Experimental Investigation of Free Liquid Metal Jets in Vacuum

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Experiments are under development at UCLA designed to simulate the liquid slab jets of the HYLIFE-II thick liquid cavity concept. The break-up length and surface will be measured for flows with Reynolds and Weber number of the same scale as that proposed for HYLIFE-II. The experimental setup consists largely of components which are already on hand, including the LM alloy (44.7% Bi, 22.6% Pb, 19.1% In, 8.3% Sn, 5.3% Cd) used in the UCLA MeGA-Loop. After opening of a control valve, the pressure differential between an upper reservoir and the vacuum chamber accelerates the fluid up to the desired speed, 0-16 m/s for initial experiments. A pressure on the order of 100 PSI will be required in the upper reservoir to generate the maximum speed. The discharge will reach steady state by 2 s after initiation, and continue for at least 10 s where data can be taken. The control valve is then closed, before the LM level in the upper reservoir is exhausted, in order to avoid pressurization of the vacuum chamber. The LM in the lower reservoir is then recirculated to the upper reservoir and the experiment run again.

The use of a liquid metal alleviates concerns regarding cavitation during the entrance into vacuum, and allows near Reynolds and Weber Number similarity at a significantly reduced size (4.4 x 22 mm) and flowrate (1.6 l/s at 16 m/s) of the jet. Calculations with the RIPPLE (ref. 1) program have shown that at these dimensions, the jet will not significantly deform in the working region due to influence of surface tension and so the slab character of the jet is retained.

Measurements of surface ripple and break-up length will be made based on photographic images of the flow from a high speed camera and flash, and flowrate data obtained from a real-time flowmeter. The experiment can be run with a selection of nozzles and upstream conditioners in order to determine the optimum configuration for suppressing disturbances. Data is expected to aid in the proof-of-principle for thick liquid cavity designs, provide insight into design requirements of such systems, and increase the fundamental understanding of turbulent liquid jet flow in vacuum.

1. R.B. Kothe, R.C. Mjolsness and M.D. Torrey, RIPPLE: A computer program for incompressible flows with free surfaces, LANL Report LA-12007-MS, 1991.