Assessing the Nature of Emulsified Fuels by Rheological Property

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The use of emulsions water- fuel is a way to improve fuel burning, andto decrease the specific fuel consumption, while reducing ambient pollution. Preparation of emulsion fuel was performed in a laboratory installation provided with mechanical agitation. Cationic, anionic and nonionic emulsifiers were used in the preparation of emulsions both pure and mixed. Water content of the fuel emulsion preparations ranged between 5 and 30% wt. and the emulsifier content was 1.5%. The stability of the prepared emulsion was evaluated with Turbiscan Lab apparatus. Rheology behaviour of fuel emulsions prepared was achieved by determining the viscosity at a temperature of 90°C. Viscosity of fuel emulsions prepared with hydrophilic emulsifiers, alone or combined, decreased with increasing water content thereof. Their viscosity variation curve with water content presents a more pronounced slope in the range of concentration of water in that the emulsion reversal occurs.

Keywords: emulsion, fuel, monoglycerides, emulsifier

The data presented in the literature have shown that the use of emulsions water / fuel is a way to improve fuel burning, and secondly, a way of reducing the specific fuel consumption, while reducing ambient pollution. These findings have increased interest in studying the combustion process of fuel emulsifiable [1, 2].

The behavior of emulsions based on oil, heated to boiling point of water has been experimentally studied. It observed that adding water does not change the reaction chemistry and that heating water emulsion - fuel leads to the disappearance of differences between emulsion and fuel switching simple. It was also confirmed that auto-ignition is driven mainly by the way of forming the mixture [3].

Garo and collaborators have shown that sudden vaporization is due to nuclear boiling of water near the interface - fuel. If this phenomenon occurs when burning oil, fuel considered a “multicomponent”, the problem becomes more complicated by the gradual evaporation of volatile light. He studied the influence of volatility of oil and the formation of the emulsion on the combustion characteristics of oil in water dispersion. The parameters studied are burning, the start time of distillation and evaporation rate [4].

The quantity of water recommended in the preparation of the emulsion is 4% -10% by weight. It is preferable to use demineralized or deionized water to avoid the formation of scabs on the surface of the combustion chamber or injector. Emulsion has good stability a certain period of time, generally over three months, without shape aqueous phase inside the storage tank in the field from -20 to 50°C [5].

A first requirement for such fuel emulsions is related to the nature of emulsifiers used, it is recommended the use of emulsifiers to present value index HLB between 4 and 13, preferably between 4 and 8. The concentration of emulsifiers should be between 0.1 and 4%, preferably between 1 and 2.5%. There are recommend for use cheap emulsifiers, such as the non-ionic. This favorite polymer, water-resistant component is a carbohydrate chain and the hydrophilic component consists of poly-oxy-alkylen units. You can also use emulsifiers type of fatty acid partial esters with polyhydric alcohols [6].

In order to achieve the optimal combustion of emulsions in water - fuel, it is necessary to determine the characteristics that they must have, and technological conditions of their use. The main issues to be considered are: the stability of emulsions, the optimum allocation of water droplet size and behaviour of emulsions in terms of rheology. These characteristics depend on the conditions of preparation of emulsions, of which the most important are: the mixing conditions, the nature and content of surfactant and water content of emulsions. It is very important to determine how the variables mentioned above affect the characteristics of emulsions and their behavior. The parameters mentioned above have a particularly important rheological behavior of emulsions.

Experimental part

Experimental program aimed at the preparation and characterization of emulsion fuels. Raw material used in the preparation of fuels has been a fuel derived from refining heavy outbreaks Petrobrazi, whose characteristics are presented in table 1 and three types of emulsifiers (a cationic emulsifier, an ionic emulsifier and an anionic emulsifier).

Aminoethyl imidazoline tall oil (noted EC) is the cationic emulsifier. Its characteristics are presented in table 2.

Nonionic emulsifiers, noted EN, contains mono and diglycerides of fatty acids, and were prepared by esterification of fatty acids obtained by neutralization of soapstock resulting in the refining of edible oils, with glycerol [7].

Anionic emulsifier selected is lauryl ether-sulfate sodium (dioxietilen-dodecyl-ether-sodium sulfate), noted EA, a compound whose surfactant activity is determined by anionic sulfate group and by nonionic dioxietilen group. The structure of this emulsifier it recommend as effective

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Table 1
PHYSICAL CHARACTERISTICS OF HEAVY FUEL

No.	Characteristic	Value
1.	Density at 20 °C, kg/m^3	1,0253
2.	Mineral acidity	absence
3.	Water, %gr.	0.2
4.	Pour Point, °C	-5,7
5.	Point of inflammation, °C	220
6.	Viscosity at 90°C, °E ,	41,55
7.	Water and sediment, % wt.	1.4
8.	Calorific value, kcal/kg	9628

Table 2
PHYSICAL CHARACTERISTICS OF AMINOETHYL IMIDAZOLINE TALL OIL, EC

No.	Characteristic	Value
1.	Density at 20°C, kg/m^3	0.93
2.	Alcaline Value, ml HCl 0.1 N/g	39.96
3.	pH	12.01

Table 3
PHYSICAL CHARACTERISTICS OF ESTERIFIED OLEIN, EN

No.	Characteristic	Value
1.	Acid value, mg KOH / g	38,6
2.	Saponification index, mg KOH / g	182,3
3.	Hydroxyl value, mg KOH/g	254,1

Table 4
PHYSICAL CHARACTERISTICS OF LAURYL ETHER-SULFATE SODIUM

No.	Characteristic	Value
1.	Density at 20°C, kg/m^3	1.11
2.	pH (10% in water)	7.8
3.	Active matter, %	73.0

emulsifier in basic medium, but also as a co-surfactant for neutral or acid environment.

Conditioning of cationic emulsifiers was achieved by dispersing the emulsifier in the aqueous phase *p*H value of 2.5 with a mineral acid.

Emulsifying equipment

Preparation of emulsion fuel was performed in a laboratory installation provided with mechanical agitation. Emulsifying process took place in an autoclave with possibility of programming and maintaining the temperature, fitted with variable speed stirrer. Emulsifying temperature was 50°C at a stirrer speed of 1800 rpm for a duration of 30 min. Water content of the fuel emulsion preparations ranged between 5 and 30% wt. and the emulsifier content was 1.5%.

Emulsifiers were used in the preparation of emulsions both pure and mixed; when used as emulsifiers blends they contain:

- cationic emulsifiers EC and anionic emulsifiers EA at a rate of 2 / 1 (emulsifier E1), at a rate of 1 / 1 (emulsifier E2), and at a rate of 1 / 2 (emulsifier E3);
- cationic emulsifiers EC and nonionic emulsifiers EN in the ratio of 1 / 2 (emulsifier E4) and at a rate of 1 / 1 (emulsifier E5);

The stability of the prepared emulsion was evaluated with Turbiscan Lab apparatus. Characterization in terms of rheology of fuel emulsions prepared was achieved by determining the viscosity at a temperature of 90°C with a Engler viscosimeter.

Emulsion type rating has been achieved by comparing its viscosity with viscosity non-emulsified fuel. So, for direct emulsion, viscosity is less than their non-emulsified fuel but higher that water, while in the case of inverse emulsion viscosity is higher than their non-emulsified fuel.

Results and discussion

All emulsions prepared were stable. Stability curve for a duration of 50 min. for these emulsions was similar, as shown in figure 1.

Apparatus

Variation of viscosity of emulsion fuel with water content in case of using cationic emulsifiers (emulsifiers EC) is shown in figure 2. From that figure is seen that at concentrations of less than about 17% water, their viscosity is higher than for non-emulsified fuel and decreases slowly. In the field of concentrations range between 17-25% fuel emulsion viscosity decreases sharply with increasing water content and at concentrations above 25% tends to be stabilizing.

Variation of viscosity emulsion fuel with water content, when used as emulsifiers mixture of EC and EA at a mass ratio 2:1, is shown in figure 3. Note that if using this blend of emulsifiers, the curve of variation of viscosity with water content is similar to that in the case of emulsion based on emulsifiers EC.

The same behaviour occurs in fuel emulsions prepared with the mixture of emulsifiers at concentrations equal to EC and EA. Field of viscosity variation on the same field of concentration of water is close to that in the case of emulsions prepared with the two emulsifiers described above. Variation of viscosity with water content in the case of using mixture of emulsifiers EC and EA at a rate echimasic, is shown in figure 4.

Elevated concentration of emulsifier EA and reduced concentration of emulsifiers EC (mass ratio EC / EA: 1/2),

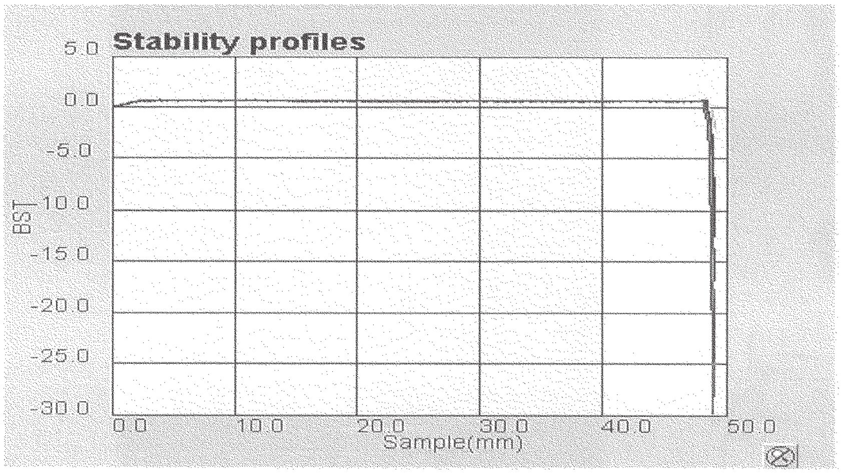

Fig. 1. Profile of stability of emulsions prepared determined by Turbiscan Lab

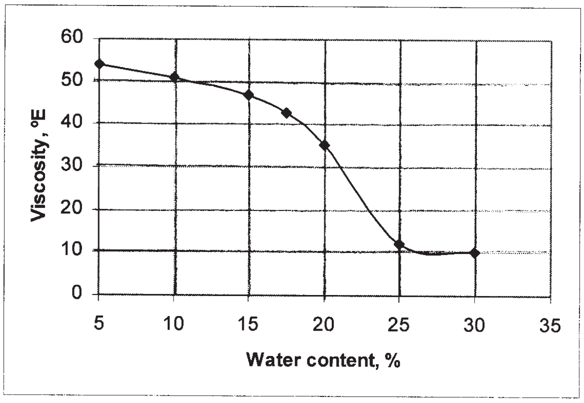

Fig. 2. Variation of viscosity of fuel emulsions with water content in the presence of emulsifier EC

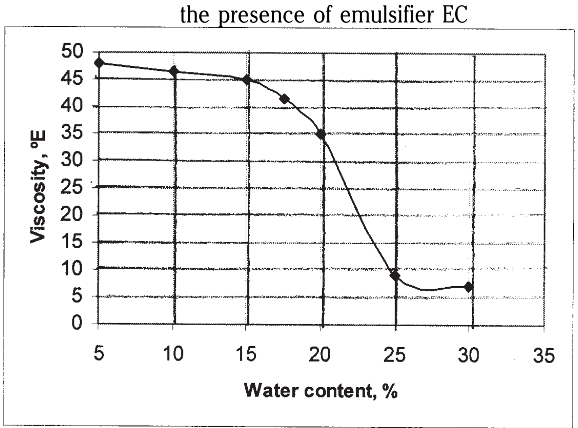

Fig. 3. Variation of viscosity of fuel emulsions with water content in the mixture of emulsifiers EC / EA at a rate of 2/1

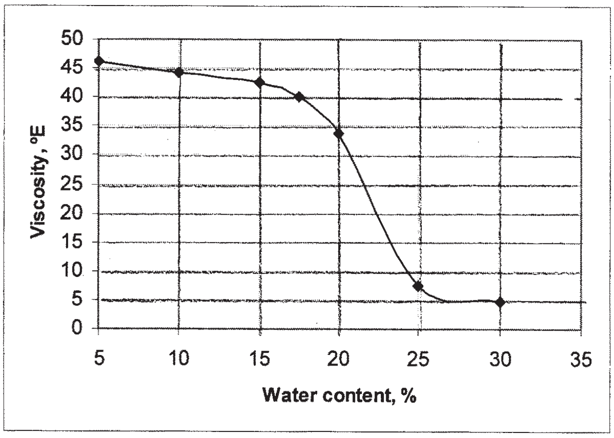

Fig. 4. Variation of viscosity of fuel emulsions with water content in the mixture of emulsifiers EC / EA at a rate of 1 / 1

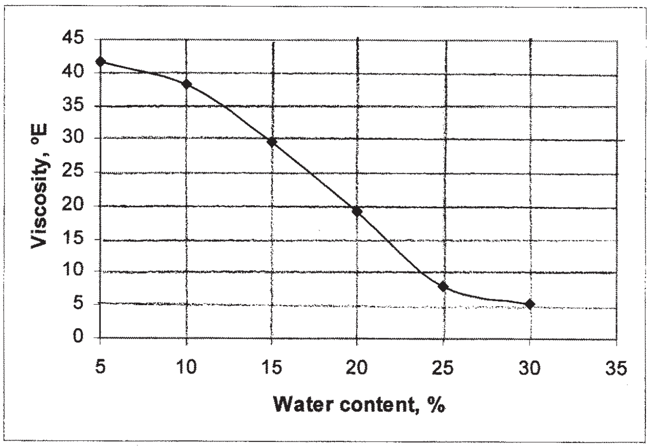

Fig. 5. Variation of viscosity of fuel emulsions with water content in the mixture of emulsifiers EC / EA at a rate of 1 / 2

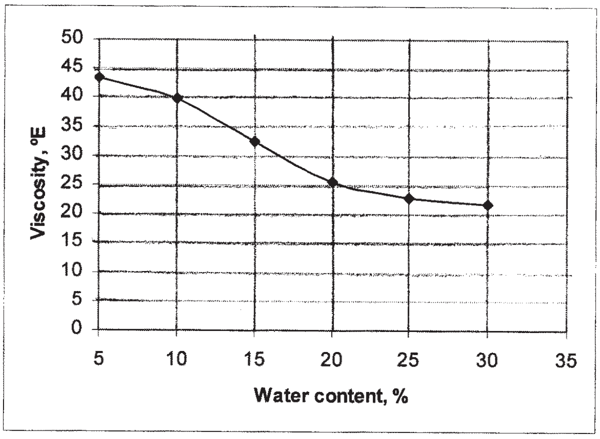

Fig. 6. Variation of viscosity of fuel emulsions with water content in the presence of emulsifier EA

generate a similar variation of emulsion viscosity fuel with water content; the slope of variation of emulsion viscosity is slower when compared to previous emulsifiers. Variation of viscosity with water content in case of using this mixture of emulsifiers is shown in figure 5.

If emulsions are prepared with EA emulsifier, viscosity decreases with increasing water content. The field of variation of viscosity and curve slope values variation are lower than in the earlier case of emulsions. The variation of viscosity with water content in the case of using emulsifiers is presented in figure 6.

The variation of viscosity with water content in the case of using mixture of emulsifiers EC and EN at a rate of 1/2 is shown in figure 7.

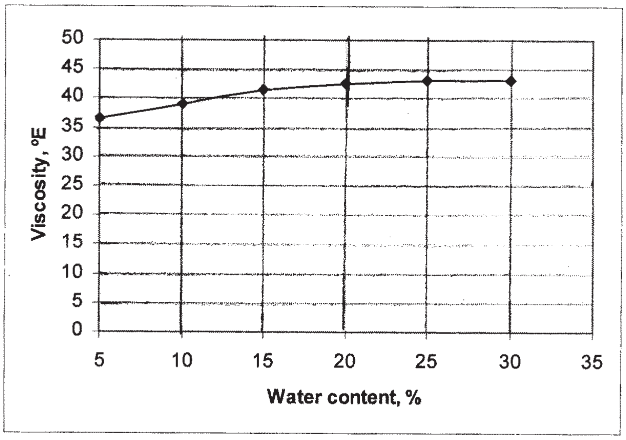

Fig. 7. Variation of viscosity of fuel emulsions with water content in the mixture of emulsifiers EC / EN at a rate of 1 / 2

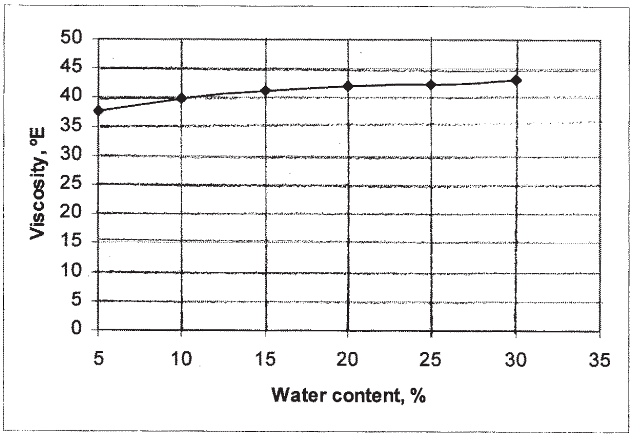

Fig. 8. Variation of viscosity of fuel emulsions with water content in the mixture of emulsifiers EC / EN at a rate of 1 / 1

In the case of emulsions prepared with the mixture of emulsifiers EC and EN at a rate of 1 / 2, viscosity increases with increasing water content. The slope of the curve has values decreased with increasing moisture content of the emulsion.

The emulsion mixture of emulsifiers based on EC and EN at equal concentrations, presents a variation of viscosity with temperature similar to that in which the concentration of two emulsifiers differs. The field variation of emulsion viscosity is similar to the previous case. The variation of viscosity with water content in case of using this emulsifier is shown in figure 8.

Fuel emulsions prepared with mono and diglycerides of fatty emulsifier EN, show an increase in viscosity with water content; growth occurs at a much higher slope than in the case of using this emulsifier mixed with EC emulsifier. The field variation of the viscosity of the emulsion is much higher than in the case of emulsions containing non-ionic emulsifier blend with cationic emulsifiers EC. The variation of viscosity with water content in the case of using emulsifiers EN is shown in figure 9.

Conclusions

The comparison of the fuel emulsion viscosity with non-emulsified fuel, is an efficient and fast criteria for identifying the type of emulsion fuel in case of emulsions on the basis

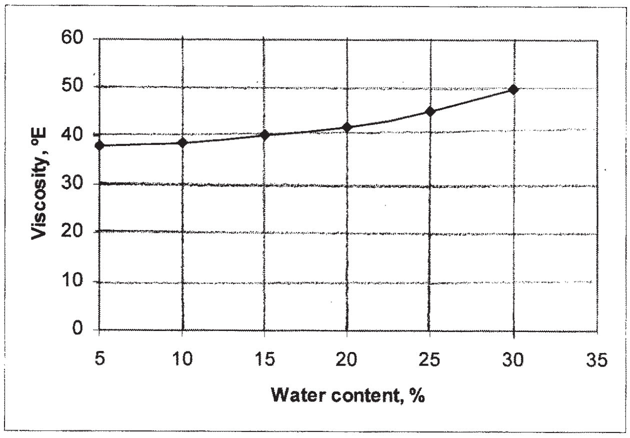

Fig. 9. Variation of viscosity of fuel emulsions with water content in the presence of emulsifier EN

of hydrophilic emulsifiers; so, fuel inverse emulsion viscosity is greater than that of non-emulsified fuel and fuel direct emulsions viscosity is lower than that of non-emulsified fuel.

Viscosity fuel emulsions prepared with hydrophilic emulsifiers, alone or combined, decreased with increasing water content thereof. Their viscosity variation curve with water content presents a more pronounced slope in the range of concentration of water in that the emulsion reversal occurs.

Viscosity fuel emulsions prepared with hydrophobic emulsifiers type mono and diglycerides, individually or in combination with hydrophilic emulsifiers, increases with increasing water content in the area of the water concentration studied. Their viscosity variation curve with water content show a slope of less variation than in those prepared with hydrophilic emulsifiers.

Report phases is an important factor in determining the type of emulsion. Thus, for a low water content, fuel emulsions on hydrophilic emulsifiers are usually the type water in oil. Different behavior of emulsions based hydrophobic emulsifiers, type mono-glycerides, or which contain such emulsifiers, can be explained by the tend to form microemulsions due to their high capacity of solubility the organic phase.

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