# METHODS FOR THE DETERMINATION OF THE THERMAL STABILITY OF MAGNETIC FLUIDS.

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## INTRODUCTION

One of the existing possibilities today for using magnetic fluids is their utilization as heat carriers. The thermal agents should have a high specific heat and thermal conductibility, low viscosity, low vapour pressure and high thermal stability.
The presence of the solid phase inside the magnetic liquid increases the thermal conductibility because the thermal conductibility of the solid material surpasses on an average that of the liquid agents used.
As a series of existing technological processes are carried out at high temperature, the thermal stability of the magnetic fluid is very important. The stability of the magnetic colloid is provided by the layer of superficially active substance adsorbed on the surface of the colloidal particles. At high temperatures it becomes possible the coagulation of the system as the result of both the desorption of the stabilizer from the surface of particles and the intensification of the Brownian movement.
The high thermal resistance of the magnetic fluid may be achieved by setting up around the colloidal particle of an absorbing envelope more consistently bound to the particle surface or by maintaining the molecules of the superficially active substance at the surface during the desorption process.
By choosing a certain stabilizer of a polymeric nature one may achieve a more stable colloidal system as compared with the configuration of the adsorption envelope consisting of lower molecular weight molecules[1].

## EXPERIMENTAL

### 1. The determination of magnetic fluids thermal stability by filtration method

In order to evidence the formation of the agglomerates, samples of magnetic fluids obtained in the laboratory (consisting of magnetite and petroleum as supporting liquid) have been submitted to heating in a cylinder drum electric furnace at controlled temperature.
The samples introduced in closed glass vials have been maintained for 4-8 hours at different temperatures between 160 and 200°C.
Formation of agglomerates in magnetic fluids can be evidenced by filtration.

### 2. The determination of magnetic fluids thermal stability by impedance measuring

A vertical column of magnetic fluid introduced in the coil of the oscillating circuit alteres the resonance frequency of the circuit[2].
The impedance of a real coil with ferromagnetic core terminal supplied at terminals with a sinusoidal voltage is :

$$Z = \sqrt{R^2 + X_L^2} \qquad (1)$$

where R - ohmic resistance [ Ω ], $X_L$ - inductive resistance [ Ω ] ;

$$X_L = \omega \cdot L \qquad (2)$$

$\omega = 2\pi f$ ; f - frequency [ Hz ];

L - the self-inductance of the coil [ H ] :

$$L = \frac{N\Phi}{i} \qquad (3)$$

N - the number of turns of the coil

Φ - the magnetic flux [ Wb ];

i - current intensity through the coil [A].

The resonance frequency changes proportionally with the magnetic saturation of the magnetic flux, hence with the volume fraction of the solid magnetic material in suspension.

By moving vertically the magnetic fluid column one may obtain the space profile of the magnetic material concentration.

Samples of magnetic fluid, heated at a temperature of 160-200°C for 8 hours have been introduced in a glass tube which has been moved vertically through a coil of 1000 turns with the diameter d = 15 mm connected to an impedance measuring device, the frequency being 500 kHz.

## RESULTS AND DISCUSSION

### 1. The determination of magnetic fluids thermal stability by filtration method

The suspension filtration process is described by the following differential equation[3] :

$$\frac{dR}{dV} = K \cdot R^n \quad [\, n \in ▯ = (-\infty, 2)\,] \qquad (4)$$

known in the literature as ''the generalized equation of filtration'' which describes the variation of the filtration resistance versus the specific volume of the filtrate, V, where K is a constant that characterizes the increase of the total resistance to filtration.

The real parameter n characterizes the different filtration manners according to the values ascribed within the mentioned range▯. Thus we have :

for n = 2 ; 1.5 - filtrations with pancaking of pores ;

for n = 1 - filtration of the intermediate type ;

for n = 0.5 ; 0 - filtrations with the formation of the precipitate

and for the negative values of the parameter are obtained filtrations with a low variation of the filtration resistance, such as at the limit, for $n \to \infty$, the filtration becomes of a constant resistance[3].

The filtration rate is defined by the equation :

$$w = \frac{1}{R} = \frac{dV}{A d\tau} \quad \text{or} \quad R = \frac{A d\tau}{dV} \qquad (5)$$

$$\frac{dR}{dV} = A \frac{d^2\tau}{dV^2} \qquad (6)$$

$$A \frac{d^2\tau}{dV^2} = K \cdot A^n \left( \frac{d\tau}{dV} \right)^n \qquad (7)$$

$$\frac{d^2\tau}{dV^2} = K' \cdot \left( \frac{d\tau}{dV} \right)^n , \quad K' = K \cdot A^{n-1} \qquad (8)$$

By the logarithmation of equation (8) and the graph $\lg\left(\frac{d^2\tau}{dV^2}\right) = f\left(\lg\frac{d\tau}{dV}\right)$ one obtaines the value of the parameter n.

In Figure 1 is presented the variation of the filtrate volume V versus the time τ for a sample of magnetic fluid maintained for 8 hours at a temperature of 200°C.

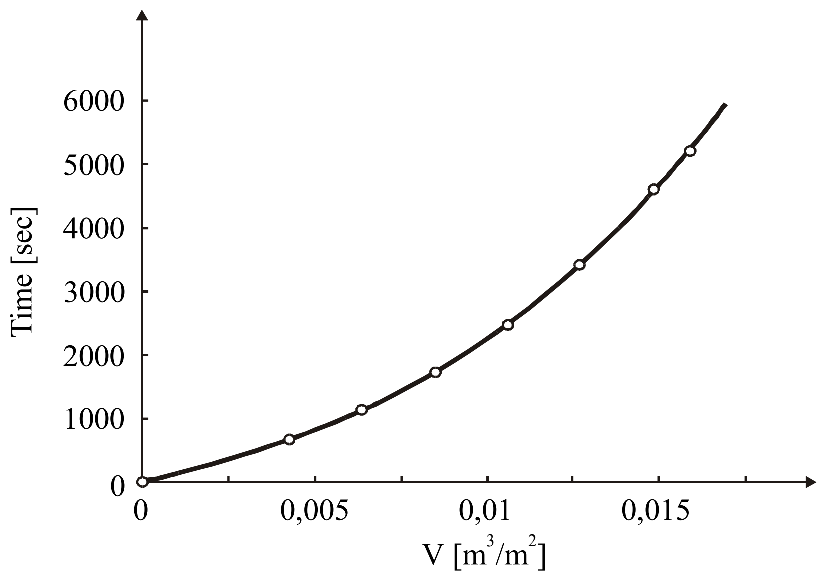


Figure 1. Variation of the filtrate volume, V, versus time, τ.

From the graph $\lg\left(\frac{d^2\tau}{dV^2}\right) = f\left(\lg\frac{d\tau}{dV}\right)$ (Figure 2) one obtaines the value of the parameter n.

The increase of the value of parameter n from 0.57 for the sample of magnetic fluid maintained at 160°C to 0.80 for that maintained at 200°C indicates the formation of agglomerates in the fluid.

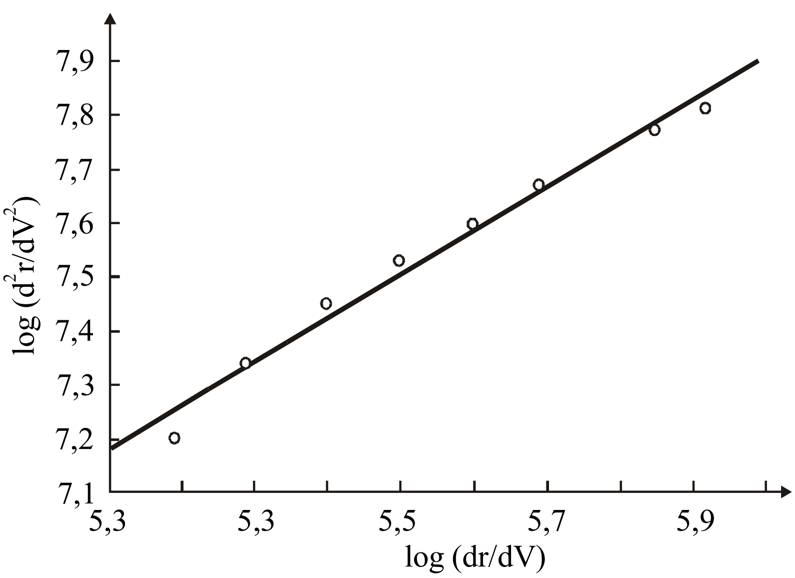


Figure 2. The determination of the value of parameter n.

## 2. The determination of magnetic fluids thermal stability by impedance measuring

By measuring the impedance (Z) of the coil with ferromagnetic core for a power supply with a voltage of known frequency, a proportional dependence on the magnetic material concentration in the fluid has been found.
In Figure 3 is presented the dependence of the impedance (Z) on height for samples of magnetic fluid at three temperatures (160, 180, and 200°C).

The experimental determinations show an increase of the agglomerates in magnetic fluid and sedimentation with the increase of temperature.

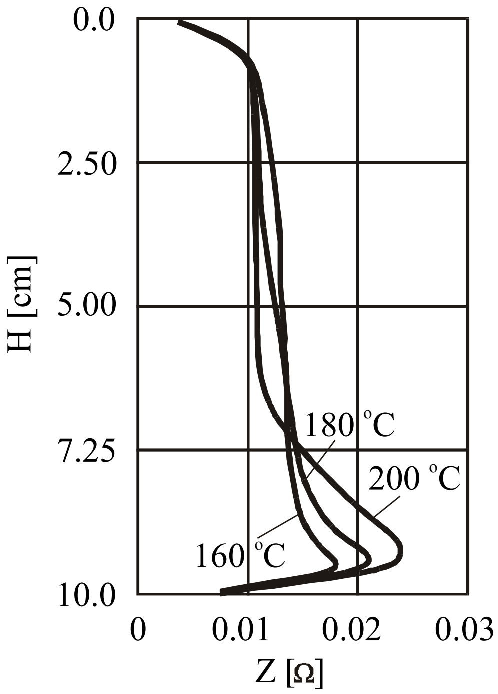


Figure 3. Impedance versus height.

## CONCLUSIONS

The paper presents two methods for the determination of magnetic fluids thermal stability. These methods allowed to appreciate the quality of magnetic fluids for their use in various industrial applications.

## REFERENCES

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