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High-Fidelity 1D Dynamic Model of a Hydraulic Servo Valve Using 3D Computational Fluid Dynamics and Electromagnetic Finite Element Analysis

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Abstract : The dynamic performance of a 4-way solenoid operated hydraulic spool valve has been analyzed by means of a one-dimensional modeling approach capturing flow, magnetic and fluid forces, valve inertia forces, fluid compressibility, and damping. Increased model accuracy was achieved by analyzing the detailed three-dimensional electromagnetic behavior of the solenoids and flow behavior through the spool valve body for a set of relevant operating conditions, thereby allowing the accurate mapping of flow and magnetic forces on the moving valve body, in lieu of representing the respective forces by lower-order models or by means of simplistic textbook correlations. The resulting high-fidelity one-dimensional model provided the basis for specific and timely design modification eliminating experimentally observed valve oscillations.

Keywords : dynamic performance model, high-fidelity model, 1D-3D decoupled analysis, solenoid-operated hydraulic servo valve, CFD and electromagnetic FEA
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