SUMMARY OF Ph.D. DISSERTATION

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Title

Development of Gel-structured Electro-rheological Fluids and Their Application to Machine Elements

Abstract

Electro-rheological fluids (ERF) are functional fluids whose viscoelastic properties vary with the intensity of the applied electric field. The property of ERF has been expected to control the performances of machine elements, and the ERF has been applied to machine elements such as variable dampers and clutches. However, the disadvantages of ERF are the sedimentation of ER particles and the requirement of seal mechanism. The sedimentation of ER particles reduces the ER effects, results in low stability of ER devices. To solve these problems, gel structured electro-rheological fluids (ERG) were developed in this study. The separation and sedimentation of ER particles from the base oil are successfully suppressed because the frames of gel prevent the particles from sedimentation. The basic characteristics of ERG were experimentally and numerically analyzed. On the basis of the results of the basic analysis, ERG was applied to the machine elements and their performances were evaluated.

Chapter 1 summarizes the background, reviewing the trend of the research of ERF and issues of ERF.

Chapter2 describes the structural characteristics of the developed ERG. Moreover, the relation between the constituents of ERG and the performance are experimentally investigated.

Chapter 3 explains the basic performance of ERG. The experimental analysis clarified that the generated shear stress of ERG under electric field is 20~30 times as large as that of ERF. The ERG also shows the high repeatability of ER effect. These high performances of ERG suggest that the occurrence mechanism of ER effect in ERG is different from that in ERF, which originate the particle chain formation.

Chapter 4 elucidates the occurrence mechanism of ER effect in ERG. The ER effect of ERG originates the change of frictional condition on ERG surface due to the variation of surface properties according to the applied electric field.

Based on the performance analysis, ERG was applied to several devices. Chapter 5 shows its application to clamp mechanism for aero-static slider. The zero force clamping mechanism was proposed by using the ERG. The error movement of slider in clamping does not occur and the clamping force is adjusted electrically. Chapter 6 shows the application to polishing pad for molding. The polishing characteristics can be optimized by adjusting the applied electric fields. The ERG polishing method provides the possibility to automate the polishing process.

Chapter 7 represents the application of one-sided electrodes to ERG, and the performances were analyzed. The result of the analysis shows that the ER effect can be also obtained in insulating material, applying the one-sided electrodes.

Chapter 8 shows the application of ERG to clutch mechanism. Torque transfer device with ERG clutch was developed and its performance was evaluated. The transferred torque is adjustable electrically. The ERG on one-sided electrodes is useful for the various mechatronics systems.

Chapter 9 summarizes the results of this study.