JOURNAL OF NANO- AND ELECTRONIC PHYSICS
Vol. **5** No 4, 04042(2pp) (2013)

ЖУРНАЛ НАНО- ТА ЕЛЕКТРОННОЇ ФІЗИКИ
Том **5** № 4, 04042(2cc) (2013)

Short Communication

Fundamental Research of Physics of Magnetic Nanodispersed Fluids as Hardware Dampers

V.V. Kovarda

Southwest State University, 50 let Oktyabrya st., 94, 305040 Kursk, Russia

(Received 27 October 2013; published online 10 December 2013)

This article analyzes the findings from an investigation of magnetic fluid column vibration against magnetic field direction and intensity. This article also reviews various applications for the obtained results.

Keywords: Magnetic fluid, Hardware damper.

PACS number: 47.65.Cb

Southwest State University (former Kursk State Technical University) researches fundamental properties of magnetic nanodispersed fluids including their rheological characteristics [1].

The described stand [2] has been used as test vibration system with magnetic fluid column as inert element. Experimental results show that damping factor of certain fluids increases along with increasing magnetic field frequency and intensity, however the damping factor of other fluids decreases along with increasing magnetic field intensity $\vec{H}$ (Fig. 1 and 2).

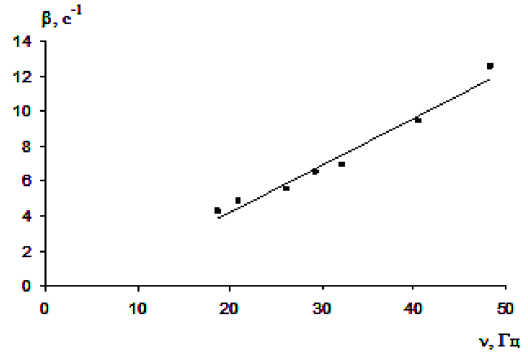

Fig. 1 – $\beta(H)$ graph

Fig. 1 shows the damping factor β against the magnetic field intensity H in the magnetic fluid (MF) column between electric magnet poles. $\beta(H)$ graph in less concentrated colloids is characterized by positive derivative [8].

Fig. 2 shows approximated straight $\beta(\nu)$ graph for MF-3 with MF column equilibrium stabilized by ring magnet. β values at the frequency of 32 Hz for two different types of MF-3 stabilization (Fig. 1 and 2) are the same within the measurement accuracy validating the measurement results.

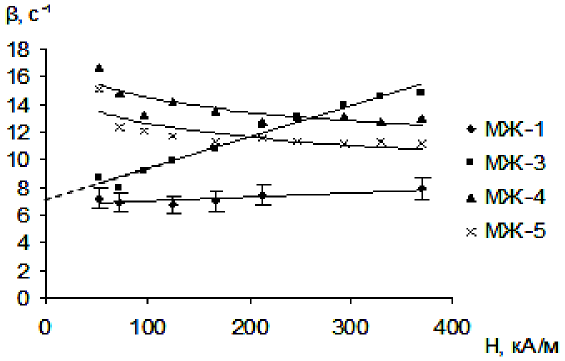

Fig. 2 – $\beta(\nu)$ graph for MF-3

Conventionally measured (at 20 °C) basic parameters of tested kerosene-based magnetite magnetic fluids are listed in table 1.

In table 1, ρ is magnetic colloid density, M_s is saturation magnetic moment, χ is initial susceptibility, η_s is static viscosity, φ is solid volume fraction.

If circumference of fluid column side surface is significantly longer than viscous wave length λ ($\lambda = 2\sqrt{\pi\eta/\rho\nu}$) then the damping factor should be calculated according to the Helmholtz equation:

$$\beta_\eta = \frac{2}{d}\sqrt{\frac{\pi\eta\nu}{\rho}} \tag{1}$$

Table 1 – Basic parameters of tested magnetic fluids

Sample	Carrier fluid	ρ, kg/m^3	M_s, kA/m	χ	φ, %	η_s,Pa·s
MF-1	Kerosene	1345	–	-	8.8	$3.1\cdot10^{-3}$
MF-2	Kerosene	1294	52	6.3	7.3	$3.9\cdot10^{-3}$
MF-3	Kerosene	1294	52	6.3	7.3	$3.5\cdot10^{-3}$
MF-4	Kerosene	1499	60	7.5	10.2	$8.1\cdot10^{-3}$
MF-5	Kerosene	1500	60	–	10.2	$12\cdot10^{-3}$

The article was reported at the International Conference «Physics and Technology of Nanomaterials and Structures», Kursk, 21-22 November, 2013

For small d and ν, if $\pi d < 2\lambda$ is true then the damping factor should be calculated according to the Poiseuille equation:

$$\beta_{\Pi} = \frac{16\eta}{\rho d^2}\,. \tag{2}$$

Fig. 3 shows β measured values for various frequencies and also it shows predicted $\beta(\nu)$ according to the equation (1) (solid line) and the equation (2) for infrasound (dash line).

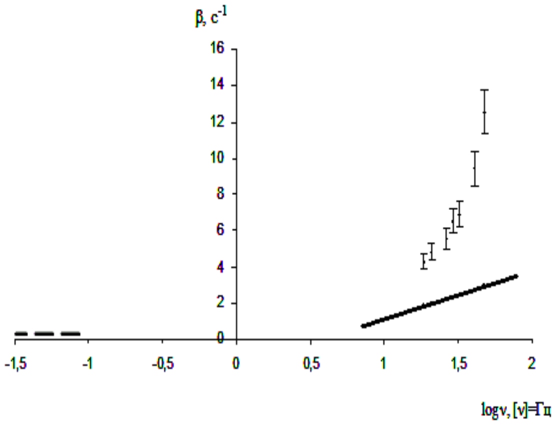

Fig. 3 – Semi-log scale $\beta(\nu)$ graph for MF-3

Fig. 4 shows lnβ(lnν) graphs for MF-3 (dash line) and MF-1 (solid line) in case of ring magnet-stabilized magnetic fluid column in a resting contact upon air bubble of different height. Due to the fact that effective viscosity rises along with increasing frequency, frequency dependence of the damping factor is almost direct i. e. $\beta \sim \nu$ although the classic dependence is $\beta \sim \sqrt{\nu}$.

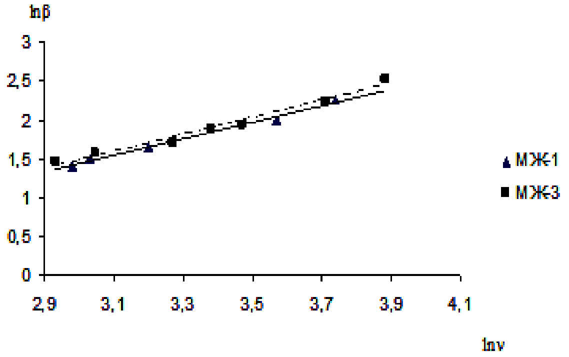

Fig. 4 – lnβ(lnν) graph

One can suggest that excess damping (fig. 3) with peculiar relation to vibration frequency (fig. 4) and magnetic field intensity (fig. 1) is due to ferrous particle lagging behind the carrier fluid within viscous wave penetration depth h_η ($h_\eta = \lambda/2\pi$).

Therefore magnetic field changes some characteristics of MF and increases its damping factor. Such fluids can be applied in various dampers with adjustable magnetic field.

A sustainable development concept implies that human potential will rise and it will demand using new hardware to improve the life quality and counter increasing human impact on the environment [3], increasing incidence, and worsening morale [4].

The dampers become more common in leg prostheses.

Fig. 5 – Prosthesis c with magnetic fluid damper

In USA, prostheses with magnetic fluid dampers are already being developed [5] (Fig. 5). These devices are featured by magnetically adjustable damper stiffness.

REFERENCES

1. G.V. Karpova, A.N. Kutuev, P.A. Ryapolov, V.M. Polunin, E.K. Zubarev, V.V. Kovarda, *Magnetohydrodynamics* **45** No1, 85 (2009).
2. V.V. Kovarda, *Research of Elastic and Dissipative Properties of Vibrating System with Magnetic Fluid Inert Element. Candidate of Physics and Mathematics Thesis* (Kursk: 2005).
3. V.V. Kovarda, *World Appl. Sci. J.* **24**, 675 (2013).
4. V.V. Kovarda, *World Appl. Sci. J.* **25**, 460 (2013).
5. V.V. Kovarda, A.K. Marchuk, *Young Scientist* No6, 169 (2012).