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Author: Dr. Aleksander Grah
ZARM, Germany

Mr. Peter Canfield
ZARM University of Bremen, Germany

FLOW STABILITY EXPERIMENTS ON THE INTERNATIONAL SPACE STATION (ISS)

Abstract

This presentation concerns an ongoing experimental and numerical investigation on capillary channel flow in a compensated gravitational environment. The experiments are performed on the International Space Station (ISS). The flow through a capillary channel is established by suction using a gear pump. The channel consists of glass plates with several configurable geometries (i.e. parallel plates, grooves, and wedge). A fluid meniscus in a parallel conduit 'compensation tube' maintains a constant system pressure. Steady and dynamic pressure effects in the system demand that the free surface curvature adjusts to balance these forces. A maximum flow rate is achieved just as the free surface collapses, leading to a/periodic gas ingestion at the outlet. This critical flow rate depends on the channel geometry, the flow regime and the liquid properties. The principle aim of the experiments is to determine the dynamic free surface shape and maximum flow rate. To study the unsteady liquid loop behavior, dimensionless one- and three-dimensional models were developed. The one-dimensional model is based on unsteady Bernoulli and continuity equations with specific geometry considerations for the surface curvature and flow cross-section. In the case of a steady flow at maximum flow rate, when 'choking' occurs, the surfaces collapse and gas is ingested into the channel. This critical state is related to the Speed Index, where at the critical flow rate the Speed Index reaches the value 1—an analogue to Mach number equal to 1 for compressible flows. Interestingly, unsteady choking does not necessarily lead to surface collapse. We show that temporary Speed Index values exceeding unity may be achieved for a perfectly stable supercritical dynamic flow. The current experiments performed aboard the ISS aim in part to demonstrate the accuracy of the new theory. Variants of the capillary channel geometry allow a range of conduit configurations to be studied. The experiment is housed and conducted in the Microgravity Scientific Glovebox in the Destiny module of ISS and controlled from a Ground Station in Bremen (Germany) via telecommand. Different flow regimes are established and the stability monitored remotely. Thus far the regimes identified consist of steady, unsteady, oscillatory and two phase flows.