TEMPERATURE INFLUENCE ON PHASE STABILITY OF ETHANOL-GASOLINE MIXTURES

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Abstract. The article investigates phase stability of ethanol-gasoline mixtures depending on their composition, water concentration in ethanol and ethanol-gasoline mixture and temperature. There have been determined the perfect functioning conditions of spark ignition engines fueled with ethanol-gasoline mixtures.

Keywords: composition, ethanol, gasoline, mixtures, phase stability, temperature.

Introduction

Researches on phase stability of monoatomic alcohol-gasoline mixtures for different compositions and hydrodynamic conditions were performed previously [1] at constant temperature (18 ... 20° C). In connection with the fact that the smallest capacities of phase stability among studied fuels have been demonstrated by ethanol-gasoline mixtures with ethanol volume fraction up to 50% (E10...E50), the purpose of our research is to study the phase stability of ethanol-gasoline mixtures depending on temperature, water concentration in ethanol and in ethanol-gasoline mixture.

Methodology of experimental researches

For our researches we used ethanol C_2H_5OH (volume fraction of absolute alcohol - 97.0 ... 99.9%) and Regular gasoline-80 with low octane number (LON ≥ 80). In order to research phase stability there were prepared fuel samples, each one having a volume of 100 ml 0.5 ml of water was added to each sample until the appearance of liquid turbidity.

Admissible water concentration for each experiment was determined based on the existing volume of added water and the one existing in ethanol at initial time.

The point of turbidity was assessed according to the existing standard norm GOST5066-91. Based on a bibliographical research [2,3,4,5] it was established that the decrease in temperature increases the danger of phase separation in fuel mixtures. Therefore we studied the range of temperatures below + 18 ºC.

Results and discussions

The obtained results (Fig. 1, 2) confirmed previous results. A drop in temperature from 18 °C to 0 °C reduces the admissible water concentration in ethanol from 6% vol. to 4% vol. in the mixture E10 and from 14.3% vol. to 11.5% vol. in the mixture E70 (Fig. 1). In other mixtures (E20...E50), under mentioned conditions, the reduction of admissible water concentration in ethanol was on average by 2% vol.

It should be mentioned that exceeded admissible water concentration results in liquid turbidity and subsequent separation of phases. The increase of ethanol fraction in the mixture from 10% vol. to 70% vol. enables the dissolution of larger quantities of water. For example, at the temperature 18°C, the admissible water concentration in ethanol is 6% vol. for the mixture E10, and 14.3% vol. for the mixture E70.

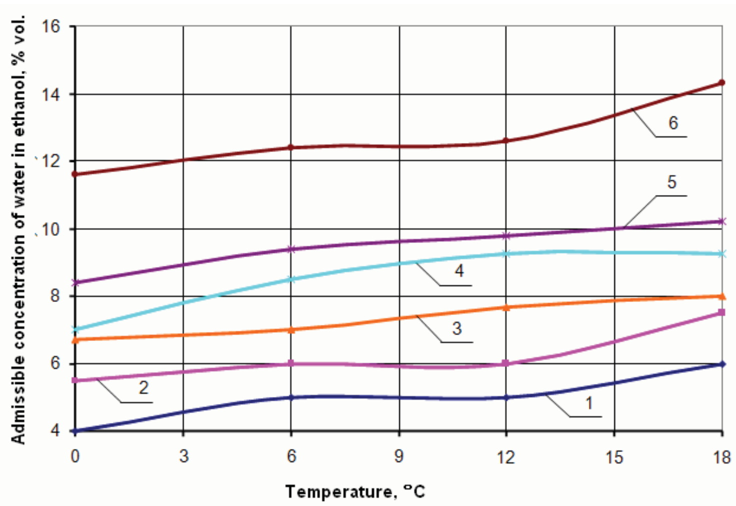

Fig. 1. Dependence of admissible water concentration on the liquide temperature for ethanol – gasoline mixture (1 – 10%; 2 – 20%; 3 – 30%; 4 – 40%; 5 – 50%;6 – 70% vol. ethanol)

After the distillation and rectification, different fractions of ethylic alcohol contain 93 ... 96.6% vol. of absolute alcohol (respectively 7 ... 3.4% vol. of water). Therefore, according to the results of our investigations, the ethanol obtained in these conditions can be used for direct preparation of gasoline mixtures at temperatures above 0° C, if the fraction of ethanol in the mixture exceeds 30% vol. (≥ E 30) (Figure 1.). Otherwise ($C_{ethanol}$ < 30% vol.) it is necessary an additional dehydration of ethanol.

The values of admissible water concentration in ethanol-gasoline mixtures at temperature changements in the range of 0 ... 18 ° C (Fig. 2) vary little: in the mixture E10 - 0.4 ... 0.7% vol. (ΔC = 0.3% vol.), in the mixture E70 - 7.6 ... 9.3% vol. (ΔC = 1.7% vol.). The variation of admissible water concentration in other mixtures (E20...E50) takes intermediate values. It can be noticed the tendency for variation increase of admissible water concentration ΔC along with the increase of ethanol fraction in the mixture from 10% vol. to 70% vol.

Researches results concerning the influence of liquid temperature on the values of admissible water concentration in ethanol and ethanol - gasoline mixtures are necessary in particular for the practical use in preparing and operating these mixtures.

No less important is the dependence of admissible water concentration on the ethanol fraction in the mixture with gasoline. The obtained results demonstrated (Fig. 3) that the increase of ethanol fraction in the mixture from 0 to 90% vol., when changing the values of admissible water concentration, allow to observe four characteristic sectors:

a) Ethanol concentration 0...10% vol.: the gradient of admissible water concentration change is ΔC_{adm}=0,5 % vol./% vol. ethanol;

b) C_{ethan}=10…60 %vol. : ΔC_{adm} =0,11 %vol./% vol. ethanol;

c) C_{ethan}=60…80 %vol. : ΔC_{adm} = 0,3%vol./% vol. ethanol;

d) C_{ethan}=80…90 %vol. : ΔC_{adm} =1,2%vol./%vol. ethanol.

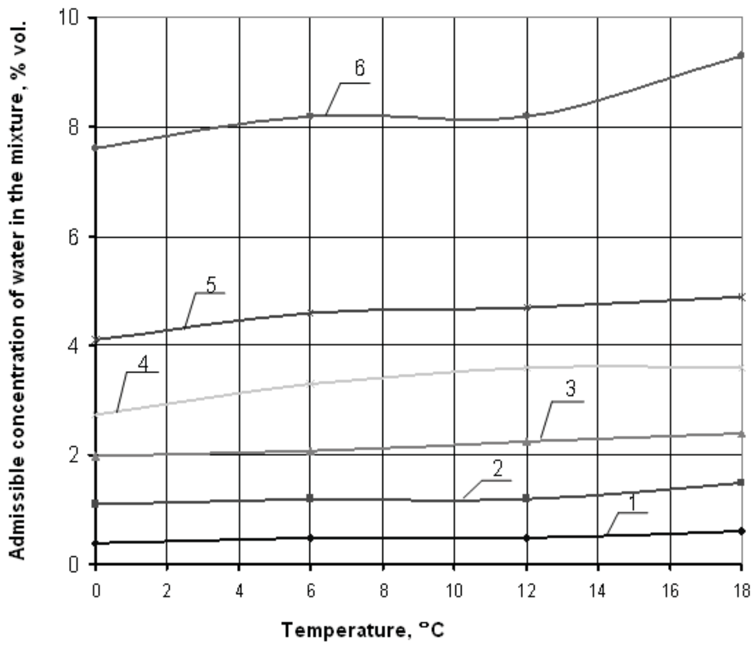

Fig. 2. Dependence of admissible water concentration on the liquide temperature, for ethanol – gasoline mixture (1 – 10%; 2 – 20%; 3 – 30%; 4 – 40%; 5 – 50%; 6 – 70% vol. de etanol)

It is well known that with the increase of ethanol concentration in the mixture with gasoline up to 100%, water solvency in ethanol increases to infinity. Therefore, the domain a) reflects the transition from pure gasoline (C ethanol = 0) to ethanol-gasoline mixture (C ethanol = 10%/vol.), where the influence of ethanol begins absorbing some water (C adm = 5% /vol.) without phases separation. The domain b) shows the influence of ethanol, which increases proportionally and slowly. The domain c) constitutes, as mentioned recently [1], a transition area to the mixtures in which ethanol influence is predominant (sector d).

The use of alimentary alcohol and ether-aldehyde fraction did not essentially change the values of admissible water concentration in ethanol (Fig. 3).

The analysis of research results concerning phase stability in ethanol-gasoline mixtures [1] and admissible water concentration in ethanol (Fig. 3) shows a good concordance.

Taking into account the fact that 5 ml of water were added in the ethanol-gasoline mixture with a volume of 100 ml and the fraction of absolute alcohol in ethanol of 98% vol., we will calculate the real water concentration in ethanol from these mixtures (Table 1). At the same time for the analysis we'll use the values of admissible water concentration in ethanol, determined based on our research (Fig. 3).

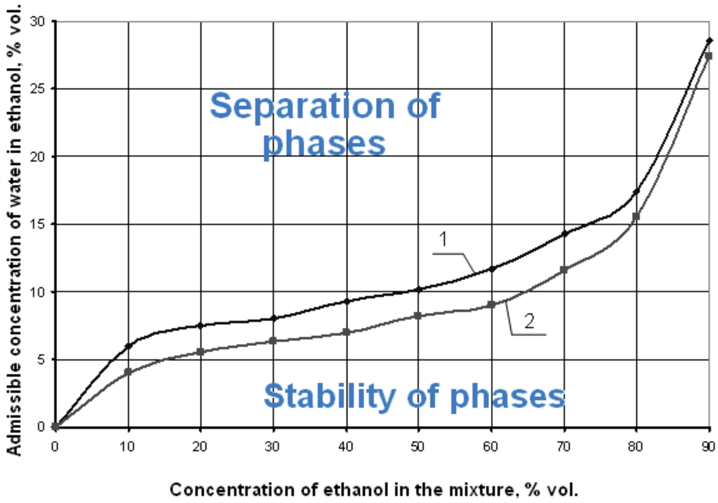

Fig. 3. Dependence of admissible water concentration in the ethanol with gasoline mixture (1 – alimentary; 2 – etero fraction – aldehyde)

When real water concentration in ethanol is higher than the admissible one (mixtures E10 ... E40), is can be clearly observed phases separation with and without agitation. The mixtures E50 and E60, under studied conditions, and as mentioned recently, are in the transition area. Water addition (5ml) in these mixtures without agitation leads to phase separation. Intensive agitation during 20 min stimulates the formation of a transparent and homogeneous liquid in the mixture E60 (Table 1, [1]). Real water concentration in ethanol in the mixture E85 (7.4% vol.) is much smaller than the admissible one (22.5% vol.), and as a result of water addition, the mixture E85 instantly clears for all the studied conditions.

Table 1

Values of real and admissible water concentration in ethanol for different mixtures (t = 18°C)

	Ethanol-gasoline mixtures							
Indicator	E10	E20	E30	E40	E50	E60	E70	E80
1.Real water concentration in ethanol, %vol. [1]	34,7	21,6	16,0	12,9	10,9	9,5	8,5	7,4
2.Admissible water concentration in ethanol, %vol. (fig.3)	5,0	6,5	7,2	8,1	9,2	10,4	13	22,5

Mixtures with high ethanol fraction (E85) are distinguished by increased phase stability, but these mixtures require the change of engine's fuel construction system [2 ... 5]. It was also established [5,6] that the use of ethanol-gasoline mixtures with ethanol fraction up to 30% vol. doesn't require the modification of engine construction, but put stringent requirements concerning admissible water concentration in ethanol. Therefore, for the mixtures E10 and E20, we studied additionally the reaction at low temperatures (down to - 55 ° C).

Although among the results obtained in the two stages mentioned above there are some discrepancies, the study of turbidity temperature dependence of ethanol-gasoline mixtures on the absolute alcohol fraction in ethanol (Fig. 4) demonstrates the same tendencies: at similar temperatures the admissible water concentration is higher in the mixture E20 (compared to E10), and the decrease of turbidity temperature when decreasing water concentration or increasing absolute alcohol concentration in ethanol.

In order to ensure the perfect operation of the engine at temperatures up to -30° C, the mixture E20 should contain water no more than 1.6% vol. (98.4% vol. a.a.) and the mixture E10 - respectively 1.1% vol. of H_2O (98.9% vol. a.a.). For the temperature up to - 20°C, the values of admissible water concentrations increased: in the mixture E20 - up to 2.2% vol., and in the mixture E10 - up to 1.5% vol.

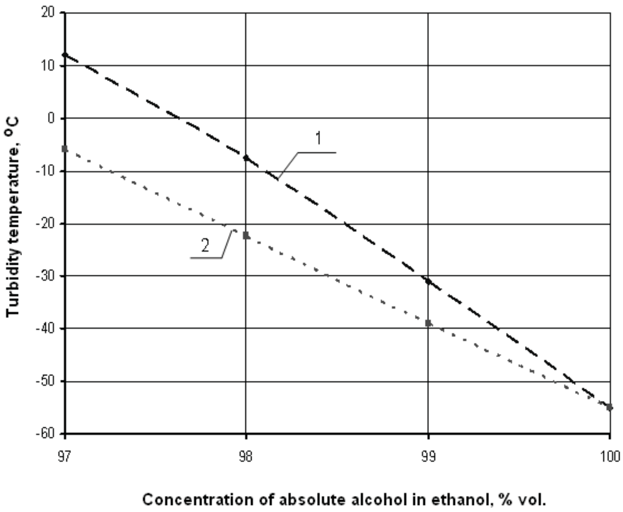

Fig. 4. Dependence of turbidity temperature of ethanol-gasoline mixtures on absolute alcohol concentration in ethanol

Therefore, the obtained results demonstrate that for the existing conditions in the Republic of Moldova, the most efficient solution is to use the mixtures E20 for fuel spark ignition engines. This fact will allow:

- ✓ the use of existing engines without their design modification;
- ✓ perfect operation of the engine having biofuel phase stability at the required level in temperature range up to -20 ...- 30 ° C and water concentration in ethanol less than 2.2...1.6% vol.
- ✓ to reduce the danger of phase separation by shaking the biofuels.

Conclusions

1. The admissible water concentration in ethanol (ethanol-gasoline mixture) depends on biofuel composition and temperature. Temperature increase in the range of 0...+18ºC and ethanol concentration in the mixture allow an increase of admissible water concentration values.

2. The ethanol obtained by distillation and rectification with the help of existing machinery in the Republic of Moldova can be used to prepare directly gasoline mixtures at temperatures above 0°C, if ethanol fraction in the mixture exceeds 30% vol. Otherwise, (at temperatures below 0ºC and C (ethanol) <30% vol.) it is required an additional ethanol dehydration.

3. The change of ethanol fraction in the mixture with gasoline from 0 to 90% vol. allows (t=18°C) to increase admissible water concentration in ethanol from 0 to 28% vol., and to notice four characteristic domains in the gradient of admissible water concentration increase.

4. The use of alimentary alcohol and ether-aldehyde fraction did not essentially change the values of admissible water concentration in ethanol in the mixture with gasoline.

5. In order to ensure the perfect operation of the engine at temperatures up to -30 ° C, the mixture E20 should contain water no more than 1.6% vol. (98.4% vol. a.a.) and the mixture E10 respectively - 1.1% vol. of H_2O (98.9% vol. a.a.). For the temperature up to - 20 ° C, the values of admissible water concentrations increased: in the mixture E20 - up to 2.2% vol. and in the mixture E10 - up to 1.5% vol.

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