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EXPRESS METHOD FOR QUANTITATIVE WATER DETECTION IN AVIATION FUEL

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It was determined that the temperature and amount of water in aviation fuel affect the nature and process of cavitation. The values of cavitation threshold as a function of temperature of the fuel TS-1 were obtained at different amount of water

Objectives. Water in the tanks of aircraft can occur in a free and dissolved state. In jet fuel, free water exists as a separate liquid phase. Water can occur in different forms in jet fuel – as a separate layer on the bottom of the tank (bottom water), in the form of suspended droplets (emulsion) and in solid form (snow crystals). It is considered that the water dissolved in the fuel exists in the form of individual molecules and that it does not enter into any chemical bonding. Some of the water dissolved in the fuel can separate as free water and water-fuel emulsion under certain conditions.

Water in the fuel may cause corrosion of the fuel system elements. Thus, water is the reason of iron hydroxide flakes formation in the fuel. The presence of water emulsion in the fuel leads to increase in hydraulic resistance of filters. This process does not depend on properties of filtration materials (hydrophobic or hydrophilic properties).

Free or non-dissolved water in fuel turns into ice crystals and bottom water in the tank is frozen as the low temperature operating conditions. Ice crystals can build up on filters, restricting flow and compromising performance.

The technique of purity determination for aviation fuel and lubricate materials (FLM) is based on use of fuel quality indicator (FQI). FQI changes while sample of FLM runs through it [1]. Change of indicator is the base for detection of free water in aviation FLM. ПОЗ-Т (device for fuel contamination determination) is a device used for performance of above-mentioned experiment. Its action is based on filtration of fuel sample through the two-layer indicator element which is made of analytical porous tape НЭЛ-4. One layer of the indicator element is saturated by Iron (III) chloride (also called ferric chloride), the other one by Potassium Hexacyanoferrate (II) (also known as yellow prussiate of potash) and Potassium Hexacyanoferrate (III). The ПОЗ-Т has sample application syringe (volume is 50 ml) with clamping device for indicator element. The fuel sample is inhausted by the syringe through the calibrated orifices. The first layer of indicator element (it is white) catches mechanical impurities, and dark spots may appear on it. The blue spots appear on the other layer (it is yellow) if emulsion water is in the fuel. The conclusion about amount of admixtures is subjected to coloring power of spots.

FQI reacts if the mass of free water is in the range 0,001-0,003 %. It corresponds to the fuel purity standard in civil aviation.

Method for quantitative water detection in mineral oil (in compliance with ГОСТ 8287-57, ГОСТ 7822-75) is based on interaction of Calcium hydride with water in the fuel, and amount of hydrogen isolated during this reaction: $CH_2 + 2H_2O = Ca(OH)_2 + 2H_2$. The water amount which is dissolved in mineral oil is determined depending on amount of isolated hydrogen.

Amount of condensed water is calculated by the formula:

$$c = \left(\frac{V\text{c}_{mo}}{M} \right) 100\%$$

where c_{mo} – density of the mineral oil $\frac{\text{g}}{\text{cm}^3}$; M – mass of mineral oil sample, g – [2–3].

The described method is made in laboratory, and it takes long period of time. That is why the topical problem is preparation of express methods for quantitative water detection in aviation fuel.

The purpose of the work is to determine the total amount of water in the fuel by use of hydrodynamic cavitation phenomenon.

Experiment. Experimental installation was designed for determination of cavitation threshold pressure as a function of temperature at different amount of water [4]. The general view and scheme of the installation is shown on fig. 1 and 2.

Volume type pump *1* is a source of pressure. The pressure at the inlet and outlet of the nozzle *10* is controlled by throttles *11* and *9* and supervised by manometers *6* and *8*. Pressure in the compressed part of the nozzle *10* is measured by mercury pressure and vacuum gauge *7*. The tank *2* is filled up with sample of FLM. Thermometer *3* is used to control the temperature of FLM. There is the refrigerator *5* for sample cooling. Pressure and vacuum gauge *4* is used to control the pressure inside the tank *2*. Thermometer 3 is the vessel that is filled up with toluene; manometer is the indicator. Toluene is readily soluble fluid. Pressure is changed as a function of toluene volume [5].

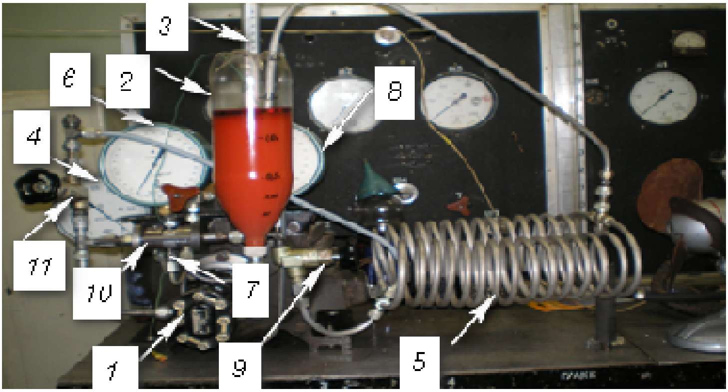

Fig. 1. Installation for determination of cavitation threshold pressure of the aviation fuel (general view)

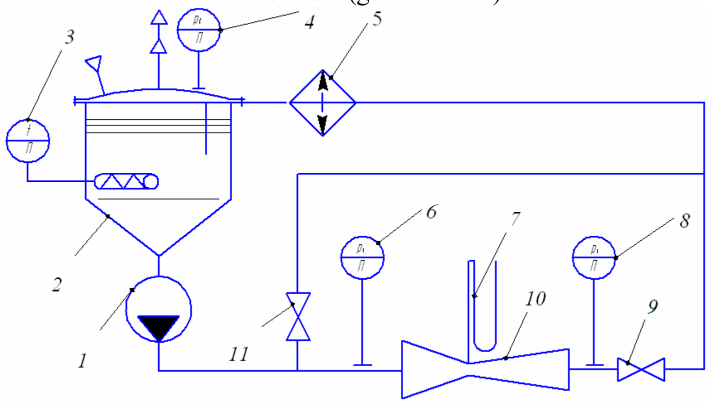

Fig. 2. Scheme of the installation for determination of cavitation threshold pressure of mineral oil:*1* – gear pump; *2* – tank; *3* – thermometer; *4* – standard pressure and vacuum gauge; *5* – refregerator; *6* – standard manometers (ГОСТ 6521-53); *7* – mercury pressure and vacuum gauge; *9*, *11* – needlelike throttles; *10* –nozzle

Calculation. Samples of fuel TS-1 were used to perform experiment that is described above. The results are tabulated (table 1–4 and fig. 3 [curves *1*–*4*]). p_{in}, p_{out}, p_{atm}, p_c are measured in kPa. Cavitation threshold pressure as a function of temperature of the fuel TS-1 is shown in fig. 3 (curve *5*).

Table 1

Fuel TS-1, $W = 2$ l, water – 0 %

№	p_{in}	p_{out}	T, K	p_{atm}	p_c
1	540	300	298	98,26	6,94
2	520	300	303	98,26	7,44
3	500	300	308	98,26	7,94
4	490	300	313	98,26	8,63
5	480	300	318	98,26	9,13
6	470	300	323	98,26	9,62

Table 2

Fuel TS-1, $W = 2$ l, water – 0,5 %

№	p_{in}	p_{out}	T, K	p_{atm}	p_c
1	540	300	298	99,33	7,25
2	520	300	303	99,33	7,44
3	500	300	308	99,33	8,31
4	490	300	313	99,33	9,00
5	480	300	318	99,33	9,60
6	470	300	323	99,33	10,61

Table 3

Fuel TS-1, $W = 2$ l, water – 1 %

№	p_{in}	p_{out}	T, K	p_{atm}	p_c
1	540	300	298	100,10	6,21
2	520	300	303	100,10	6,51
3	500	300	308	100,10	6,81
4	490	300	313	100,10	7,31
5	470	300	318	100,10	8,41
6	460	300	323	100,10	10,22

Table 4

Fuel TS-1, $W = 2$ l, water – 3 %

№	p_{in}	p_{out}	T, K	p_{atm}	p_c
1	550	300	298	99,75	6,00
2	540	300	303	99,75	6,31
3	520	300	308	99,75	6,50
4	500	300	313	99,75	6,70
5	480	300	318	99,75	8,00
6	460	300	323	99,75	9,63

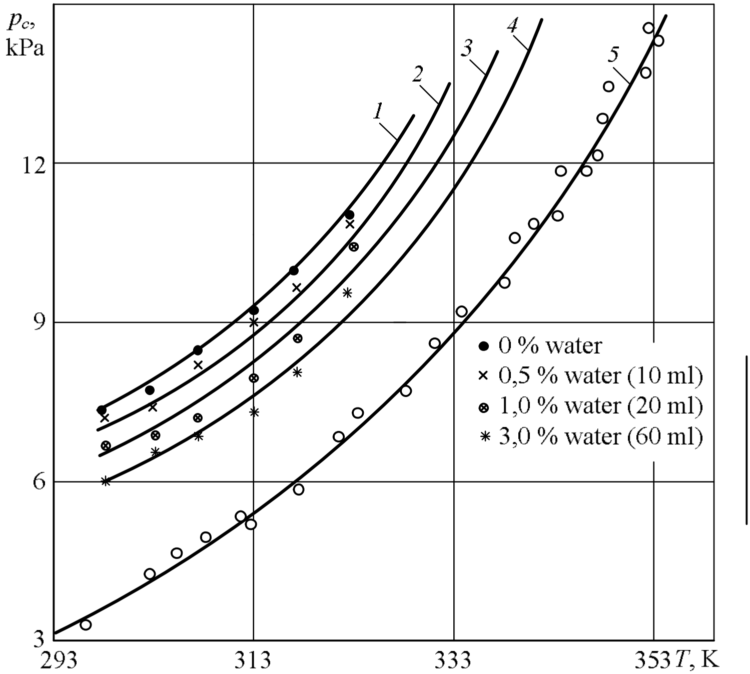

Fig. 3. Cavitation threshold as a function of temperature of the fuel TS-1
1 – amount of water 3,0 %; *2* – amount of water 1,0 %; *3* – amount of water 0,5 %; *4* – fuel without water; *5* – TS-1 in delivery.

Fig. 3 shows that presence of water in aviation fuel results in increase of cavitation threshold pressure; also cavitation threshold pressure is a function of temperature.

Fig. 4 shows the cavitation threshold p_{ct} as a function of water amount (%) in the fuel TS-1 at different temperature. If the cavitation threshold and temperature of the fuel is known, the amount of water in fuel can be determined by the diagram. If cavitation threshold equals to 7 kPa and fuel temperature 313 K, the water amount will be 1,29 %; 293 K – 1,7 % [6–7].

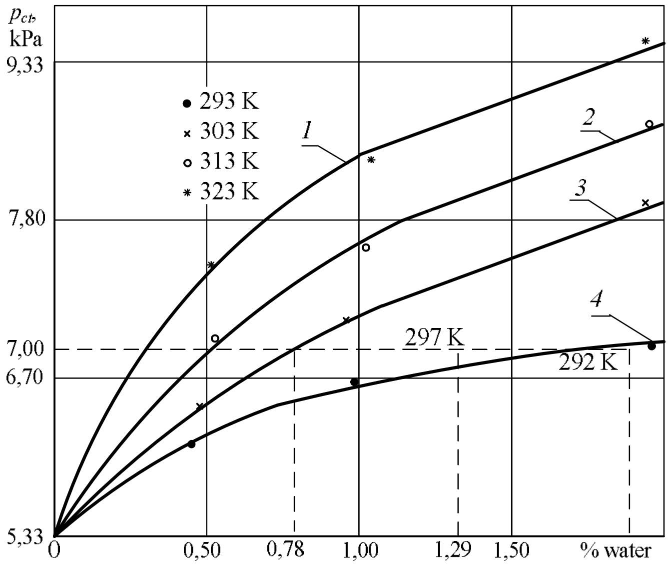

Fig. 4. Cavitation threshold as a function of water amount (%) in the fuel TS-1: *1* – curve (temperature is 323 K); *2* – curve (temperature is 313 K); *3* – curve (temperature is 303 K); *4* – curve (temperature is 293 K)

Conclusion:

1. Express method for quantitative water detection in aviation fuel was experimentally substantiated. This method is based on dependence of cavitation threshold pressure on amount of water in aviation fuel. Originality is confirmed by Ukrainian patent on useful model.

2. Recommendations on experimental determination of water amount in aviation fuel by numerical value of cavitation threshold are theoretically substantiated. It is necessary to graph dependence of cavitation threshold on amount of water in aviation fuel (experimental data should be used) in order to use this technique.

3. Cavitation mixing of water in the fuel TS-1 changes the color of the fuel.

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Глазков М.М., Ланецький В.Г., Пузік О.С., Хлєбнікова В.В. **Експрес спосіб кількісного виявлення води в авіаційному паливі //** Проблеми тертя та зношування: наук.-техн. зб. – К.: НАУ, 2011. – Вип. 56. –С.265–271.

З'ясовано, що температура і кількість води у авіапаливі впливають на характер виникнення і перебіг кавітації. Отримані значення «порогу» кавітації рідини ТС-1 залежно від температури при різних значеннях вмісту води.

Рис. 4, табл. 4, список літ.: 7 найм.

Глазкоа М.М., Ланецкий В.Г., Пузик А.С., Хлебникова В.В. **Экспресс способ количественного определения воды в авиатопливе**

Определено, что температура и количество воды в авиатопливе влияют на характер возникновения и протекания кавитации. Получены значения «порога» кавитации жидкости ТС-1 в зависимости от температуры при разных значениях содержания воды.

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