TEKA Kom. Mot. i Energ. Roln. – OL PAN, 2011, 11, 450–456

ESTIMATION OF BIODIESEL FUEL ON THE BASIS OF RAPE OIL AND ISOPROPYL ALCOHOL

Victor Zaharchuk, Valentyna Tkachuk, Oleg Zaharchuk

Lutsk National Technical University, Lutsk, Ukraine

Summary. The article is devoted to the analysis of operating properties of biodiesel fuels, in particular thermal energy indexes on the basis of which a conclusion is made about the prospects and advantages of application of biodiesel fuel on the basis of rape oil and isopropyl alcohol.

Key words: biodiesel fuel, diesel engine, toxicity, isopropyl esters, rape oil.

INTRODUCTION

Presently in our state there is a large park of the wheeled transport vehicles and agricultural vehicles with diesels which work on the diesel fuel (DF) of mineral oil origin. However, from facts of numerous sources, supplies of mineral oil accessible on our market can be sufficient only to the year 2015, therefore the cost of diesel fuel will be constantly growing. In such situation the use of alternative fuels becomes economically justified. In addition, the automobile industry is one of the greatest polluters of the environment. Application of alternative fuels will allow for a significant decrease of the harmful fumes emission from diesels and improvement of the ecological situation in cities and rural settlements. Application of alternative fuels which are made from renewable sources will allow for the promotion of Ukraine's independence from the imported energy resources.

One of the basic ways of solving the complicated situation is adaptation of diesels for work on alternative fuels. Such fuels are: compressed natural gas, dimethyl esters (DME) and biofuel, in particular methyl esters of rape oil (MERO). Natural gas is approximately two times cheaper than diesel fuel. However, for making a diesel work on natural gas its substantial re-equipment is required into a gas diesel or into a gas engine with spark lighting. Thus a gas diesel works on the mixture of natural gas and diesel fuel, for it has a considerably more difficult system of feeding compared to the diesel. As to gas engines with spark lighting, their researches are not yet completed.

This publication aims at a determination and analysis of effective calculation indexes of a diesel working on different biofuels.

MATERIALS AND RESEARCH

Recently, a wider application has been found by alternative biofuels on the basis of vegetable oils. Biodiesel fuel, i.e. methyl and ethyl esters of vegetable oils, whose most widespread form is rape oil, belongs to such fuels. Research on fuels made from vegetable oils is conducted by the well-known motor-building firms of the USA, Great Britain, Germany, Sweden, Japan. Presently, more than 6,5 million t biofuel is made in Europe. Work is conducted concerning the application of esters of vegetable oils as diesel fuel on territories of the former USSR. There should be mentioned: MVTU named after Bauman, MSAU named after Goryachkina, Klaipeda University, National University of Bioresources and Environmental Management of Ukraine, KHPI and others.

Application of biodiesel fuel requires no changes in the construction of engine. Tests showed the increase of expenditure of biodiesel fuel to 10%, which can be explained by the lower combustion temperature. At the same time the emission of fumes with harmful compounds is diminished [1].

A traditional biodiesel fuel is made with the use of methyl alcohol which is highly toxic and dangerous for the health of people. Its possible concentration in the air around the working area reaches 5 mgs/m, whereas for ethanol it reaches 1000 mgs/m. It is a substantial negative factor from the standpoint of ecological safety at the production of biofuel (especially in the conditions of agricultural production) and its use, in fact through the effects of destruction a selection from the biofuel of methyl alcohol is possible, especially at deviation from normal work of the fuel system of engine. Also, the lack of methyl ether is that it is an aggressive enough matter in relation to precise materials of engine parts (metals, rubber). Therefore, at its application replacement of fuel tanks, fuel hoses and gaskets is required, with the ones made from material approved by MERO, and also more frequent replacement of motor oil.

A biodiesel fuel can also be made with the use of ethyl spirit (EERO). But such a fuel has a fairly high cost due to the high cost of ethyl spirit. In addition, the reaction of esterification with an ethyl spirit is considerably slower.

RESULTS OF RESEARCH

In the Lutsk National Technical University a new biodiesel fuel is created with the use of isopropyl alcohol instead of methyl. This type of alcohol has insignificant toxicity and aggressiveness. The fuel is obtained by the reaction of pre-esterification of rape oil with an isopropyl alcohol in presence an alkaline catalyst. Optimum correlation of components of new biofuel is certain according to a mathematical design. The search of optimum parameters was carried out, utilizing a three-factor experiment. As a parameter of optimization the temperature of freezing (t_{freez}) of biofuel is chosen (Fig 1).

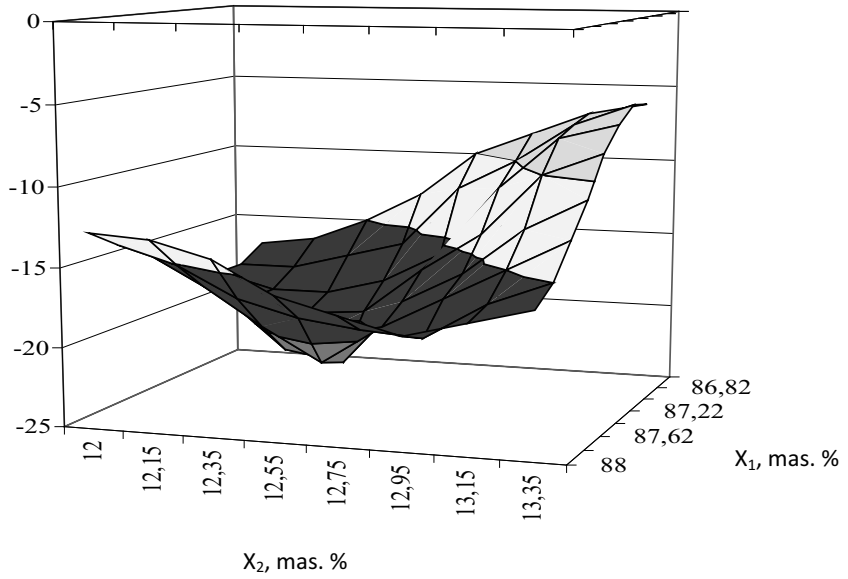

Fig. 1. Dependence of the biofuel freezing temperature on the maintenance of rape oil (X_1) and isopropyl alcohol (X_2)

Elementary composition (content of carbon C, hydrogen H and oxygen O) of isopropyl ester of rape oil (IERO) was certain in accordance with maintenance of acids in rape oil [2]: ester of erucic acid - 50,0 %, by an oleic- 29,0 %, linoleic - 15 %, other esters of other acids. The experimental values of operating properties of biodiesel fuels were compared to the requirements of DSTU, as diesel fuel «L» is easily soiled (Table 1).

Table 1. Comparative description of indexes of operating properties of diesel and biodiesel fuels

№	Name of index	Method of tests	Norm of DSTU 3868-99	Diesel fuel	Biodiesel fuel	
					MERO	IERO
1.	Cetane number	DSTU 3868-99	not below 45	47	48	49
2.	Density, g/sm^3 at 15°C	DSTU 3900-99	no more than 0,860	0,84	0,88	0,88
3.	Kinematic viscosity at 40°C, sSt	DSTU 33-00	3,0-6,0 at 20 C	5,4	5,6	16,1
4.	Acidity, mg KOH on 100 sm^3	GOST 5985-79	no more than 5,0	2,7	-	-
5.	Temperature of freezing, °C	GOST 20287-91	no more than -10	-14	-12	-22

The new fuel has the best consumer characteristics, in particular, lower temperature of freezing. It obtained the toxicological and sanitary passport, its technical properties were developed and

ratified. In the private enterprise «Limeks Invest» the industrial endorsement of the production of the offered biofuel is carried out. In the near future the stand tests of diesel will be conducted on such fuel.

For comparison and estimation of effective indexes of diesel D-240 during its work on oil diesel fuel and biodiesel fuels in the conditions of identical middle effective pressure, the computer calculation of its work cycle was executed for the nominal mode. The initial data for calculation are presented in Table 2, and results of calculation in Table 3.

It is obvious from the calculations that the less carbon in the molecules of biodiesel fuels the lower the combustion temperature. For the obtainment of identical effective power of diesel during its work on oil diesel fuel and biodiesel fuels a specific effective expense of fuel will be large in the case of the use of biofuels. In addition to some worsening of indexes of diesel during work on biodiesel fuels their large viscidity is a negative factor, compared to an oil fuel. Investigation revealed its worst atomization by sprayers. Therefore some researchers recommend using biodiesel fuel in mixtures with diesel fuel (30% biodiesel and 70% DF).

Table 2. Results of calculation of effective indexes of diesel during its work on different fuels

№	Index	Fuel			
		DF	MERO	EERO	IERO
1	Elementary composition, %: C H O	 87 12,6 0,4	 77,5 12,0 10,5	 77,54 12,04 10,42	 76,28 13,16 10,05
2	In theory necessary amount of air for combustion of 1 kg of fuel, kg	14,45	12,70	12,73	12,98
3	Lower temperature of combustion, MJ/kg	42,44	37,50	37,56	38,33
4	Coefficient of surplus of air	1,5	1,5	1,5	1,5
5	Middle effective pressure, MPa	0,694	0,698	0,698	0,699
6	Effective coefficient	0,350	0,350	0,350	0,350
7	Specific effective expense of fuel, g/kW*h	242,63	274,54	274,06	268,05
8	Effective power, kW	60,43	60,76	60,76	60,88

But among biodiesel fuels IERO has the highest combustion temperature and the least expense of fuel, which advantageously distinguishes it from MERO and EERO. The presence of oxygen in the molecules of biodiesel fuels allows for the intensification of the process of combustion. Other effective indexes of engine on condition of increase of specific effective expense of fuel are identical.

Viscosity of IERO is higher compared with the proper value of normative requirements, which can hamper the passing of fuel through filters, deteriorate the working of fuel sprayers and worsen mixing. It can be considered as the lack of IERO. Therefore, at low temperatures it is expedient to utilize such fuel in mixtures with an oil diesel fuel. On the other hand, higher viscosity of fuel will provide good greasing of the diesel fuel apparatus parts. The solidification temperature of IERO is 2 times lower than in MERO. In fact it enables to use such fuel in a winter period at the temperature reaching -22˚C, while the standard is to - 12˚. Acidity in IERO is absent so that it is not a corrosive agent. Ash content in IERO stays within the limits of norm which points out to low content of mineral ash in this fuel.

Biodiesel fuel, and above all IERO, is safer from the viewpoint of ecology. As experiments showed, biodiesel leak in water does not affect living organisms. In addition, it is fully biodegradable –it is decomposed in soil or in water by microorganisms within 28 days. The conducted toxi-

cological and hygienic researches of IERO allowed to draw the conclusion that this fuel belonged on average to the 4th class of danger (the lowest class).

The stand tests of diesel of D-240 were conducted during its work on IERO and oil DF, the loading descriptions of which were obtained as a result (Fig. 2). It is evident from the test results that the power Ne of diesel during work on these fuels is practically identical. In the case of work of diesel on IERO the increase of specific expense of fuel remains within the range of 4…6 % as a result of lower combustion temperature and increase of nitrogen oxides concentration NOx in exhaust gases through higher content of oxygen in a biopropellant. The rejection of sizes of other compared indexes (for example exhaust smoking of D of exhaust gases) is within the limits of possible accuracy of their measurement.

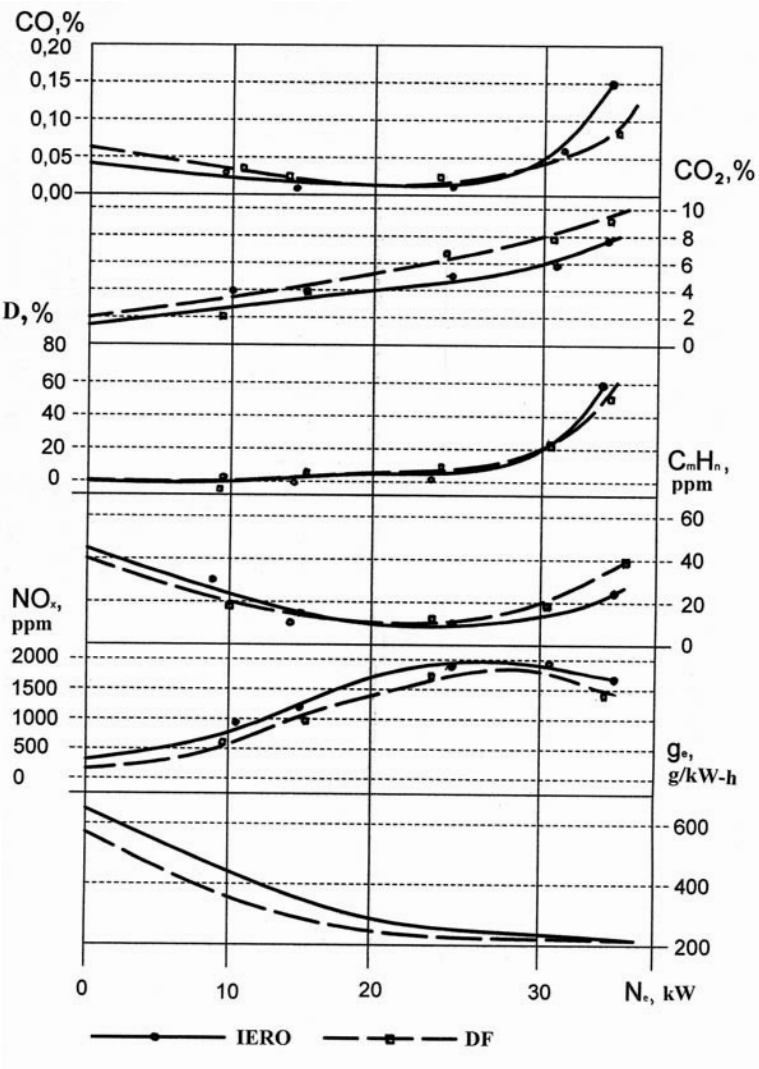

Fig. 2. Loading characteristics of diesel D-240 (n = 1500 rpm)

Biodiesel fuel practically does not contain sulphur, which is why an engine working on this fuel has a zero level of SO2 emissions, and this advantageously distinguishes it from the diesel in which the emissions of sulphur oxides cause substantial environmental damage. It is especially topical for our state, because in the diesel fuels produced in our petroleum refinery factories the sulphur contents significantly exceed the admissible norms. An important advantage of engines working on biodiesel fuel are low emissions of dioxide carbon which is instrumental in the formation of the greenhouse effect on the Earth. It is explained by the fact that there is less carbon in biodiesel fuel than in oil fuels.

CONCLUSIONS

The analysis of operating properties of biodiesel fuels shows that the new biodiesel fuel has a lower temperature of freezing than methyl ester of rape oil and is characterized by toxicity and aggressiveness comparable to ethyl esters of rape oil, but is considerably cheaper. The results of the experimental findings confirm that the new environmentally clean biofuel has improved consumer characteristics and is suitable for production and use in transport.

REFERENCES

1. Adamenko O., Visochanskiy V., Letko V., Mikhayliv M., 2001: Alternative fuels and other untraditional energy sources. Ivano-Francovsk, 432 p. (in Ukrainian).
2. Tkachuk V., 2007: Biopropellant as perspective energy saving resource//The Scientific news of Institute of management and economy the «Galichina academy». Special issue of materials IV international scientific and technical conference the rence "Ecological and economic problems of European Region of Carpathians «EEPKE 2007». Ivano-Francovsk, p. 32-37. (in Ukrainian).
3. Maslo V., 2005: Ways of development of production of biodiesel in Ukraine//Announcer of agrarian science. № 10, p. 78-80. (in Ukrainian).
4. Markov V., Gayvoronskiy A., Devyanin S., Ponomarev E., 2006: Rape oil as alternative fuel for a diesel//Motor industry. - № 2, 8.
5. Marchenko A., Prokhorenko A., Osetrov A., 2004: A comparative estimation of efficiency of application of vegetable fuels is in the diesel engine of origin//Combustion engines. Khar'kov: NTU «KHPI»- № 3, p. 46-51. (in Ukrainian).
6. Marchenko A., Minak A., Slabun I., 2003: Results of researches of working process and toxicity of diesel working on the fuels of plant origin// Combustion engines. Khar'kov: NTU «KHPI». № 2, p. 33-40. (in Ukrainian).
7. Marchenko A., Strokov A., Minak A., 2002: Toxicity of working gases of diesel at the use of fuels of phytogenic// Combustion engines. Khar'kov: NTU «KHPI»- № 1, p. 22-25. (in Ukrainian).
8. Mel'nichuk M., 2009: Technical problems biodiesel production in Ukraine//Announcer of national university of Life and Environmental Sciences of Ukraine. Prod. p. 141-154.
9. Zabarniy G., 2006: Thermodynamics efficiency and resources of liquid biopropellant in Ukraine: Monograph/ Zabarniy G., Kudrya S., Kondratyuk G. K. 226 p.
10. Cossack V., 2007: Determination of content of methyl esters of fatty acids in a diesel fuel by the methods of chromatography-spectroscopy/ IV a scientific and technical conference is

«Advancement in oil and gas and to petrochemical industry». Lvov. p. 137-138. (in Ukrainian).
11. Letko V., 2000: Application of alternative fuels in combustion engines / M.: MADI. 311 p.
12. Tyutyunnikov B., Bukhshtab Z., 1992: Chemistry of fats. M. 448 p.
13. Biodiesel Zieht Stark An // of Produktion., 2002. - № 13. S. 4.
14. Tkachuk V., 2007: Improvement of physical and chemical indexes of biofuels due to the use of frapeseed oil izopropilesteriv/Collection of theses of lectures V scientific and technical conference «Advancement in oil and gas and to petrochemical industry» (on September, 11-14 in 2007). Lvov. p. 220-222.
15. Chulkov P., 1998: Motor fuels: resources, quality, substitutes. M. 416 p.
16. Terent'ev G., 1989: Motor of fuel from alternative sources of raw materials. M. 271 p.
17. Zakharchuk V., 2007: Bases of theory, construction and calculation of motor-car engines. Lutsk: LDTU. 216 p.
18. Devyanin S., Markov V., Semenov V., 2007: Vegetable oils and fuels on their basis for diesel engines. Kharkiv, 452 (in Ukrainian).
19. Fizer L., Fizer M., 1966: Organic chemistry. Moscow, 782 p. (in Russian).
20. Zakharchuk V., 2010: Application of alternative fuels in diesel engines. Kiev. №2, p. 26-28 (in Ukrainian).

OCENA WŁAŚCIWOŚCI EKSPLOATACYJNYCH PALIWA OLEJU NAPĘDOWEGO BIO NA PODSTAWIE OLEJU RZEPAKOWEGO I ALKOHOLU IZOPROPYLOWEGO

Streszczenie. Artykuł dotyczy analizy właściwości eksploatacyjnych paliwa napędowego bio, szczególnie temperatury tężenia, na podstawie której omówiono perspektywy i zalety alkoholu izopropylowego z oleju rzepakowego.

Słowa kluczowe: olej napędowy bio, diesel, toksyczność, alkohol izopropylowy, olej rzepakowy.