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A Theoretical and Experimental Study for a Developing Flow in a Thin Fluid Gap[1] QIANHONG WU, JI LANG, KEI-PENG JEN, Villanova University, RUNGUN NATHAN, Penn State Berks, VUCBMSS TEAM — In this paper, we report a novel theoretical and experimental approach to examine a fast developing flow in a thin fluid gap. Although the phenomena are widely observed in industrial applications and biological systems, there is a lack of analytical approach that captures the instantaneous fluid response to a sudden impact. An experimental setup was developed that contains a piston instrumented with a laser displacement sensor and a pressure transducer. A sudden impact was imposed on the piston, creating a fast compaction on the thin fluid gap underneath. The motion of the piston was captured by the laser displacement sensor, and the fluid pressure build-up and relaxation was recorded by the pressure transducer. For this dynamic process, a novel analytical approach was developed. It starts with the inviscid limit when the viscous fluid effect has no time to appear. This short process is followed by a developing flow, in which the inviscid core flow region decreases and the viscous wall region increases until the entire fluid gap is filled with viscous fluid flow. A boundary layer integral method is used during the process. Lastly, the flow is completely viscous dominant featured by a typical squeeze flow in a thin gap. Excellent agreement between the theory and the experiment was achieved. The study presented herein, filling the gap in the literature, will have broad impact in industrial and biomedical applications.

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Qianhong Wu
Villanova University

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