A rheological interface model for fluid-structure interaction and numerical investigation of controlled flow-induced vibrations

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This contribution discusses extended physical interface models for fluid-structure interaction problems and investigates their phenomenological effects on the behavior of coupled systems by numerical simulation \cite{Legay2009}. Beside various types of friction at the fluid-structure interface the most interesting phenomena are related to effects due to additional interface stiffness and damping. The paper introduces extended models at the fluid-structure interface on the basis of rheological devices (Hooke, Newton, Kelvin, Maxwell, Zener). The interface is decomposed into a Lagrangian layer for the solid-like part and an Eulerian layer for the fluid-like part (see Fig. 1). The mechanical model for fluid-structure interaction is based on the equations of rigid body dynamics for the structural part and the incompressible Navier-Stokes equations for viscous flow. The resulting weighted residual form uses the interface velocity and interface tractions in both layers in addition to the field variables for fluid and structure. The weak formulation of the whole coupled system is discretized using space-time finite elements with a discontinuous Galerkin method for time-integration leading to a monolithic algebraic system. The deforming fluid domain is taken into account by deformable space-time finite elements and a pseudo-structure approach for mesh motion. The sensitivity of coupled systems to modification of the interface model and its parameters is investigated by numerical simulation of flow induced vibrations of a spring supported fluid-immersed cylinder. It is shown that the presented rheological interface model allows control of flow-induced vibrations.

\begin{figure}[h]
\centering
\includegraphics[width=0.8\textwidth]{rheological_layer.png}
\caption{Rheological interface layers}
\end{figure}

References