Stabilized Finite Element Methods for Computational Design of Blood-Handling Devices

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The development of reliable blood damage (hemolysis) models is a key issue for the virtual design of ventricular assist devices (VADs). Commonly used stress-based hemolysis models assume an instantaneous deformation of red blood cells. Therefore, a strain-based model is considered, which is able to compute the time-dependent (viscoelastic) deformation of the cells.

The flow and hemolysis quantities are computed by stabilized finite element methods. The stabilization theory is critically reviewed and tailored to the individual problem statements. Efficient and accurate variational multi-scale formulations for anisotropic meshes, in combination with discontinuity-capturing, will be presented. Furthermore, we will discuss turbulence modeling with large eddy simulation and the handling of rotating objects with multiple reference frames or moving mesh techniques.

For the hemolysis estimations, we will discuss a logarithm transformation for a viscoelastic tensor equation that is able to improve the convergence of the equation system significantly. The numerical methods will be applied to benchmark devices and state-of-the-art VADs.