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Three-Dimensional Fluid-Structure-Thermal Coupling Dynamics Simulation Model of a Gas-Filled Fluid-Resistance Damper and Experimental Verification

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Abstract : Fluid resistance damper is an important damping element to attenuate vehicle vibration. It converts vibration energy into thermal energy dissipation through oil throttling. It is a typical fluid-solid-heat coupling problem. A complete three-dimensional flow-structure-thermal coupling dynamics simulation model of a gas-filled fluid-resistance damper was established. The flow-condition-based interpolation (FCBI) method and direct coupling calculation method, the unit's FCBI-C fluid numerical analysis method and iterative coupling calculation method are used to achieve the damper dynamic response of the piston rod under sinusoidal excitation; the air chamber inflation pressure, spring compression characteristics, constant flow passage cross-sectional area and oil parameters, etc. The system parameters, excitation frequency, and amplitude and other excitation parameters are analyzed and compared in detail for the effects of differential pressure characteristics, velocity characteristics, flow characteristics and dynamic response of valve opening, floating piston response and piston rod output force characteristics. Experiments were carried out on some simulation analysis conditions. The results show that the node-based FCBI (flow-condition-based interpolation) fluid numerical analysis method and direct coupling calculation method can better guarantee the conservation of flow field calculation, and the calculation step is larger, but the memory is also larger; if the chamber inflation pressure is too low, the damper will become cavitation. The inflation pressure will cause the speed characteristic hysteresis to increase, and the sealing requirements are too strict. The spring compression characteristics have a great influence on the damping characteristics of the damper, and reasonable damping characteristic needs to properly design the spring compression characteristics; the larger the cross-sectional area of the constant flow channel, the smaller the maximum output force, but the more stable when the valve plate is opening.

Keywords : damper, fluid-structure-thermal coupling, heat generation, heat transfer
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