УДК 681.2.08: 537.622

RESEARCH OF ULTRASONIC SENSING AND MIXING ELEMENTS FOR CONTROL OF MAGNETORHEOLOGICAL FLUIDS STABILITY

Dragašius E., Jūrėnas V., Mačiukienė V., Mažeika D.

Kaunas University of Technology, Kaunas, Lithuania

Using of magnetorheological fluids (MRF) can reduce energy costs and weight and increase the devices speed and lifetime. In order to fully use all the qualities of MRF properties one must from time to time mix them and measure their properties. These systems are still being designed and tested in the laboratories. There are many structures with rheological fluid, but in many devices fluids are sealed and mechanical mixing and direct measurement of fluid properties are not possible. Effective stability control system for the rheological fluids, which supports homogeneity of the fluid, is described. (E-mail: edraga@ktu.lt)

Key Words: magnetorheological fluid, ultrasound, control system, oscillation frequency.

Introduction

This article describes several ways of using ultrasonic mixing and sensing elements for control of magnetorheological fluids (MRF) stability. Described devices have been developed and tested in the laboratory. At the beginning mixers have been designed similar to an ultrasound bath design, but when they were tested in the laboratory they showed that using of these mixers with large volumes of MRF will result in insufficiently good mixing. Therefore using piezoceramic elements has been developed ultrasonic cavitations, which have mixed small and large quantities of the rheological fluid.

MRF mixing using the ultrasound

Using piezoceramic elements some mixers were developed and tested in two ways:

1st – piezoceramic element was attached to the bottom of vessel and immersed into MRF or piezoceramic element was attached to the bottom of vessel outside (figures 1);

2nd – piezoceramic element was used for excitation of the ultrasonic horn, which was immersed into the MRF.

First construction was designed with two functions, because you can mix MRF and find fluid viscosity and volume from measured resonant characteristics of the device.

In the experiment resonant frequency of the vessel was measured by the KD91 accelerometer as a function of MRF level in the vessel. The results are presented in the figure 2.

In this experiment it was shown that the mixing quality is good only in particular cases. For the small MRF volumes mixer has good performance, but with increase in MRF volume or viscosity element which generates ultrasound is damped very hard. So we can say that this mixer is more suitable for lower viscosity materials or very small volumes of MRF.

In ***another mixing method*** ultrasonic horn was immersed in vessel with the MRF, which was affected by the sedimentation. Oscillation frequency was 20 kHz, ultrasonic horn end diameter – 4 mm, excitation power – 100 W, vessel volume – 50 cm^3. MRF mixing quality will depend on excitation power, processing time and volume of fluid. In the considered case MRF was efficiently mixed only in volume of small radius (about 12 mm) around the immersed ultrasonic horn. For mixing of MRF in all volume it is necessary to provide additional rotational movement of the ultrasonic horn.

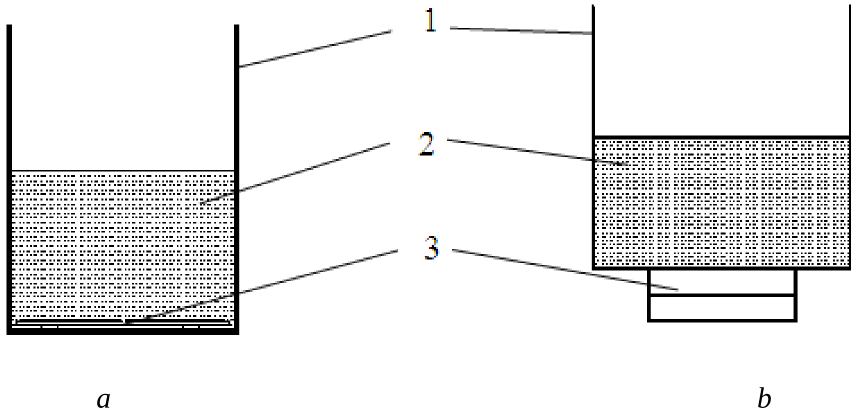

Figure 1 – MRF mixer with piezoelectric element: *a* – piezoelectric element is attached to the bottom of the vessel inside and immersed into the MRF; *b* – piezoelectric element is attached to the bottom of the vessel outside; 1 – metal vessel, 2 – MRF, 3 – piezoelectric element

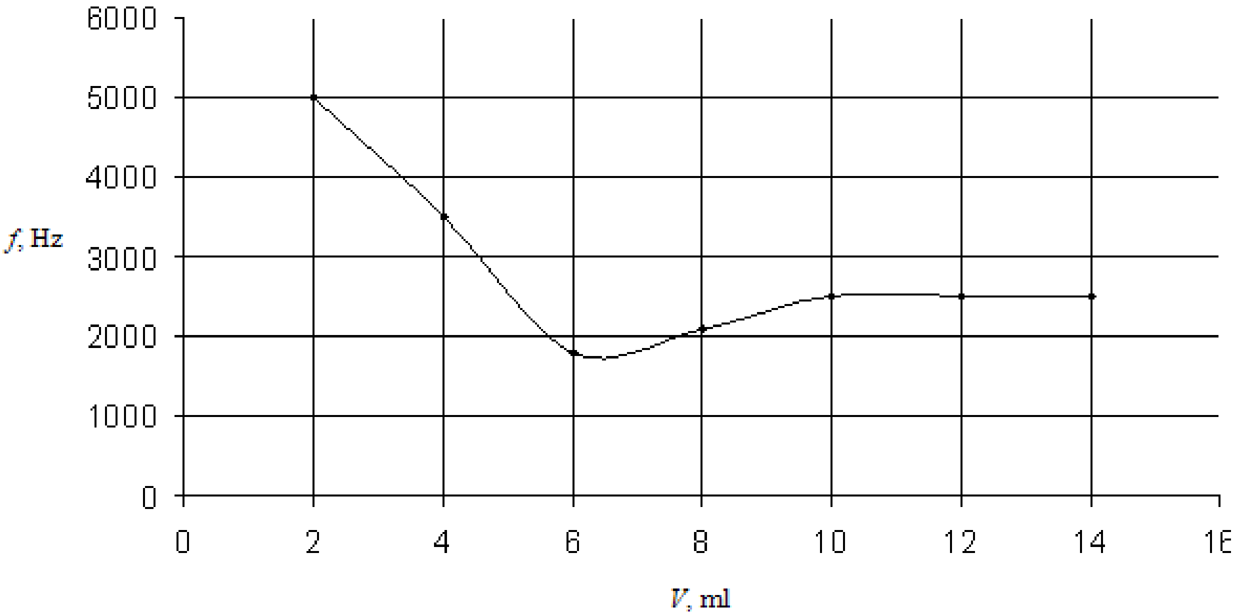

Figure 2 – Dependence of resonant frequency on the volume of MRF

In the second case ultrasonic horn was immersed into the vessel with volume 2 cm^3 filled with the MRF affected by the sedimentation. Oscillation frequency was 20 kHz, ultrasonic horn end diameter – 4 mm, excitation power – 20 W. In this case processing time was 15 seconds and the fluid temperature variation amounted about 20 degree of Celsius.

Concentration of particles in the mixed fluid was determined by measuring inductance of coil with short circuit connection of one ring. The measurement results are presented in figure 3.

Conclusion

During experiments it was found that mixers which have piezoelectric elements on the bottom of vessel inside or outside it are not suitable for mixing of larger volumes of MRF or fluids with high viscosity. Therefore, the system is ideal for mixing of small volumes of low-viscous MRF. Resonant frequencies of the vessel can be used as indicator of fluid volume and viscosity.

Mixing of MRF using high-frequency ultrasonic horn resulted in formation of vortices in the fluid. The fluid was mixed in the radius about 20 mm around the ultrasonic horn end. In the mixing zone the fluid was strongly heated, but below the critical temperature. If you want to completely mix the MRF in a small volume, there is no need to dip the ultrasonic horn to the bottom of the vessel, but if you want to mix the MRF in a large volume, then ultrasonic horn needs to be provided with additional movements or it is necessary to use several ultrasonic horns.

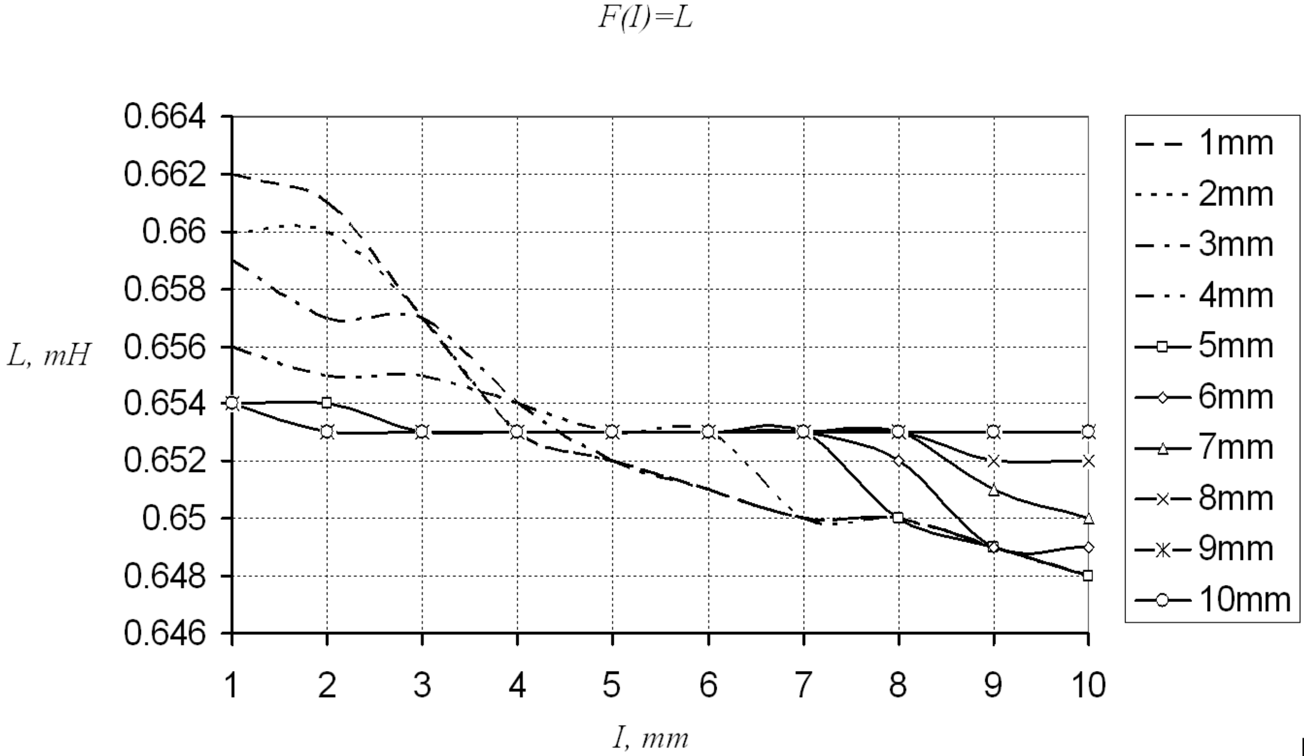

Figure 3 – Measurement results of particle concentration in MRF on different levels of fluid
Numbers indicate values of ultrasonic horn immersion depth

Acknowledgments

This research was funded by grants from the Agency for Science, Innovation and Technology and the Research Council of Lithuania.

References

1. *Jolly, M.R.* Properties and Applications of MR Fluids / M.R. Jolly, J.W. Bender, J.D. Carlson // SPIE 5-th Annual Int. Symposium on Smart Structures and Materials, San Diego, CA, 15 March, 1994.
2. *Carlson, J.D.* Controllable Fluids / J.D. Car-lson, J.L. Spronston // Status of ER and MR Fluid Technology, «Actuator 2000». – 7-th International Conference on New Actuators, 19–21 June, 2000.
3. *Bydoń, S.* Construction and Operation of Magnetorheological Rotary Brake / S. Bydoń // Proceedings of STOC'2002, Ostrava, April 26–27, 2001.

Драгашиус Е., Юренас В., Мачюкене В., Мажейка Д.

Исследование ультразвуковых чувствительных и перемешивающих элементов для управления стабильностью магнитореологических жидкостей

Использование магнитореологических жидкостей позволяет снизить энергетические затраты, вес и увеличить быстродействие и срок службы устройств. Для полного качественного использования свойств магнитореологических жидкостей их необходимо периодически перемешивать и измерять их свойства. Такие системы в настоящее время разрабатываются и тестируются в лабораториях. Существует множество структур с реологической жидкостью, однако во многих устройствах жидкости герметизированы и механическое перемешивание и прямое измерение свойств жидкости невозможны. Описана эффективная система управления стабильностью для реологических жидкостей, поддерживающая их однородность. (E-mail: edraga@ktu.lt)

Ключевые слова: магнитореологическая жидкость, ультразвук, системы управления, частота колебания.

Поступила в редакцию 23.08.2011.