Theoretical and Computational Analysis of Pulsatile Flows in Microchannels

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A coating process is generally designed based on the behaviors of the steady-state flows. However, in industrial applications, there are many external disturbances in the process, resulting performance degradations of the final product. Therefore, it is important to understand the transient behavior of flows.

In this study, the transient response of sinusoidal Poiseuille flow is analyzed in both theoretical and computational perspectives. From a theoretical viewpoint, we study the analytic solution of the pulsatile Poiseuille flow in two different ways. First, we derive the asymptotic complex solution. Then, we decompose the solution into the infinite number of modes through eigenfunction expansion. The spatial structures of the modes and convergence rates are studied. Through computational analysis, the validity of the numerical implementation of the finite element method is proven. The numerical solutions are in good agreement with the theoretical solutions in terms of pressure gradients and velocity profiles. Significant indicators such as sinusoidal amplitude, amplification factor, and phase lag are studied with the computational solution.