Device for Oil Wastes Recycling

Andreyev V.V, Duntsev A.V, Tarasova N.P, Orekhova YE.YE, Utyatnikov A.YE.

Abstract-Recently energy saving and environmental safety issues have become topical with reference to fuel power generating systems operation. Water-fuel oil emulsions (WFOE), diesel fuel are of the most interest. WFOE have some advantages over the traditional fuel oil.

The present paper describes a new installation designed for oil wastes processing and obtaining burning oil presenting water and diesel fuel mixture in some definite proportions. There are presented results of investigating the proposed installation operating modes as well as those of the water content in the assumed fuel. The installation has three circulation loops. Investigation of the operating modes assumed investigation of each loop separately and the obtained results evaluation to detect the most efficient loop for mixing oil wastes with water. As a result of the investigation it was revealed that to reach the required degree (volume) of the water inclusion in the fuel it is necessary to use all pieces of equipment, i.e. the third loop.

Keywords-oil wastes, diesel fuel, emulsion, burning oil, cavitationer, dispersant, ecology

I. INTRODUCTION.

At present the tasks of energy saving and ecological safety is actual for power fuel systems operation. For solving these problems diesel fuel-water fuel emulsions are of special interest. The use of homogenized water-fuel emulsion mixture allows increasing firing factor, saving diesel fuel and decreasing harmful emission into atmosphere.

When fuel droplet contains smaller water inclusions in case of water heating and boiling water steam is generated which breaks fuel droplet, increasing dispersion ability of the fuel supplied into the burner and the surface of the fuel contact with air. As a result, the fuel fills a furnace chamber more uniformly causing temperature alignment in the burner and local maximum temperatures reduction. In this case the fuel underburning is decreased sufficiently; the possibility appears to decrease amount of the injection air and decrease the heat losses caused by this. A part of the droplets reach the walls and burst there, and this promotes not only deposits prevention but also cleaning from old carbon formations.

When water-fuel emulsions (WFE) are burned NOx yield in gas emissions is decreased (about 90% down), carbon deposits are decreased 3-4 times, CO yield is decreased about 70% down.

At "Nuclear reactors and power plants" sub-department of nuclear power engineering and technical physics institute of Nizhny Novgorod technical university named after R.E. Alekseev an experimental system was developed for producing liquid burning oil on the basis of watered oily wastes (the system is covered by a patent [1], [2], [3]).

The system diagram is presented in Figure 1.

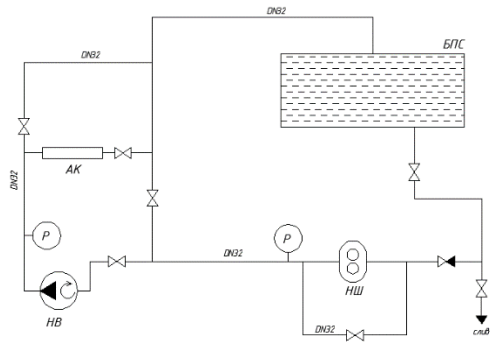

Fig. 1 Basic diagram of the system for oil wastes recycling

Designations: АК–cavitation device, НВ – peripheral pump, БПС – tank for mixture preparation, НШ – gear-type pump, P – pressure gage.

The system for wastes recycling operates in the following way:

The feed stock and water are supplied into the raw mix preparation unit and then through the controller for holding raw mix consumption stability to the suction pipe of the peripheral pump. Intensive eddy generation in the peripheral pump active volume provides the raw mixture breaking. For additional dispersion the mixture is supplied through the discharge tube and then through the controller into the jet cavitation device. The produced emulsion is fed to finished mixture tank. The system normal operation is provided by the controller for holding raw mix consumption stability [4],[5],[6]. The system is equipped by electric radiator for providing required temperature of the diesel fuel to prevent its cooling-down and solidification. As it is necessary to keep the diesel fuel temperature it is recommended to perform the works at this system in a heated room when the temperature in the room is not lower than 5° C. The bench consists of two loops for medium circulation.

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Andreyev V.V., Nizhny Novgorod State Technical University n. a. R.E. Alekseev, Russia

Duntsev A.V., Nizhny Novgorod State Technical University n. a. R.E. Alekseev, Russia

Tarasova N.P., Nizhny Novgorod State Technical University n. a. R.E. Alekseev, Russia

Orekhova YE.YE., Nizhny Novgorod State Technical University n. a. R.E. Alekseev, Russia

Utyatnikov A.YE., "LUKOIL-Volganefteprodukt" Closed corporation OOO, Russia

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The small loop is designed for preliminary mixing investigated medium and reaching the temperature mode [1]. Figure 2 presents the experimental bench model.

Рис. 2Model of experimental bench for recycling oil wastes

Table 1 presents the system characteristics.

2. RESULTS AND DISCUSSIONS

Table 1 System characteristics

Parameter	Maximum value	Minimum value
Total electric power without taking into account the electric heater	2 kW	
Time required for preparing a ton of fuel	4.8 hours	
Producing capacity	200 l/h	

The tests of the presented system for mixing water with model liquid were carried out. The model liquid represents machinery oil which has the same density as diesel fuel under some definite conditions. In figure 3 there is presented the dependence of the diesel fuel and machinery oil density on the temperature.

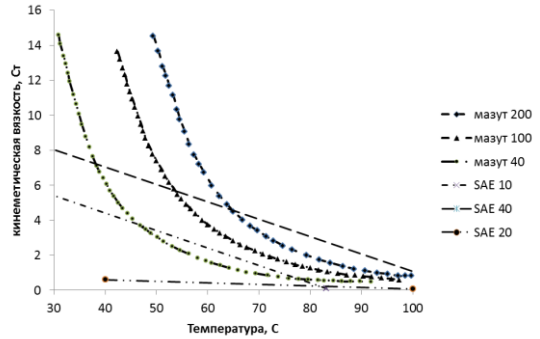


Figure3Dependence of the diesel fuel and machinery oil on the temperature

The presented dependence demonstrates that viscosity of the model liquids (machinery oil) and diesel fuels used in industry have equal values at some definite temperatures. Investigation of mixing liquids having different density was carried out when parameters were like those presented.

These investigations were carried out separately for each loop and with all loops simultaneously according to the following procedure: liquid under investigation and water were mixed in definite proportions, the resulted mixture was circulating along the studied loop for some definite time, after that sampling of the resulted mixture was provided and in some definite time periods the pictures of the samples were taken. After investigating the taken pictures a conclusion was done about separation of the obtained samples and, finally, about the obtained mixtures stability. And also, the obtained samples were studied under microscope to investigate the size of the water droplets in the mixture. As a result of study the liquid droplets in the mixture conclusions were made about the efficiency of every loop and about the possibility to use them for preparing liquid burning fuel of oil wastes. Experiments were carried out when the water content was 5%, 10%, 15%, 20%, 25%, 30%, 35%, 40%, 45%, 50%. Circulation time in the loop is 5 minutes.

Figure 4 presents the dependence of the oil columnheight on the time when the water content was equal to the said above.

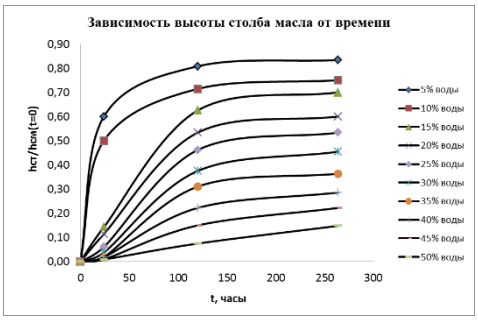
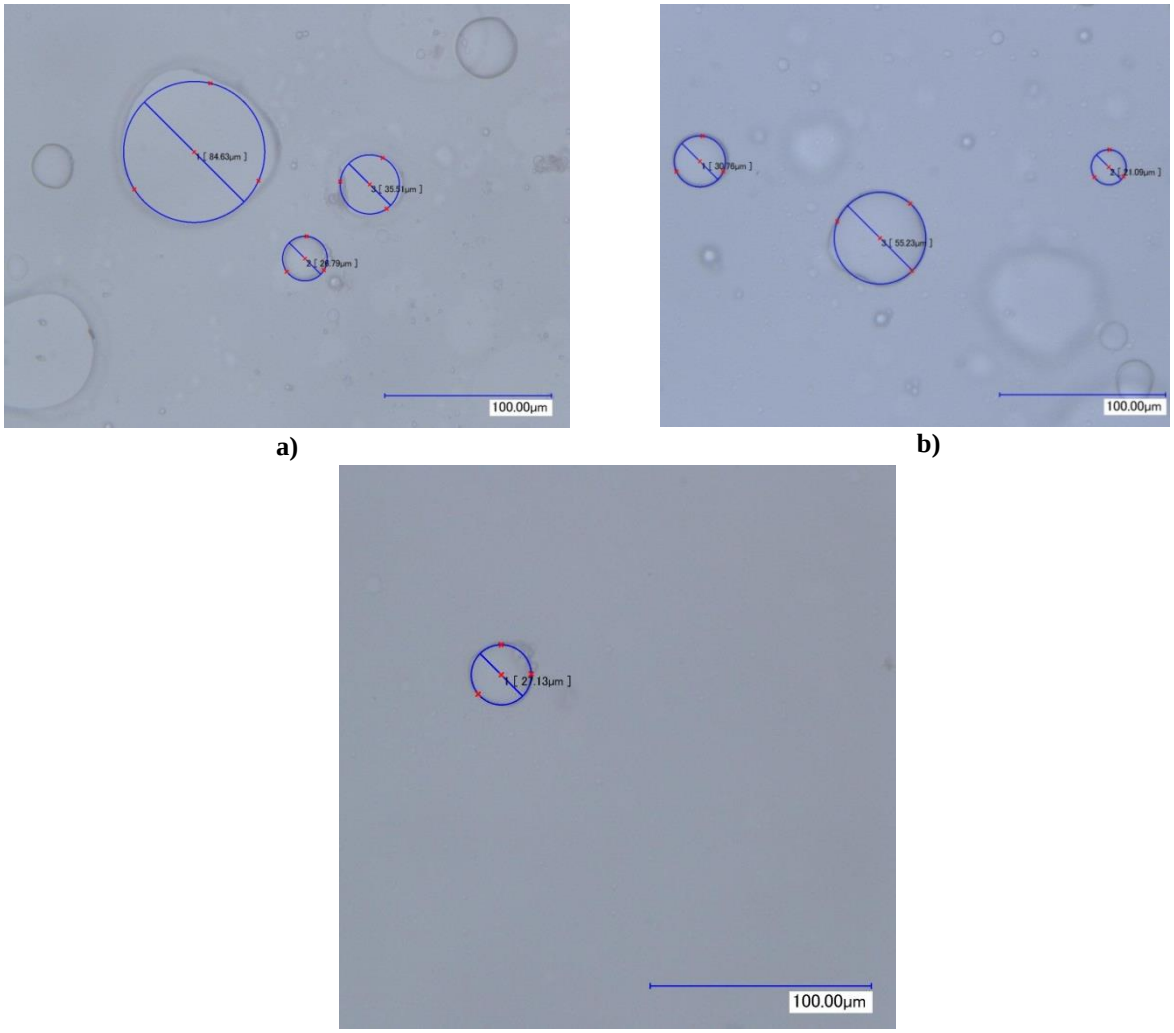


Fig.4Dependence of the oil column height on the time

On the basis of Figure 4 a conclusion may be made that when the water content is 20%-25% the mixture has the highest speed of exfoliation during 120 hours, after 120 hours increment of the oil columnreaches its minimum value, compared to other studied water concentrations. Slowing down the exfoliation when water concentration is like that shown above indicates that the state of the mixture becomes stable and indicates nearly complete termination of further exfoliation, and this is not observed when water concentration is different. When the water concentration is 5%-10%,exfoliation rate decrease does not mean that the stable state is reached, layering continues when the speed is low, and when the water content is 30% and more, the time of reaching stable state has not been fixed, during all the time of observation the exfoliation lasts at low rates.

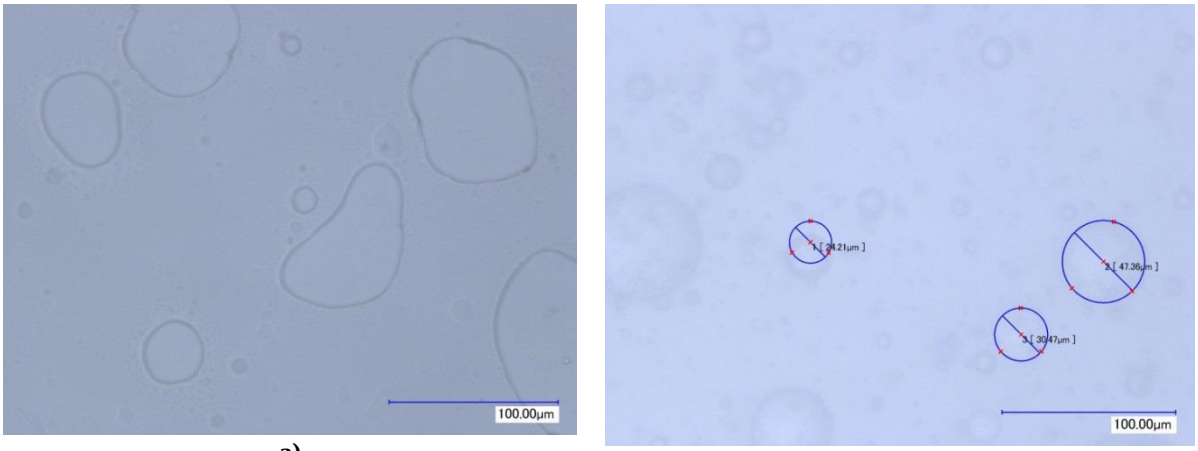
Figures 5 and 6 present mixture samples studies by the microscope enlarged 1000 times.Below there are presented the results of investigating water droplets sizes in oil when water content was 5% and 10% when circulating in the first, second and both loops.



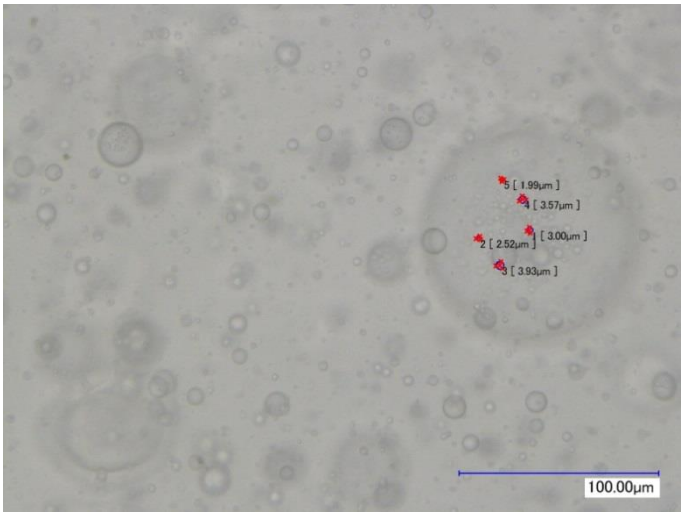
a) b)

c)

Fig.5Water droplets sizes when the water content is 5%: a)the first loop (gear-type pump),b) the second loop (two pumps without cavitationer),в) the third loop (two pumps with cavitationer)



a) b)



c)

Fig.6Sizes of the water droplets in oil when the water content is 10%:a)the first loop (gear-type pump), b) the second loop (two pumps without a cavitationer) в) the third loop (two pumps with a cavitationer)

It may be noted that when the mixture circulates in the whole loop (two pumps with cavitationer) when the water content is 10%, water inclusions in the mixture have much smaller size than during the circulation in other studied loops. In addition to this, when the water content is 10% the water droplets density in the mixture is higher than in case when the water content is 5%. It may be assumed that when the water content is 15% to 25% the water droplets sizes will meet requirements for ВМЭ, and the droplets density will be even higher. Therefore, fuel droplets dispersion in a firebox will be increased and the effects enlisted at the beginning of the paper will be more evident.

3. CONCLUSION

There was designed and developed new original device for producing burning oil of oil wastes. The burning oil is produced as a result of mixing oil industry wastes with water. The device was investigated using model liquids. Oil having diesel fuel viscosity was assumed to be model liquid. Mixture of the model liquid with water was tested for exfoliation. It was determined that when the water content is 15% to 25%the mixture terminates in some time, the mixture becomes stable. When the water content is more than 30%the mixture stable state was not detected, during all the time of the experiment exfoliation continued at low rate. Thereby, evident stable state of the fuel is possible only when the water content is 15% to 25%. In case of other water concentrations the time of the fuel sedimentation during the same time will be unstable.

As a result of investigations it was determined that the best mixing of the model liquid and water is reached when the mixture passes through all units of the equipment being the parts of the system: peripheral pump, gear-type pump and cavitationer (dispersant). The water inclusions size in average is 10 to 13 micron, on that condition that the accepted values of the water inclusions in the water-diesel fuel oil are 15 microns.

At present the system passes operational test at Sudogorsk petroleum storage depot of Vladimir regional administration.

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DEVICE FOR OIL WASTE RECYCLING

Andreev V. V. , Duncev A.V., Orekhova E.E., Utyatnikov A.E.

As it is known, water-diesel fuel mixtures a property to be exfoliated. That is why one more important task was to find out an optimum proportion of the water and oil wastes for obtaining the most stable fuel. Experiments were carried out using different water content in the mixture. As a result of the investigations it was revealed that the mixtures containing 15% to 25% of water are exfoliated most rapidly and reach stable state.