Fluid-Structure-Acoustic Interactions

Computational analysis of fluid-structure interactions (FSI) represents a considerable challenge for most computational analysis codes. Simple one-way coupled problems, in which the fluid pressure deforms a structure but does not substantially affect the fluid flow characteristics, can be solved by a variety of techniques. Solutions to the more complex two-way coupled fluid-structure interactions are more elusive. These occur when pressure of the flow of fluid deforms a structure in such a way that the resulting deformation alters the flow of fluid. The two-way coupled approach solves this problem and produces accurate, time dependent results.

Through the use of COMSOL Multiphysics, AltaSim Technologies has developed practical solutions to "real world" FSI problems across a wide range of applications in the biomedical, automotive and petrochemical industries. Examples of FSI problems in these industries include: blood flow through flexible systems, characteristic acoustic signatures of valve components, structural vibration due to intermittent transient flow through compressors and control of fluid cavitation in a flowing medium.

COMSOL Multiphysics has been used to develop a specialized multi-physics model describing closure of a valve from a transient pressure pulse. The flow of fluid results in vibration of the valve and associated generation of noise—all of which can predicted using COMSOL Multiphysics.

The FSI solution couples the continuum equations of solid mechanics with the Navier-Stokes equations of fluid mechanics. COMSOL Multiphysics solves these equations simultaneously over the same computational domain using an Arbitrary Lagrangian-Eulerian formulation (ALE). The moving mesh capabilities in the ALE formulation of COMSOL allow a stable solution with increasing the amounts of valve deformation.

Solutions of this type can quantify the influence of "key design variables" of the system. For example, the operating stress experienced by the valve, stream lines of the fluid flow, and acoustic sound pressure levels of the operating valve (Figure 1). Additional results of specific interest to valve designers include the contact force on the valve at closure and the vibration response of the valve during operation.

The results of fully coupled FSI analyses have allowed AltaSim to resolve performance issues with new products prior to mass production, significantly reducing the time and cost of new product development and manufacture.

This work was performed by Dr. S.P. Yushanov, Dr. J.S. Crompton, and Dr. K.C. Koppenhoefer using COMSOL Mulitphysics. For more information please contact: K. Koppenhoefer, AltaSim Technologies, Suite 140 Cascade 1, 130 East Wilson Bridge Rd, Worthington, OH 43085.

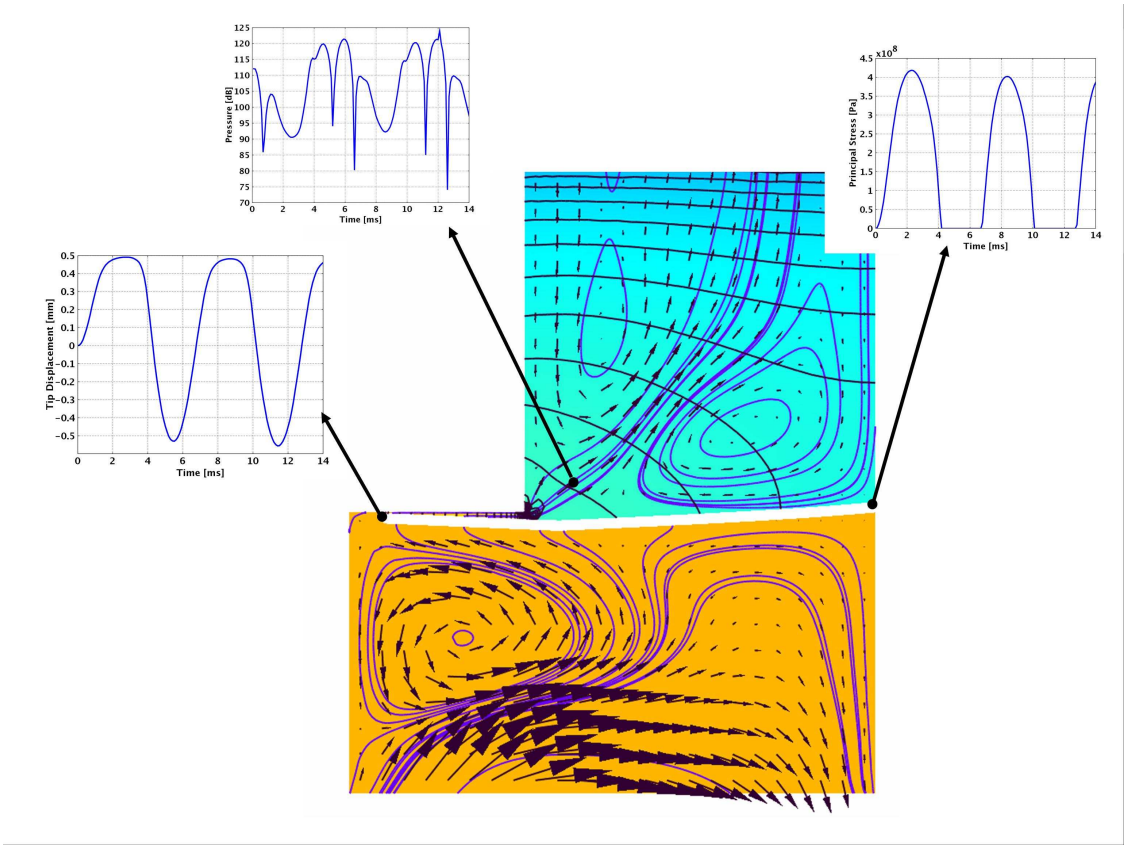

Figure 1. Flexible valve in flow of gaseous fluid forced at a variable pressure. Blue lines are streamlines of velocity field, black lines are pressure contours (in dB)