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FUEL SYSTEM OF THE TRACTOR DIESEL WITH MULTISTAGE HEATING

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ABSTRACT: The researches in the field of alternative and renewable fuels have been the prerogative of the energy and resource saving programs of many countries for a long time. The design of the fuel system of the tractor diesel with the multistage heating, allowing applying pure rapeseed oil as fuel in the diesel engine is described in the article.
Keywords: fuel, rapeseed oil, kinematic viscosity, fuel system, multistage heating

1. INTRODUCTION

Despite the development of new deposits of traditional energy sources, the question of their alternatives is extremely sharp. The reason for it is the fact that natural resources are limited, the prices for traditional energy sources constantly increase while the ecological situation on the planet gets worse. The researches in the field of alternative and renewable fuels have been the prerogative of the energy and resource saving programs of many countries for a long time [1,6,7]. Many scientists of worldwide reputation achieved good results in the sphere of alternative energy sources. Data released in the sphere of atomic energy, solar energy, the usage of wind power generators and tidal energy of seas and oceans, as well as the application of biofuels revealed the positive points of alternative power-engineering, defined tasks and the ways of their solutions. In spite of high variability of alternative power-engineering, the majority of scientific works with positive results won't get wide manufacturing application in the nearest future for many reasons. Therefore, many European scientists and engineers think that "atom", "hydrogen" and recuperative system will be applied in manufacturing only in 40-50 years. This time will take a transitional period, when biofuel will be used as a fuel for already existing combustion engine models. By now biofuel gained trust and confidence of many countries. It is used in its pure state (alcohols replacing gasoline; biodiesel replacing traditional mineral diesel fuel; biogas in gas generator units) as mixtures with mineral fuels (E5, E15, E80, E85, B10, B20, etc.) and as a fuel additives [2,7].

In the context of agricultural enterprises the most suitable alternative for diesel fuel nowadays is bleached RO, meeting the requirements of the German standard V 51605. The use of pure RO as a fuel for diesel engines results in the following negative effects: loss of power, increased fuel consumption, shortened life of the fuel equipment, impair starting in cold weather, increased incrustation and lacquer formation, etc. [1,3,8].

The presence of negative moments in the operation of diesel engines due to RO, is primarily connected with the increased values of the kinematic viscosity compared to diesel fuel (DF). In terms of agricultural enterprises heating is the most effective way to reduce the viscosity of the pure RO and its mixtures with diesel fuel with a high content of RO.

2. MATERIAL AND METHOD

Based on the temperature characteristics and the seasonal fieldwork, we investigated the dependence of the kinematic viscosity of the pure RO and its mixtures with diesel fuel on the temperature and the content of the RO in the mixture with diesel fuel. As the RO we used a sample obtained by hot pressing followed by filtration settling of these breeds of rape: Northerner, Salsa, Ahat, Luned, Rohan, Krauser, Solar KL, Mobil KL, Lighthouse, Zorn, Proxima, Capital, Leader, Winner, Sfint and Heros. The DF applied in the research met the requirements of GOST R 52368 - 2005 "The National Standard of the Russian Federation. Diesel fuel Euro. Specifications were in line with quality D, class 2.

In the process of research, we determined the kinematic viscosity of pure RO, as well as its mixtures with DF, where DF content was gradually increased to 100% in 10% increments. The temperature range of viscosity determination was from 20 to 90ºC. The determination of kinematic viscosity was carried out according to GOST 33-2000 "Oil products. Transparent and opaque liquids. Determination of kinematic viscosity and calculation of dynamic viscosity". The mixture heating was conducted in a water-bath, the instruments for measuring kinematic viscosity were capillary viscometers type IWF-1m. The experimental methods were treated with the methods of interpolation and extrapolation

3. RESULTS

The determination of dependences of kinematic viscosity on temperature and composition of fuel mix (figure 1 and 2) was the result of the researches, first of all.

The more RO the mixture contains, the lower the content of harmful substances in the exhaust gases and the fuel price and the higher energy independence of the enterprise (on condition of intrafarm RO production), however the kinematic viscosity of the mixture is higher. At a temperature of 0ºC the RO viscosity is by 36,67-22,003 times higher than of the DF. Gradual temperature increase of the fuel mixtures to 40ºC gives sharp decrease in viscosity. For example, at pure RO the kinematic viscosity of the testing sample while heating to 40ºC decreases by 4,5 times in comparison with value at 0ºC and attains 24,503 cSt. Further temperature increase entailed to slower decrease in viscosity. Moreover, at a temperature of 90 ºC the viscosity of pure RO attains the value of about 7,384 cSt that allows to minimize the above-mentioned negative moments at operation of diesel engines of a domestic production on this fuel.

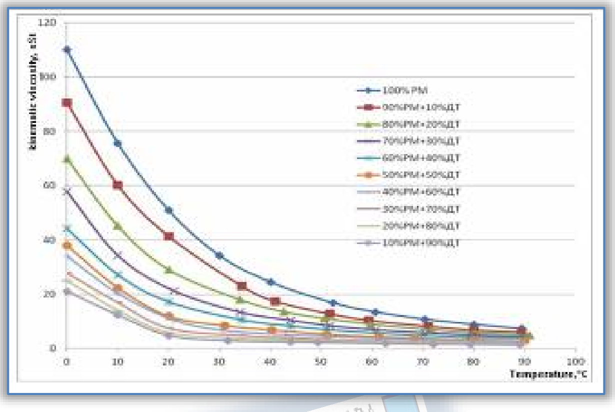

Figure 1. The dependence of the fuel mixture kinematic viscosity on temperature - kinematic viscosity, PM-RO

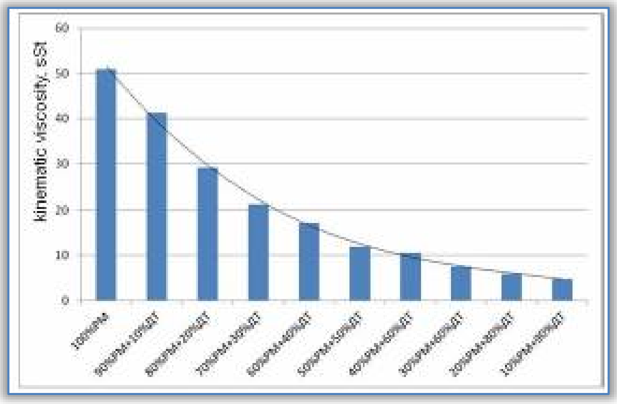

Figure 2. The dependence of the fuel mixture kinematic viscosity on its content at a temperature of 20ºC

For temperature range from 0 to 40ºC for all the fuel mixtures sharp decrease in viscosity is typical. The raised content of DF in them (from 40% and more) also gives decrease in fuel mix viscosity.

In general, the analysis of the results of researches with testing samples confirmed the possibility of use as fuel for diesel engines fuel mixtures containing less than 30% of RO at an ambient temperature 20ºC. However, the use of fuel mixtures with the low content of RO is ineffective from the point of view of ecology and economy, and the use of fuel mixtures with the high content of RO without heating is impossible. The heating of RO up to the temperature of 70-90ºC provides decrease in kinematic viscosity, increase in the fineness of injection, reduce of the flame length, i.e. promotes the improvement of the carburetion and combustion processes [5].

We offered a design (figure 3) of a dual-fuel system of the tractor diesel with RO multistage heating, which provides the use of vegetable-based oil. It contains a mineral fuel tank 1, vegetable-based fuel tank 2, where are a heat exchanger 6 and a temperature sensor 21 of the vegetable-based fuel set, mineral fuel intake line 3, vegetable-based fuel intake line 7, hydraulic directional valve 11 located in front of the fuel fine filter 12, ultrasonic filter 13 located in front of the injection pump 14, electric heaters 16 located in front of the nozzles 15, a fuel drain line 17 from the nozzles 15 and a fuel drain line 18 from the injection pump 14, an electronic control unit (ECU) 19, position sensor 20 of the fuel pump rail, located in the fuel pump regulator body. Line 3 of the intake mineral fuels contains first -stage fuel filter 4 and an electric booster pump 5 with a pressure relief valve. Line 7 of the vegetable-based fuel intake, in its turn, contains first-stage fuel filter 8, fuel pump 9 of a standard power supply system and the PTC thermistor heater 10 [4].

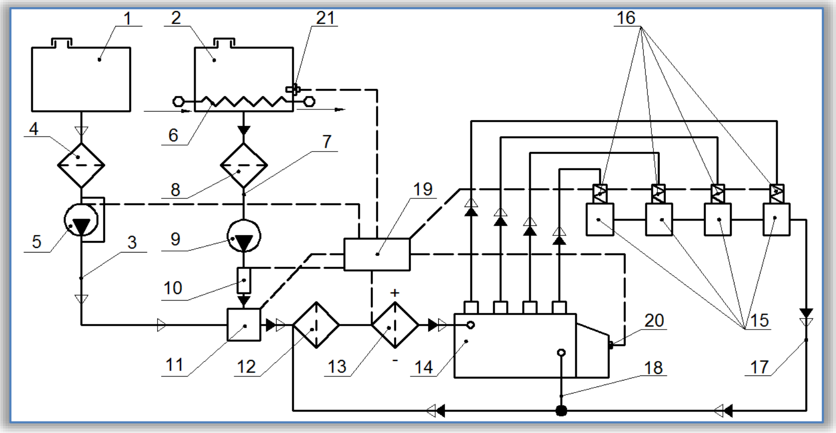

Figure 3. The diagram of the dual-fuel system of the tractor diesel with multistage heating

The first heating stage includes heat exchanger 6, connected to the engine cooling system and heating the vegetable-based oil in tank 2 to the temperature of 20-30°C, that ensures its pumpability even at low ambient temperatures.

The second heating stage is represented by PTC heater 10, which is self-regulated and serves to heat the vegetable-based oil to a temperature of 60-70°C, which ensures its good pumpability through the fine filter 12 and ultrasonic filter 13.

The third stage of heating is realized as electric heaters 16 mounted directly in front of the nozzles 15. The vegetable-based oil at this stage is heated to a temperature of 80-90°C. Electric heaters 16 contain posistors, which stand for control units, so they are self-regulated. The heating of the vegetable-based oil to a temperature of 80-90°C during injection ensures less flame length and a finer spray compared with lower preheating temperatures.

The dual-fuel system of a tractor diesel with multistage heating operates in the following way:

The start and warming up of the engine is carried out on diesel fuel. At the same time it is supplied by the electric boost pump 5 from the tank through the first- stage fuel filter 4, hydraulic directional valve 11, the fine filter and ultrasonic filter 13 in the high pressure pump 14. Then the diesel fuel through the electric heaters 16 is supplied to the nozzles 15. When the engine is warming up and during the operation with diesel fuel ultrasonic filter 13 and electrical heaters 16 are switched off. The excess of diesel fuel from the nozzles 15 and the fuel pump 14 through the drain lines 17 and 18 are supplied to the fine filter 12.

When heating and during the engine operation the coolant of its system circulates through the heat exchanger 6. Once the temperature of the vegetable-based oil reaches the level of 20-30°C in the tank 2 of the electric control unit 19, perceiving this option by the temperature sensor 21, switches the hydraulic directional valve11 in the position of supplying vegetable-based oil and also starts the work of heaters 10 and 16 as well as ultrasonic filter 13. The main function of the ultrasonic filter 13 is further reduction of the kinematic viscosity of the vegetable-based oil.

After switching the hydraulic directional valve 11 in the position of supplying vegetable-based oil, the oil supply stops because the ECU 19 turns the electric boost pump 5 off (the ECU 19 gives signal for the spool of the hydraulic directional valve to stop the diesel fuel supply into the system), the fuel boost pump 9 of the standard power system, delivers warmed to 20-30°C vegetable-based oil from tank 2 through a first-stage fuel filter 8 into the posistor heater 10 where it is heated to 60-70°C. Then the oil is sent by the hydraulic directional valve 11 through the fine filter 12 in an ultrasonic fuel filter 13, where the vegetable-based oil is subjected to cavitation treatment, whereby its viscosity is further reduced, and it is supplied into the high pressure pump 14 and then to the electric heaters 16, where it is heated up to 80-90°C and the injection nozzles 15 spray it into the combustion chamber. The excess of vegetable-based oil from the nozzles 15 and the high-pressure pump 14 through the lines 17 and 18 are sent to the fine filter 12.

Thanks to the use of PTC thermistor in the heaters 10 and 16, the latter automatically maintain the temperature of vegetable-based oil in the fuel system. In the PTC heater 10, they have two functions: they are heating elements and at the same time they maintain the oil temperature in the range of 60-70°C. The heating elements in the electric heaters 16 are spirals, while posistors serve as elements supporting the temperature in the range of 80-90°C.

At steady state conditions of the minimum stable speed and regimes of part-load engine (to 35%), the latter runs on diesel fuel. [4] When working on the above-mentioned modes the rail position sensor 20 of the fuel pump sends a signal to the ECU 19, which puts the system on diesel fuel. The ECU 19, used in the dual-fuel system, allows a person to switch from one fuel to another one manually. Before stopping the engine, the fuel system is converted to pure diesel fuel and the engine should run on it for about 5 minutes (depending on operating mode).

The usage of the offered dual-fuel system of the tractor diesel engine will allow to apply vegetable-based oil as a fuel in cold season and improve the overall efficiency of the engine on this type of fuel.

4. CONCLUSIONS

1. The dependences of kinematic viscosity on temperature and content of fuel mix are defined in the research.
2. Some additional proposals to the existing guidelines for the application of the vegetable-based oils fuel mixtures are added, among others the fuel optimum temperature range 80-90°C is determined, which provides the best injection and combustion in the cylinders.
3. The devices allowing applying RO-based biofuel for diesel engines are developed.
4. A 3-stage energy-saving fuel heating system allowing applying biofuel year-round is developed, which after all increases the operating efficiency of the machine-tractor aggregates.

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