Analysis of two-dimensional pulsatile Carreau channel flows

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Various external disturbances such as oscillations from flow pumps are commonly encountered in the chemical process industry while in a solution transfer system. When such disturbances are transmitted to flows, unexpected changes of rheological properties can occur, especially for non-Newtonian complex fluids such as polymer solutions, pastes, or battery slurries. Therefore, it is of great importance to understand the flow characteristics of transient non-Newtonian flows.

Flow properties of pulsatile Carreau flow through a two-dimensional channel were analyzed in detail. In order to perform dimensional analysis, characteristic viscosity for a non-Newtonian flow was proposed, which was used to extend the Womersley number to non-Newtonian fluids. A numerical analysis program using the method-of-lines approach was developed using the open-source platform FEniCS. The pulsatile flows of Carreau fluids were simulated with the developed program under mass flow pulsations of various frequencies. The pressure gradient was analyzed by defining amplitude factor and phase lag, and the two indicators formed a master curve, respectively, with respect to the Womersley number.