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Short Communication

Colloidal Stability and Thermal Stability of Magnetic Fluids

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Colloidal and thermal stabilities of magnetic fluids define the service life of magneto-liquid equipment. The results of the research into colloidal and thermal stabilities of original synthesized magnetic fluids based on kerosene, siloxane fluid and synthetic hydrocarbon oil are presented. The method of carrying agent substitution was used in the research into colloidal stability. The thermal tests were conducted in the research into thermal stability. The conclusions about the prospects of synthesized magnetic fluids using in technical equipment are made on the basis of received experimental data.

Keywords: Magnetic fluid, Colloidal stability, Thermal stability, Viscosity.

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1. INTRODUCTION

The efficiency of magnetic fluid application is assessed by the main technical characteristics such as saturation magnetization, viscosity, density etc. Colloidal stability is a quality criterion of magnetic fluids and possibility of their long-term usage [1]. An admissible operating temperature range is another important characteristic that determines the usage of magnetic fluids as the working medium in magneto-liquid compaction [2]. It is necessary to determinate previously the colloidal and thermal stabilities of newly synthesized magnetic fluids on different bases in the static mode. If magnetic fluids have sufficient colloidal and thermal stabilities they can be recommended for complex tests on the test benches or in the specific equipment. The conclusions about the possibility of practical usage can be made on the basis of conducted tests.

2. EXPERIMENTAL DETAILS

2.1 Research Method of Colloidal Stability Definition

Colloidal stability of magnetic fluids can be assessed by the method of carrying agent substitution [3, 4].

a) Coagulant is added in the synthesized magnetic fluid with pre-measured density, plastic viscosity and saturation magnetization. As a result disperse phase particles stabilized by surfactant precipitate.

b) The mixture of carrying fluid and coagulant is poured out. After that the precipitate is washed out several times with coagulant.

c) After drying the estimated amount of carrying fluid is added to the precipitate. Thus the repeptization of stabilized magnetite in carrying fluid happens.

d) The newly received magnetic fluid is centrifuged and then density, plastic viscosity and saturation magnetization are measured again. This procedure can be repeated several times.

If the changes of technical characteristics within permissible limits are not observed, the synthesized magnetic fluid is colloidally stable in the absence of external influence and ready to test on the test benches.

The method of carrying agent substitution is simple but very effective. It is possible that adsorbent stabilization will not be complete during the synthesis of magnetic fluids. The energy of adsorptive interaction between surfactant molecules and active sites on the magnetite surface will not be so large. In this case coagulant addition to magnetic fluid is a reason for desorption process. As a result the magnetite particles deprived of their protective shells partially or completely precipitate. The surfactant is removed with the poured off mixture of coagulant and carrying fluid.

When coagulant is added the surfactant desorbs completely from the magnetite surface, when estimated amount of carrying fluid is added the magnetic fluid does not obtain. When coagulant is added the surfactant desorbs partially from the magnetite surface, when estimated amount of carrying fluid is added the magnetic fluid forms. In this case the volume fraction of disperse phase is less than the original one. Density, plastic viscosity and saturation magnetization of magnetic fluid will differ from the original values. Moreover, oxidation and aggregation processes will happen in unprotected parts on the magnetite surface. These processes cannot be stopped. Their destructive effect leads to a significant change of technical characteristics in statics. It is impossible to use magnetic fluids in the equipment where the processes described above happen more intensively under mechanical, magnetic field, high and low temperature effects.

2.2 Research Method of Thermal Stability Definition

The temperature range of magnetic fluid operation is caused by the temperature characteristics of carrying fluid and magnetite and the energy of adsorptive interaction.

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The following processes can happen in magnetic fluids during the prolonged temperature effect. They are the surfactant desorption on the disperse phase particle surface, the polymerization of desorbed surfactant and carrying fluid, the thermal-oxidative destruction of carrying fluid. The thermal processes lead to change of magnetic fluid viscosity. Therefore the magnetic fluid viscosity is a characteristic that helps to make the conclusion about the thermal stability of magnetic fluids and the possibility of their usage under high temperature effect.

2.3 Experiment

The original synthesized magnetic fluids based on kerosene (MKK 001-60), siloxane fluid (MKS 350-40) and synthetic hydrocarbon oil (MKU 030-40) are used as the research models. The test results of initial magnetic fluids with the different volumetric content of magnetite after the first and the second coagulation procedures are presented in Table 1-3.

The thermal stability research was carried out for the magnetic fluid MKS 350-40 based on siloxane fluid. The research was carried out at the temperatures of 100 and 150 °C for 1000 hours for each temperature. The plastic viscosity of magnetic fluid was measured every 100 hours. After prolonged thermal treatment the magnetic fluid was centrifuged. The change dynamics of plastic viscosity (magnetic fluid MKS 350-40) is shown in Figure 1.

The received experimental data show that the technical characteristics of the synthesized magnetic fluids MKK 001-60, MKS 350-40, MKU 030-40 with the

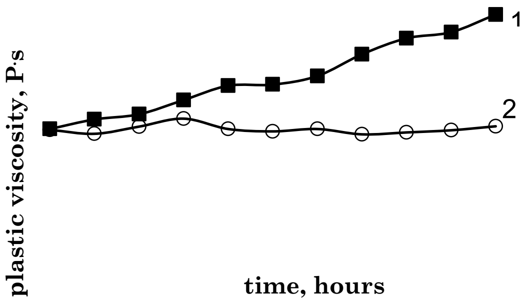

Fig. 1 – Change dynamics of plastic viscosity during prolonged temperature effect on magnetic fluid MKS 350-40 (1 – at 150 °C, 2 – at 100 °C)

different volumetric content of magnetite after the first and the second coagulation procedures change no more than ±3%. The experimental data indicate that the synthesized magnetic fluids are colloidally stable, i.e. they are able to keep their characteristics in the absence of external influence.

The thermo-tests show that the plastic viscosity of magnetic fluid MKS 350-40 does not change during the 1000 hour thermal treatment at 100 °C. After the 1000 hour thermal treatment at 150 °C the plastic viscosity of magnetic fluid MKS 350-40 increases no more than 10%.

3. RESULTS AND DISCUSSION

Table 1 – Technical characteristics of initial magnetic fluids

Magnetic fluid type	Volumetric content of magnetite, %	Saturation magnetization, kA/m	Density, g/cm^3	Plastic viscosity, P·s
MKK 001-60	9,2	35	1,15	0,0015
MKK 001-60	21,6	82	1,70	0,02
MKS 350-40	4,7	18	1,19	0,66
MKS 350-40	9,7	37	1,40	1,63
MKU 030-40	6,8	26	1,19	0,09
MKU 030-40	11,8	45	1,41	0,35

Table 2 – Technical characteristics of magnetic fluids after the first coagulation

Magnetic fluid type	Saturation magnetization, kA/m	Density, g/cm^3	Plastic viscosity, P·s
MKK 001-60	34	1,12	0,0016
MKK 001-60	84	1,69	0,021
MKS 350-40	17	1,14	0,64
MKS 350-40	39	1,40	1,65
MKU 030-40	26	1,17	0,09
MKU 030-40	44	1,42	0,35

Table 3 – Technical characteristics of magnetic fluids after the second coagulation

Magnetic fluid type	Saturation magnetization, kA/m	Density, g/cm^3	Plastic viscosity, P·s
MKK 001-60	36	1,13	0,0016
MKK 001-60	81	1,69	0,02
MKS 350-40	17	1,16	0,64
MKS 350-40	38	1,39	1,63
MKU 030-40	24	1,16	0,088
MKU 030-40	45	1,40	0,34

The initial temperature of siloxane fluid thermo-oxidation used for the magnetic fluid synthesis is 150 °C [5, 6]. That is why the plastic viscosity of the magnetic fluid MKS 350-40 does not change during the prolonged thermal treatment at 100 °C. At 150 °C the plastic viscosity of magnetic fluid increases due to the dynamic viscosity increase of carrying agent. The reason for it is thermo-oxidation. However, the experiment showed that the plastic viscosity changed slightly after the 1000 hour thermal treatment. The tests of magnetic fluid MKS 350-40 operated at the temperatures of 130 ÷ 180 °C in magneto-liquid compaction show that 10 % increase of the magnetic fluid viscosity does not influence on the operation. The precipitation of aggregated disperse phase particles was not shown after centrifugation. This fact allows to conclude that the surfactant desorption does not happen at any temperatures. Thus, the magnetic fluid MKS 350-40 has sufficient thermal stability and can be used for a long time. For example, it can be used as the working medium in magneto-fluid seals at the temperatures of less than 150 °C.

4. CONCLUSIONS

The original magnetic fluids based on kerosene (MKK 001-60), siloxane fluid (MKS 350-40) and synthetic hydrocarbon oil (MKU 030-40) are synthesized.

The method and the colloidal stability of magnetic fluids in the static mode are defined.

It is shown that the synthesized magnetic fluids are colloidal stable and can be recommended within the equipment for the tests on the test benches.

The thermal tests of the magnetic fluid based on siloxane were carried out. The tests showed that the given magnetic fluid can be used for a long time. For example, it can be used as the working medium in magneto-liquid compaction at the temperatures of less than 150 °C.

REFERENCES

1. Yu.B. Kazakov, I.M. Arefyev, T.A. Arefyeva, *13th International Conference on Magnetic Fluids (ICMF-2013)*, 226 (New Delhi: 2013).
2. Yu.B. Kazakov, I.M. Arefyev, T.A. Arefyeva, *13th International Conference on Magnetic Fluids (ICMF-2013)*, 228 (New Delhi: 2013).
3. R.E. Rosensweig, *Ferrohydrodynamics* (Moscow: Mir: 1989).
4. V.E. Fertman, *Magnetic Fluids* (Minsk: Vysshaya Shkola: 1988).
5. M.V. Sobolevskij, I.I. Skorohodov, K.P. Grinevich, *Oligoorganic Syloxanes: Properties, Production, Application* (Moscow: 1985).
6. K.M. Badyshtova, Ya.A. Bershtadt, S.K. Bagdanov, *Fuel, Lubricants, Technical Liquids. Assortment and Application* (Moscow: 1989).