ANALYSIS OF PULSATILE FLOWS OF COMPLEX FLUIDS IN TWO-DIMENSIONAL CHANNELS

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ABSTRACT

In chemical processes, solutions transported through a series of pipe systems are often exposed to various external disturbances, such as oscillations from flow pumps. The solution transport process is essential when manufacturing high value-added products, where its performance may be significantly affected by changes in the rheological properties or microstructure of complex fluids induced by unpredictable disturbances during transportation. Therefore, it is necessary to understand the flow characteristics of time-dependent complex flows.

There already exists an analytic solution for pulsatile Newtonian flows, and some limiting behaviors of non-Newtonian flows can be anticipated from flow curves. Here, we specifically targeted flow regimes where fluid cannot be simplified to a power-law or Newtonian fluid and where a numerical solution is inevitable, focusing on gaining insights into such flows with the aid of numerical methods. The characteristic viscosity was determined based on steady-state analysis of non-Newtonian flows and was used to form a non-Newtonian Womersley number, which acts as a key model parameter of the system.

Numerical experiments using Carreau fluids with various rheological parameters were conducted to assess the effect of each parameter on flow behavior. Master curves were revealed, exhibiting the amplitude and phase lag dependency on non-dimensional Womersley numbers. Such master curves imply that it is possible to effectively express the competition between viscous and pulsatile time scales by using the proposed non-Newtonian Womersley number. Notably, the shape of the master curve was found to be determined by the degree of shear-thinning. Furthermore, we demonstrate that the flow dynamics can be predicted precisely using precomputed master curves, presenting a novel method for predicting pulsatile flow dynamics of complex fluids without costly transient computations. The proposed approach is expected to be extended to three-dimensional pipe systems to be used in industrial applications[1].

REFERENCES

1. Park, N.; Nam, J. *Physical Review Fluids* **2022**, 7, 123301.