

A fem matlab code for fluid structure interaction coupling

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Fluid-Structure Interaction: A Comprehensive Overview

What is Fluid-Structure Interaction (FSI)?

FSI examines the interplay between deformable structures and surrounding fluids. It focuses on how the motion of fluids affects the structure and vice versa.

FSI in Multiphysics

In multiphysics simulations, FSI is an important coupling mechanism that connects the fluid dynamics and solid mechanics domains. It enables the exchange of forces, displacements, and other data between these domains.

Formula for Fluid Coupling

The fluid coupling formula represents the interaction between the fluid and the structure:

$$F = -\rho \cdot V \cdot u \cdot (u - v)$$

where:

- F is the force applied by the fluid on the structure
- ρ is the fluid density
- V is the fluid velocity

- u is the structural velocity
- v is the fluid velocity at the fluid-structure interface

FSI in Computational Fluid Dynamics (CFD)

In CFD, FSI helps simulate the flow of fluids around flexible structures. It accounts for the structural deformation caused by the fluid forces and the impact of these deformations on the fluid flow.

Equation for Fluid-Structure Interaction

The fundamental equation for FSI involves the Navier-Stokes equations for fluid flow coupled with the structural deformation equations:

$$\rho \left(\frac{\partial u}{\partial t} + u \cdot \nabla u \right) = -\nabla p + \eta \nabla^2 u + F$$

where:

- u is the fluid velocity
- p is the fluid pressure
- η is the fluid viscosity
- F is the external force (including the force applied by the structure)

Applications of Fluid-Structure Interaction

FSI has wide applications in engineering, including:

- Analyzing the behavior of heart valves
- Simulating the flutter of aircraft wings
- Predicting the dynamics of wind turbines
- Designing fluidic devices with moving parts

Two-Way Fluid-Structure Interaction

Two-way FSI models both the effect of the fluid on the structure and the impact of the structural deformation on the fluid. This allows for a more realistic simulation of the interaction.

Structure of a Fluid Coupling

A fluid coupling consists of two rotating impellers enclosed in a housing. One impeller is connected to the driving shaft, while the other is connected to the driven shaft.

Formula for Coupling

The formula for coupling between two systems (e.g., fluid and structure) is:

$$K = F / X$$

where:

- K is the coupling stiffness
- F is the force transmitted between the systems
- X is the relative displacement between the systems

Types of Fluid Coupling

There are two main types of fluid coupling:

- **Hydraulic coupling:** Uses oil as the working fluid.
- **Hydrodynamic coupling:** Uses the viscosity of the working fluid to transmit torque.

Coupling Interactions

Coupling interactions refer to the exchange of data and forces between different physical domains in a multiphysics simulation.

Fluid-Structure Interaction Pair

In FSI, the fluid-structure interaction pair refers to the deformable structure and the surrounding fluid.

Coupling in Fluid Mechanics

Coupling in fluid mechanics refers to the connection between different aspects of a fluid system, such as the coupling between the flow and heat transfer or the coupling between the fluid and the electromagnetic field.

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