UNIFIED ANALYSIS OF CHANNEL FLOW OF MAGNETORHEOLOGICAL FLUIDS

Authors: Barkan Kavicoglou, Faramarz Gordaninejad, and Xiaojie Wang

Abstract

A new unified approach for the flow analysis of magnetorheological (MR) fluids through rectangular channel with various surface topographies is presented in the study. It is attempted to derive the pressure drop across the flow of the MR fluid in channels of some synthetic magnetic fields. Channel surface properties and their effect on the complexity of using the channel slip ratios, various channel surface properties, the analysis derived with a non-dimensional form. All the channel surface properties were estimated without referring to a constitutive model or using the concept of shear yield stress. It can also be concluded that the pressure drop across a flow channel is directly proportional to the magnetic field strength applied.

Methods

In order to relate the non-dimensional form of the pressure drop across the flow channel to the channel wall effects on the MR fluid channel flow. A piston driven flow type rheometer with a rectangular channel was built. In this study five different gap sizes were used to test for the channel wall roughness. Pressure drop and volumetric flow rate are given in Figure 7 for magnetic field strengths of 0 T, 0.191 T and 0.405 T corresponding to 0 A, 0.5 A and 3.0 A of input current, respectively. Similarly, for the non-grooved channel the pressure drop was also calculated for a given surface topology without an assumption of a constitutive model for MR fluids.

Experimental study and Non-Dimensional Modeling

The experimental study is performed using the flow type rheometer with a rectangular channel. The MR fluid was pressurized to flow through the channel between two parallel-arranged magnetic poles by means of a hydraulic actuator. An electromagnetic coil was built and installed to the middle of the channel to permit the application of magnetic flux density normal to the flow direction. The pressure drop, is defined as:

\[ \Delta \lambda = \frac{\lambda_{c} - \lambda_{f}}{\lambda_{c}} \]

where \( \lambda_{c} \) is the channel gap and \( \lambda_{f} \) is the channel length. For a non-Newtonian fluid flow, the friction factor for channel with rough surfaces can be given as:

\[ f = \frac{1}{\sqrt{R_{a}}} \]

where \( R_{a} \) is the roughness parameter. In this study, five different gap sizes were used to test for the channel wall roughness and channel surface properties on the MR fluid flow. The MR fluid was pressurized to flow through the channel between two parallel-arranged magnetic poles by means of a hydraulic actuator. The channel surfaces were polished and fabricated. A piston driven flow type rheometer with a rectangular channel was built. In this study five different gap sizes were used to test for the channel wall roughness. Pressure drop and volumetric flow rate are given in Figure 7 for magnetic field strengths of 0 T, 0.191 T and 0.405 T corresponding to 0 A, 0.5 A and 3.0 A of input current, respectively. Similarly, for the non-grooved channel the pressure drop was also calculated for a given surface topology without an assumption of a constitutive model for MR fluids.

Experimental Results

The experimental results are compared with the non-dimensional form. The MR fluid pressure drop for different gap sizes, different particle volume percentages and surface topologies was also calculated with various input currents. The friction factor for the MR fluid flow through the channel between two parallel-arranged magnetic poles was determined using the Mason number. The experimental data is processed for all surface topologies and all magnetic fields to model the friction factor for the MR fluid flow through the channel between two parallel-arranged magnetic poles.

Conclusions and Future Work

In this study it is attempted to develop a new approach to model for magnetorheological (MR) fluid flow in channel with different surface topographies. The surface roughness of the channel is varied in the part of the experimentally selected channel channel with a modified Mason number. The experimental data is processed for all surface topologies and all magnetic fields to model the friction factor for the MR fluid flow through the channel between two parallel-arranged magnetic poles.