424332 e-mail: kdarek@tu.kielce.pl

[4] Cracow University of Economics. Faculty of Commodity Science.

[5] Lviv National Agrarian University; Department of Automobilesand Tractors e-mail: vtomyuk@ukr.net,

Received October 18, 2018: accepted December 20, 2018

Abstract. The paper presents the results of research on the impact of Perkins 1104D-44TA engine powered with sunflower oil methyl esters and, for comparison, with diesel fuel, in terms of emission of CO, THC, NO_x and O2. The tests were carried out on the engine test stand. During the tests, the engine worked according to the external speed characteristics in the range from 1000 to 2200 rpm. The esters used for powering the tested engine were produced using the GW 200 reactor designed and made by Grzegorz Wcisło, one of the co-authors of the paper. The results of the tests carried out showed a decrease in the concentration of carbon monoxide in the exhaust gases, hydrocarbons when powering the engine with sunflower oil esters in relation to powering the engine with diesel fuel. At the same time, the concentration of nitrogen oxides and oxygen in the exhaust gases increased. The reduction of THC and CO emissions is the result of better combustion and afterburning of fuel. However, the increase in the amount of oxygen in the exhaust gases results from the fact that in the biofuel structure there is oxygen which is used in combustion and reduces the oxygen demand from the atmosphere. On the other hand, the increase in NO_x emissions is the result of a higher combustion temperature than when the engine is powered by diesel fuel.

Keywords: combustion engine, biofuels, methyl esters of sunflower oil SME, external speed characteristics

INTRODUCTION

Fuel crises, armed conflicts, increase in energy prices, limited access to its sources and pollution of the environment have resulted in increased interest in renewable energy sources. According to Directive 2001/77 / EC, renewable energy sources are renewable, non-fossil energy sources, among which liquid biofuels for transport are most developed [6].

Biofuel intended for supplying compression piston internal combustion engines are esters of fatty acids of vegetable oils [12,13].

In Poland and Europe, rapeseed is the most commonly cultivated vegetable oilseed. Esters can also be obtained from animal fats constituting the most common production waste [1, 2, 4, 5, and 7]. In addition, they can be obtained from used oils previously used in the processing and preparation of food, for example, used oil after frying [8].

Carbon monoxide (CO) is a product of incomplete combustion similar to not combusted THC hydrocarbons. They are generated mainly when during combustion there is a shortage of oxygen or the period of combustion is too short; then the oxygenation process cannot be completed, which should result in CO_2 and H_2O. Both CO and THC have carcinogenic effects and contribute to creating smog. Nitrogen oxides (mainly NO_2) are also very dangerous. The amount produced during combustion in the combustion chamber depends on the peak temperatures during the combustion process and the time of their impact. Nitric dioxide has strong poisonous properties. The compound binds to hemoglobin and can cause symptoms of paralysis in a short time. It irritates the lungs, and with prolonged exposure leads to erosion of the lung tissue and then to its perforation which can result in death. To limit the emissions of the above in recent years, we have observed the introduction of increasingly stringent standards [15-20].

TEST SUBJECT

The test subject was a Perkins 1104D-44TA four-cylinder compression engine - Fig. 1. It is used to drive a wide range of commercial vehicles for off-road applications. In terms of exhaust emissions, the engine meets the Stage IIIA and EPA Tier 3 standards. The engine is equipped with a sixteen valve type OHV valvetrain with one camshaft located in the engine block. It is driven from the crankshaft of the engine using toothed gears. The engine fuel system uses the Delphi DP310 rotary injection pump and an electric pre-pump, which supplies fuel to the high-pressure pump at 6 bars. The engine inlet system uses a turbocharger controlled by a bleed valve connected to a high boost pressure.

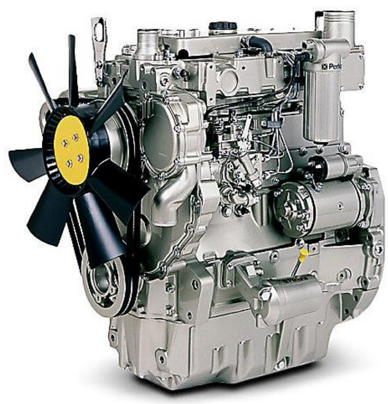

Fig. 1. Perkins 1104D-44TA engine

TEST STAND

The measurement of concentrations of harmful components of exhaust gases was carried out using Horiba exhaust analyzers and the smoke emission was measured using an AVL smoke meter – Fig. 2.

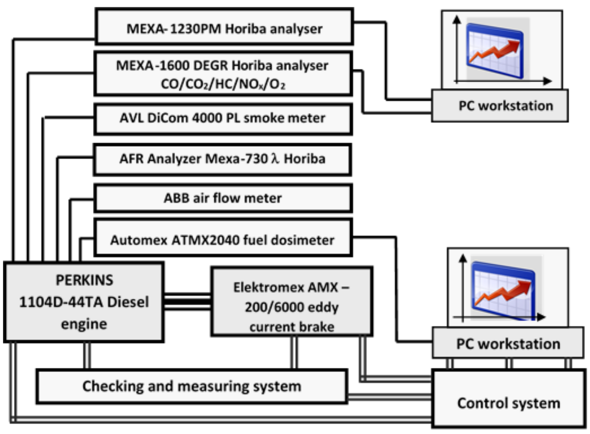

Fig. 2. A diagram of the test stand

EXHAUST GAS CONTENTS MEASUREMENT EQUIPMENT

The analysis of the exhaust composition of the tested Perkins 1104D-44TA engine was carried out using the Horiba exhaust gas analyzers: MEXA-1600DEGR and MEXA-1230PM. In these analyzers, all elements of the exhaust gas intake system, their transport and preparation for measurement are in accordance with the requirements of ISO-8178. The MEXA-1600DEGR analyzer is used for continuous measurements of real-time concentrations of five components of piston internal combustion engine exhaust fumes: carbon monoxide CO, carbon dioxide CO_2, THC hydrocarbons, nitrogen oxides NO_x and O_2 oxygen [3, 14]. For the measurement of the content of carbon monoxide CO and carbon dioxide CO_2 in exhaust fumes, the measurement system uses an analyzer operating according to the method of non-dispersive absorption of infrared radiation, NDIR. The measurement of the total amount of THC hydrocarbons was carried out using a FID flame ionization analyzer. For the measurement of nitrogen oxides NO_x in the measurement system, an analyzer based on the CLD chemiluminescence method was used. The O_2 oxygen concentration in the flue gas was measured using the PMD paramagnetic analyzer.

FUELS SELECTED FOR TESTING

The tests were carried out on the Perkins 1104D-44TA engine supplied with sunflower oil methyl esters produced in the Malopolska Center for Renewable Energy Sources "BioEnergia". They were obtained in the transesterification process of sunflower oil with methyl alcohol CH_3OH in the presence of a catalyst in the form of alkaline potassium hydroxide KOH. A GW-200 reactor designed by Grzegorz Wcisło [11] was used for this purpose. The view of the GW 200 reactor is shown in Figure 3. It enables the production of esters from various types of vegetable oils and animal fats.

Fig. 3. Reactor GW 200 for production of Biodiesel FAME (SME)

TEST CONDITIONS

The tests were carried out on a test stand located in the Thermal Engine Laboratory of the Kielce University of Technology (Figure 1). The stand includes a Perkins 1104D-44TA engine and an eddy-current type AMX-200/6000 Elektromex Centrum brake with 200 kW, maximum torque of 700Nm and a maximum speed of 6000 rpm. The work of the stand is controlled and supervised via a desktop computer with Automex software. In addition, this software enables the visualization and archiving of indicators and parameters of the engine and other components of the stand measured during the tests. The engine's fuel consumption is measured using the Automex gravimetric fuel meter. The fuel dose control in the Perkins 1104D-44TA engine is done by means of a cable connecting the high pressure pump with the servo. The servo is connected to the engine control cabinet. The air consumption measurement was carried out using ABB's thermal mass air flow sensor.

Perkins 1104D-44TA engine tests were carried out according to its external speed characteristics. The measurements were carried out in the range of rotational speed values of the crankshaft from 1,000 to 2,200 rpm. Measurements for powering the engine with esters and diesel fuel were carried out under the same fixed operating conditions.

ANALYSIS OF THE EXHAUST COMPOSITION OF AN ENGINE POWERED BY DIESEL FUEL AND ESTERS OF SUNFLOWER OIL

The values of the basic concentrations of Perkins 1104D-44TA gaseous fuel components operating according to the external velocity characteristics, and powered with SME and, for comparison, with diesel fuel are shown in Figures 4 to 7.

For all measuring points, in addition to the first one (n = 1000 rpm), lower concentrations of carbon monoxide and oxygen were obtained when the engine was supplied with esters. Supplying the engine with esters resulted in clearly lower THC hydrocarbon concentrations at all measuring points compared to its supply with diesel fuel. Similar results were obtained by other authors. Karabektas et al. [10], and Jazair [9] conducted an experiment using a four-stroke, four-cylinder DI diesel engine to study the effects of biodiesel from rapeseed oil on hydrocarbon emissions. Their research shows that the use of rapeseed oil biodiesel increases the emission of hydrocarbons in the exhaust gases.

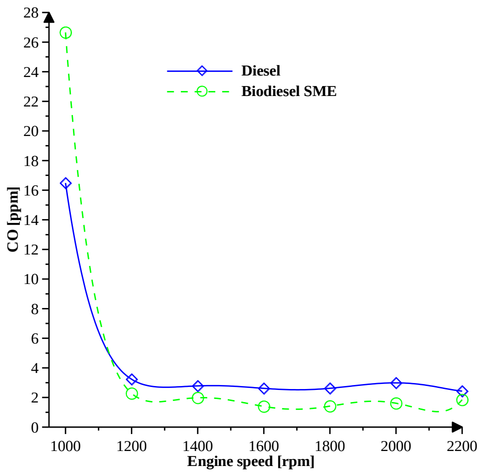

Fig. 4. Comparison of concentrations of carbon monoxide CO in the exhaust of the Perkins 1104D-44TA engine powered by SME and diesel fuel.

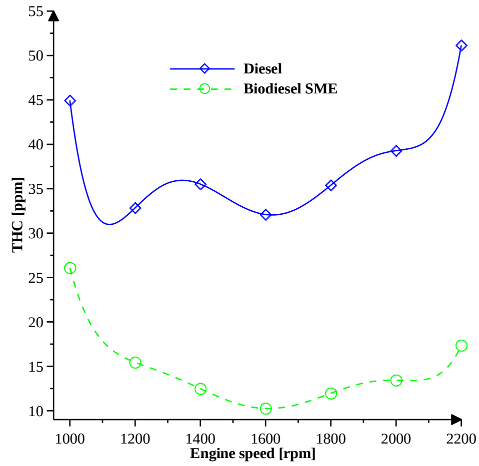

Fig. 5. Comparison of concentrations of carbon monoxide THC in the exhaust of the Perkins 1104D-44TA engine powered by SME and diesel fuel.

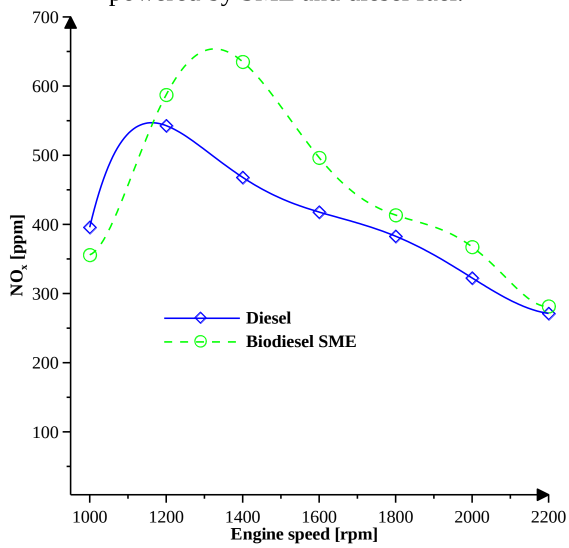

Fig. 6. Comparison of concentrations of carbon monoxide NO_x in the exhaust of the Perkins 1104D-44TA engine powered by SME and diesel fuel.

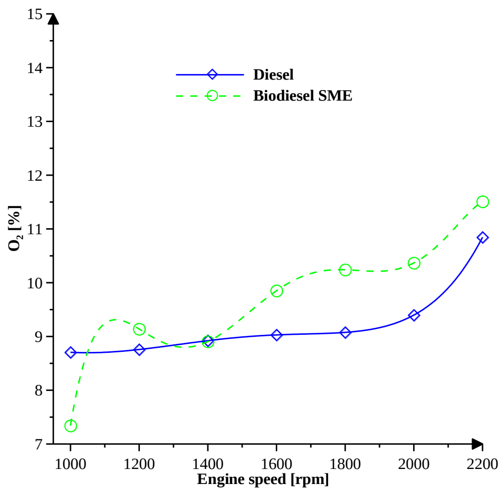

Fig. 7. Comparison of concentrations of carbon monoxide O_2 in the exhaust of the Perkins 1104D-44TA engine powered by SME and diesel fuel.

When supplying the engine with esters at all measuring points, with the exception of the first one (n = 1000 rpm), higher concentrations of nitrogen oxides were obtained in the exhaust of the tested engine.

CONCLUSIONS

The analysis of the obtained test results showed a significant effect of the use of methyl esters of sunflower oil on the concentrations of the basic components of the Perkins 1104D-44TA engine exhaust. SME and diesel fuel are two fuels that differ in their origin and physicochemical properties. By powering the engine with sunflower oil esters, its operation, according to the external velocity characteristics, has shown a decrease in the concentration of carbon monoxide and hydrocarbons in the exhaust. This is due to the fact that the process of better combustion and burning of fuel, i.e. combustion, was closer to total and complete.

When powering the engine with esters, higher values of the excess air coefficient were obtained than when it was powered with diesel fuel. This is due to the fact that there is oxygen in the structure of biofuels, therefore less oxygen from the atmosphere was used to totally and completely burn the combustible components contained in the fuel. During combustion, the average process temperature also increases, which is why, unfortunately, there was an increase in the concentration of nitrogen oxides in the exhaust of the engine powered with esters compared to when it was powered with diesel fuel.

REFERENCES

1. **Adewale P., Dumont M.-J., Ngadi M. 2015**. Recent trends of biodiesel production from animal fat wastes and associated production techniques. Renewable and Sustainable Energy Reviews 45, p. 574–588.
2. **Alptekin E., Canakci M., Sanli H. 2014**. Biodiesel production from vegetable oil and waste animal fats in a pilot plant. Waste Management 34, p. 2146–2154.
3. **Ambrozik A., Kurczyński D., Łagowski P., Warianek M. 2016**. The toxicity of combustion gas from the Fiat 1.3 Multijet engine operating following the load characteristics and fed with rape oil esters. Proceedings of The Institute of Vehicles 1(105), pp. 23-35.
4. **Banković-Ilić I. B., Stojković I. J., Stamenković O. S., Veljkovic V. B., Hung Yung-Tse. 2014**. Waste animal fats as feedstocks for biodiesel production. Renewable and Sustainable Energy Reviews 32, pp. 238–254.
5. **Cunha A. Jr., Feddern V., De Prá M. C., Higarashi M. M., G. de Abreu P., Coldebella A. 2013**: Synthesis and characterization of ethylic biodiesel from animal fat wastes. Fuel 105, pp. 228–234.
6. Directive 2001/77/EC of the European Parliament and of the Council of 27 September 2001 on the promotion of electricity produced from renewable energy sources in the internal electricity market.
7. **Encinar J.M., Sánchez N., Martínez G., García L. 2011**. Study of biodiesel production from animal fats with high free fatty acid content. Bioresource Technology 102 , pp. 10907–10914.
8. **Issariyakul T., Dalai A. K. 2014**. Biodiesel from vegetable oils. Renewable and Sustainable Energy Reviews 31, pp. 446–471.
9. **Jazair W., Kubo S., Takayasu M., Yatsufusa T., Kidoguchi Y. 2011**. Performance and emission characteristicsof a dieseln engine fueled by rapeseed oil bio-fuel. Journal Mek., 33/2011, 32-39.
10. **Karabektas M., Ergen G., Hosoz M. 2013**. Effects of the blends containing low ratios of alternative fuels on the performance and emission characteristics of a diesel engine. Fuel, 112, 537-541.
11. **Kousoulidou M., Fontaras G., Ntziachristos L., Samaras Z. 2010**. Biodiesel blend effects on common-rail diesel combustion and emissions. Fuel 89, pp. 3442–3449.
12. **Millo F., Debnath B.K., Vlachos T., Ciaravino C., Postrioti L., Buitoni G. 2015**. Effects of different biofuels blends on performance and emissions of an automotive diesel engine. Fuel, vol. 159, p. 614–627.
13. **Serrano L., Lopes M., Pires N., Ribeiro I., Cascao P., Tarelho L., Monteiro A., Nielsen O., Gameiro da Silva M., Borrego C. 2015.** Evaluation on effects of using low biodiesel blends in a EURO 5 passenger vehicle equipped with a common-rail diesel engine. Applied Energy, vol. 146, p. 230–238.
14. System do pomiaru spalin silnikowych MEXA-1600D/DEGR. Instrukcja obsługi.
15. **Wcisło G. 2013.** Analiza wpływu odmian rzepaku na własności biopaliw RME oraz parametry pracy silnika o zapłonie samoczynnym. Monografia habilitacyjna. Wydawnictwo FALL. Kraków.
16. **Wcisło G., Labak N. 2017.** Determination of the impact of the type of animal fat used for production of biofuels on the fractional composition of AME. Econtechmod. An international quarterly journal, vol. 6, No. 1. p. 111-114.
17. **Żmudzińska-Żurek B., Kożuch B., Rakoczy J. 2009.** Badanie reakcji transestryfikacji triglicerydów oleju rzepakowego bioetanolem. Nafta-Gaz, 4, pp. 338-344.
18. **Tziourtzioumis D., Stamatelos A. 2012**. Effects f a 70% biodiesel blend on the fuel injection system operation during steady-state and transient performance of a common rail diesel engine. Energy Conversion and Management 60/2012, pp. 56-67.
19. **Wcisło. G. 2010**: Utilization of used oils and fat for manufacturing FAME biofuels. Teka Komisji Motoryzacji I Energetyki Rolnictwa, 2010, Vol. X, pp. 509-516..
20. **Drygaś B., Depciuch J., Puchalski Cz., Zaguła G.. 2016.** The impact of heat treatment on the components of plant biomass as exemplified by Junniperus sabina and Picea abies. Econtechmod. Vol 5, no 3, pp. 41-50.