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A Transient Hydrodynamic Lubrication Model for Piston/Cylinder Interface of Variable Length

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Abstract

Hydraulic machinery transfers energy between a fluid and a mechanical system. The swash plate pump is one of the most widely used pumps because of its simple and compact structure. The piston/cylinder system is the core of the swash plate pump, and its lubrication characteristics greatly affect the overall pumping performance. This study is aimed at the development of a transient hydrodynamic lubrication model for the pumps with varying length of the piston-cylinder interface and the investigation of the influences of cylinder length, clearance, as well as other design parameters, on the pump piston forces and friction. The changing domain and moving boundaries of the varying piston-cylinder interface impose a challenge to the modeling, and a novel equal-displacement-step method is developed to tackle this issue. The pressure, film thickness, and friction performances of varying and constant interface-length systems are studied, and the former is further analyzed in detail. The results indicate that increasing the cylinder length reduces the misalignment angle and raises the minimum film thickness, but it increases the maximum friction force at and slightly off the location for the maximum velocity because friction is related to velocity and the interfacial area. A longer piston is preferred, and the optimal length for stability should be L_0 / L_{min} =1.71 for the system analyzed in this study.

Keywords:

Transient Hydrodynamic Lubrication, Variable Piston/Cylinder Interface, Swash Plate Pump.