8th. World Congress on Computational Mechanics (WCCM8)
5th European Congress on Computational Methods in Applied Sciences and Engineeering (ECCOMAS 2008)
June 30 –July 5, 2008
Venice, Italy

INFLUENCE OF BLOOD MICROSTRUCTURE ON COMPUTATIONAL ANALYSIS AND DESIGN OF BLOOD PUMPS

*** Marek Behr, Mehdi Behbahani, Mike Nicolai and Markus Probst**

Chair for Computational Analysis of Technical Systems (CATS)
CCES, RWTH Aachen University, 52056 Aachen, Germany
{behr,mb,nicolai,probst}@cats.rwth-aachen.de
http://www.cats.rwth-aachen.de

Key Words: *Microstructured Fluids, Hemodynamics, Finite Elements, Shape Optimization.*

ABSTRACT

Modeling and computational analysis play an increasingly-important role in bioengineering, particularly in the design of ventricular assist devices (VAD). The microstructure of the blood as the flowing medium affects the outcome of the analyses to a varying degree, depending on the task at hand.

A set of modeling techniques [1] will be presented which are based on stabilized space-time finite element formulation of the Navier-Stokes equations, with a shear-slip mesh update used to accommodate the movement of the VAD impeller with respect to a non-axisymmetric housing.

This application presents a ripe target for shape optimization and optimal control. In order to assess the influence of the fluid constitutive model on the outcome of shape optimization tasks, a comparison of model problem computations based on the Navier-Stokes equations on one hand, and on a more accurate shear-thinning modified Cross model on the other, will be presented [2].

In order to obtain quantitative hemolysis prediction, cumulative tensor-based measures of strain experienced by individual blood cells must be developed; red blood cells under shear can be modeled as deforming droplets, and their deformation tracked along pathlines of the computed flow field [3].

Even more complex description of blood behavior takes into account viscoelastic phenomena, in particular via an Oldroyd-B constitutive model. Recent developments in stabilized methods of GLS-type for simulation of Oldroyd-B flows using low-order extra-stress interpolations will be outlined [4].

REFERENCES

[1] M. Behr, M. Nicolai and M. Probst. “Efficient Parallel Simulations in Support of Medical Device Design”, in G.R. Joubert et al., editors, *Parallel Computing: Architectures, Algorithms and Applications*, Research Centre Jülich, to appear, 2007.

[3] F. Abraham, M. Behr, and M. Heinkenschloss. “Shape Optimization in Unsteady Blood Flow: A Numerical Study of Non-Newtonian Effects”, *Comp. Meth. in Biomech. and Biomedical Eng.*, Vol. **8**, 201–212, 2005.

[3] D. Arora, M. Behr, and M. Pasquali. “Hemolysis Estimation in a Centrifugal Blood Pump Using a Tensor-Based Measure”, *Artif. Organs*, Vol. **30**, 539–547, 2006.

[4] O.M. Coronado, D. Arora, M. Behr and M. Pasquali. “Four-Field Galerkin/Least-Squares Formulation for Viscoelastic Fluids”, *J. Non-Newt. Fluid Mech.*, Vol. **140**, 132–144, 2006.