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SUSPENSION STABILITY OF A MAGNETORHEOLOGICAL FLUID EMPLOYING HIGH VISCOSITY LINEAR POLYSILOXANE CARRIER FLUIDS: A TWO-YEAR STUDY

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Abstract

Magnetorheological fluids (MRFs) are smart materials that exhibit remarkable control over their rheological properties. By applying an external magnetic field, these fluids can dynamically alter their apparent viscosity and yield stress. In the absence of a magnetic field, MRFs behave as Newtonian fluids, exhibiting a linear relationship between fluid stress and shear rate. However, upon exposure to a magnetic field, MRFs effectively transform their physical property from a fluid-like state to a semi-solid state. This transition is rapid and reversible. Due to this unique characteristic, MRFs have found widespread applications in various engineering fields. MRF-based devices can precisely control their actuating forces or torques by simply adjusting the applied magnetic field. While MRF-based applications offer significant advantages, their widespread commercial adoption has been hindered by sedimentation, particularly the long-term instability observed during periods of inactivity. This instability arises primarily from the significant density difference between the magnetic particles and the non-magnetic carrier fluid. To address this challenge, high-viscosity linear polysiloxane-based MRFs (HVLP MRFs) have been recently developed. These fluids utilize highly viscous carrier fluids to mitigate sedimentation, as the settling velocity of particles is inversely proportional to the fluid viscosity. In this study, we experimentally investigated the long-term sedimentation stability of highly stable HVLP MRFs using an automated vertical axis inductance monitoring system (AVAIMS). Our previous studies utilized a non-automated VAIMS to track the "mud-line" (the boundary between the supernatant and original concentration zones) in HVLP MRFs with lower particle loadings (up to 32 vol%). However, these studies primarily focused on particle descent from the top of the MRF column within a test tube, neglecting the characterization of sedimentation zones below the mud-line, such as the original concentration, variable concentration, and sediment zones. In our other study, the particle concentration profiles of HVLP MRFs with higher particle loadings (up to 45 vol%) over 295 days were tracked using the AVAIMS. This enabled the identification of the four distinct sedimentation zones. Furthermore, an automated method to accurately determine the boundaries between these zones was also developed. As an extended study, three HVLP MRF samples are tracked over 795 days in this study, encompassing two different particle loadings (35 vol% and 45 vol%) and two distinct carrier fluid viscosities (5,000 cSt and 10,000 cSt). For comparative purposes, a commercial MRF (LORD Corp., MRF-140CG) with a 40 vol% particle loading is also included in the study.