Interaction between carrier liquid and iron particles in MR-based sealing

SMART 2019

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ABSTRACT

The sealing approach based on ferrofluids is already well investigated and applied in many different applications. The low intrinsic friction in the absence of wear can normally be achieved. The tightness can be also maintained even at high eccentricities. Unlike ferrofluids (FF), magnetorheological fluids (MRF) consist of iron particles with the diameter in a range of 5 to 12 µm. As a consequence, MR-based sealings offer higher pressure loads compared to FF due to its higher yield and shear stress. But the MRF approach suffers from the drag torque in rotating applications. The particles of the MRF form a chain structure under the impact of a magnetic field, therefore, increasing the yield stress significantly, while the carrier liquid remains within the space between the particles. The FF approach is classified as a stable dispersion due to containing small particle size. However, Brownian motion superimposes all external effects and separation into two individual phases (particles or carrier liquid) is not possible.

This study deals with a detailed investigation of the interacting forces between the iron particles and the carrier liquid of magnetorheological fluids for a better understanding of the design of MR-based sealings. They have been successfully utilized in MR-fluid coupling elements [2]. Lately we presented an optimized design, which shows a drastically increase in the compactness and energy-efficiency [3]. Both designs were developed under the maximum pressure load considering the yield stress of the MRF due to the particle chains formed by the magnetic field.

In this study a second effect was observed on the tightness of MR-based sealing, which is most likely related to the carrier liquid within the space between the chain structures. Thus, the pressure load is acting simultaneously on the particle structure and the carrier liquid. Thereby, the counterforce of the liquid is based on the interaction force between the particles and the liquid.

Since, the applied load on the carrier liquid is transferred to the particle structure via the interaction forces, the length of the sealing gap is the most important parameter. Consequently, a shorter length of the sealing gap can result in leakage of the medium that needs to be sealed.

The proposed investigation includes a theoretical analysis, based on a filtration approach along with an experimental study. Different lengths of the sealing gaps are exposed to certain pressures and magnetic fields to determine the interaction forces between the chain structure and the carrier liquid. This information is essential to determine a sufficient length of a MR-based sealing.

REFERENCES

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