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Exact and Approximate Solutions for Transient Squeezing Flow[1]

JI LANG, SRIDHAR SANTHANAM, QIANHONG WU, Villanova University — In this paper, we report two novel theoretical approaches to examine a fast-developing flow in a thin fluid gap, which is widely observed in industrial applications and biological systems. The problem is featured by a very small Reynolds number and Strouhal number, making the fluid convective acceleration is negligible, while its local acceleration is not. We have developed an exact solution for this problem which shows that the flow starts with an inviscid limit when the viscous effect has no time to appear, and is followed by a subsequent developing flow, in which the viscous effect continues to penetrate into the entire fluid gap. An approximate solution is also developed using a boundary layer integral method. This solution precisely captures the general behavior of the transient fluid flow process, and agrees very well with the exact solution. We also performed numerical simulation using Ansys-CFX. Excellent agreement between the analytical and the numerical solutions is obtained, indicating the validity of the analytical approaches. The study presented herein fills the gap in the literature, and will have a broad impact in industrial and biomedical applications.

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