SUMMARY OF Ph.D. DISSERTATION

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Title

Properties of Ultrasonic Propagation in Magnetic Functional Fluids

Abstract

Magnetic and magnetorheological (MR) fluids are typical magnetic functional fluids, which change their rheological properties when an external magnetic field is applied. A magnetic fluid is a stable colloidal suspension of small surfactant-coated magnetic particles -about 10 nm in diameter- in a liquid carrier, such as water and hydrocarbon oil. On the other hand, the composition of an MR fluid is similar to that of a magnetic fluid, but with a typical magnetic particle size of 10 μm. Moreover, an MR fluid has controllable yield stress and high viscosity under a magnetic field. When an external magnetic field is applied to a magnetic or an MR fluid, some of the inner particles coagulate and form a clustering structure. Various applications, such as clutches and dampers, have been developed using these fluids. However, it is important to analyze these structures with respect to each application.

The ultrasound velocity profiler (UVP) method is a useful technique for measuring the velocity components of a magnetic fluid. When applying this method to magnetic fluid flow, it is necessary for the ultrasonic propagation velocity to be accurate. However, clustering structures under a magnetic field affect the ultrasonic propagation. It is therefore important to investigate the properties of ultrasonic propagation in functional fluids. In this study, the properties of ultrasonic propagation velocity and attenuation in magnetic and MR fluids are measured precisely. Based on these results, non-contact inspection of the inner structures of these fluids is carried out using an ultrasonic technique.

Chapter 1 introduces the functional fluid engineering and the ultrasonic technique. Proceedings from these introductions, the background of this study, and the objectives are detailed.

In Chapter 2, the basic theories of ultrasonic propagation are described. Because the theories of ultrasonic propagation in fluids are very complicated, experiments on the propagation in magnetic functional fluids are discussed.

Chapter 3 examines the experimental system used in this study.

Chapter 4 reports the precise measurement of the ultrasonic propagation velocity in various magnetic fluids, and the velocity properties under a magnetic field. Further, an analysis of the structure of chain-like clusters is also performed using the properties of ultrasonic propagation velocity.

In Chapter 5, the attenuation of ultrasonic propagation in magnetic fluids is described. By comparison with the results given in Chapter 4, the inner structures are investigated in greater detail.

Chapter 6 reports the properties of ultrasonic propagation velocity in MR fluids, with a detailed explanation of the measurement method. By comparison with results in Chapter 4, the differences in the clustering structure formation for each fluid is discussed.

Chapter 7 applies this study to the analysis of flow dynamics in magnetic functional fluids. Based on these results, the pipe flow of magnetic fluid is measured by UVP and the channel flow structure of the MR fluid under a magnetic field is analyzed by ultrasonic techniques.

Chapter 8 summarizes the results of this study.