From Plastic Pipes and Bottles to Bioengineering Applications:
Fluid-Structure Interaction Procedures for Flexible Systems

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Abstract

This presentation deals with methods for fluid-structure (FSI) and fluid-structure-fracture interaction (FSFI) and their application to a variety of flexible problems. Here, the term 'flexible' is associated with problems having comparable stiffnesses for both fluid (bulk modulus) and structure (modulus of elasticity) parts in a simulation. For such problems, implicit (strong) coupling is almost unavoidable; a number of iterations in each time step is required to achieve convergence for both domains and the system as a whole. These problems, therefore, represent a perfect environment for softwares capable of solving both fluid and solid problems, such as OpenFOAM - there is no need for interface tool to provide data exchange between domains and implicit coupling is easily achieved.

In order to simulate these complex FSI and FSFI problems, two methods have been developed and improved over last several years by group(s) at Imperial College London and University College Dublin: two-system procedure, where structure and fluid parts are separately solved and information exchanged between them, and one-system procedure, where both structure and fluid parts belong to the same mesh and both systems are treated as a single numerical entity. Two-system FSI procedure has been further developed to account for crack-propagation – FSFI procedure. More details about procedures developed, stability issues, material and fracture models implemented, etc. can be found in [1–3].

FSI applications above were firstly used for prediction of pressure-wave propagation in elastic pipes (waterhammer phenomenon) [1] and drop impact of fluid-filled plastic containers [3, 4]. It was shown that all procedures were capable of solving both problems; pressure and strain predictions were in a very good agreement with experimental data. On the other hand, the FSF procedure was used to simulate crack propagation in elastic pipes caused by impact with a sharp object [5,6], and fracture of bottles caused by high pressure produced by impact with floor [2,7,8]. Again, simulations showed that the developed FSF procedure has the ability to solve these complex problems.

Over past few years, however, the application of procedures developed has been mainly directed towards bioengineering problems. Here, the blood flow related problems, such as atherosclerosis, aneurisms, etc. have been of particular interest (presentation by V.Kanyanta). On the other hand, two-system procedure has been also applied to lung injury problems caused by impact/blust [9]. Here, the procedure is used to simulate wave propagation through lungs on micro level (micro alveoli system), and obtain material and fracture properties. These properties are then used to predict lung injuries caused by impact on macro level. Apart from this on-going project, a current work is also focused on application of FSI procedures to the process of biofilm detachment in bloodstream.

People involved in the past/current work

References


