IEEE Ottawa Section

Simulations of Blood Flow in Artificial and Natural Hearts

Dr. Stavros Tavoularis

Department of Mechanical Engineering, University of Ottawa

The accurate numerical modelling of blood flow in natural vessels and artificial devices requires the simultaneous determination of both the fluid flow and the motion of deformable solid walls because fluid and solid motions are coupled through forces on the boundaries. This problem is widely known as fluid-structure interaction (FSI) and poses significant numerical challenges which are currently being addressed by the international CFD (Computational Fluid Dynamics) research community. The general objective of the present research is to develop efficient and accurate numerical methods for the simulation of natural and artificial cardiovascular organs and devices. Due to the scarcity of experimental results suitable for FSI studies, the research also includes high resolution in vitro measurements in simplified models of such systems.

Using the commercial software package ADINA, we have been able to simulate blood flow in an idealized pulsatile ventricular assist device (VAD) with an elastic diaphragm. Experiments consisting of flow visualization, laser Doppler velocimetry (LDV) and particle image velocimetry (PIV) are in progress using a model constructed out of polished acrylic material and filled with a refractive index matching fluid. Initial studies show the viability of obtaining both experimental and computational results in this idealized device, which allows comparisons to validate the computational results and the adopted FSI approach.

Previous simulations of the heart have generally focussed on either the fluid mechanics of blood or the solid mechanics of the heart muscles. We are currently working on combining these two phenomena into a fully-coupled FSI model of the ventricles of the heart. Two geometries, an idealized left ventricle and a realistic model containing left and right ventricles, are being studied, based on available measurements for canine hearts. To account for the presence of muscle fibres in the heart wall, a transversely-isotropic material model has been devised and validated for use in the computational models. Solid-only simulations have been performed for the idealized geometry, along with preliminary FSI simulations using a simplified material model. Ongoing work includes the extension of the simulations to the realistic geometry, implementing a more realistic material model in the FSI simulations, and extending the FSI simulations to the large deformations commonly found in the heart.

Jan 31, 2008

admission is free

17:30 – 19:00 pm

Mackenzie Building

4359

Carleton University

Light refreshment will be served

Following doctoral studies and a research appointment at The Johns Hopkins University, Professor Tavoularis has, since 1980, been a member of the Department of Mechanical Engineering at the University of Ottawa, where he served terms as Department Chair and Director of the Ottawa-Carleton Institute for Mechanical and Aerospace Engineering. He is Director of the uOttawa Fluid Mechanics Laboratory, supervising a large team of graduate and undergraduate students, postdoctoral fellows and other researchers on a variety of experimental and computational projects concerning turbulence, turbulent mixing, vortex dynamics, aerodynamics, nuclear reactor thermalhydraulics, bio-fluid dynamics, and design of flow apparatus and instrumentation. He has initiated fundamental and applied research projects supported by grants and contracts from NSERC, MRC, NRC, DND, EMR, AECL, NRCan and Pratt and Whitney Canada and has served as a consultant to government and industry. Professor Tavoularis has been elected as a Fellow of the Canadian Academy of Engineering, a Fellow of the Engineering Institute of Canada, a Fellow of the Canadian Society for Mechanical Engineering and a Fellow of the American Physical Society and is a recipient of the George S. Glinski Award for Excellence in Research. He is the author of the graduate textbook *Measurement in Fluid Mechanics*, published by Cambridge University Press, and numerous research articles and reports.

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