Multiphysics Analysis of Electromagnetic Flow Valve

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Abstract

Solenoid valves control fluid flow by using the passage of an electric current to produce a magnetic field that controls the displacement of a pre-tensioned plunger. As the electric current increases, the induced force causes the plunger to move upward against the force exerted by a compression spring. In this way, flow of pressurized fluid through an orifice can be controlled through a coupled electromagnetic-fluid-structure interaction. In this work the operation of a solenoid valve is analyzed as a fully coupled electromagnetic-fluid-structure problem in which the motion of a plunger operates against a spring. Initially the spring holds the plunger closed against the force exerted by the pressurized fluid. Current passing through a coil surrounding the plunger generates an electromagnetic force that is resisted by a spring to allow controllable motion of the plunger; an increase in the current flowing through the coil increases plunger displacement, controls the size of the opening and promotes increased flow rates.
Analysis of the solenoid valve behavior has been conducted as a single, integrated, fully coupled multiphysics analysis using COMSOL Multiphysics® in which the electromagnetic behavior, structural response and flow of fluid through the orifice are solved simultaneously. Electromagnetic analysis determines the Lorentz force induced in the plunger composed of material having non-linear magnetic B-H behavior, the fluid is modeled as incompressible viscous fluid flow. The analyses show how applied current can be used to control mass flow through the orifice.

Figures used in the abstract

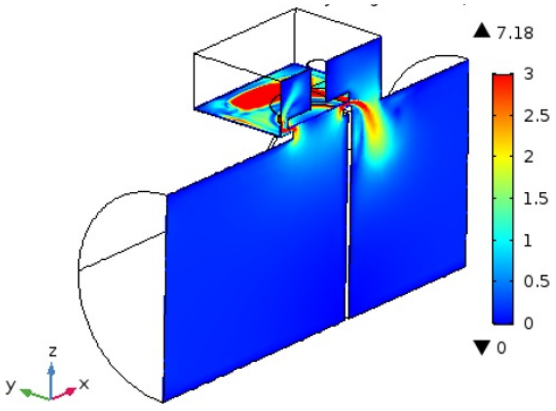

Figure 1: Fluid velocity distribution during valve opening