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# REPORT OF TECHNICAL PROGRESS FY 1992
# FOR
# CHARACTERIZATION OF JET BREAKUP MECHANISMS OBSERVED FROM SIMULANT EXPERIMENTS OF MOLTEN FUEL PENETRATING COOLANT
# (DE-FG07-89ER12900)

## Introduction

The goal of this research program has been to add to our understanding of the breakup of molten fuel jets penetrating reactor coolant. Easily handled working fluids are used to simulate fuel jet breakup, so that detailed observations may be obtained from a relatively large number of experiments. The tools used for observing this behavior are high speed motion picture photography, Flash X-radiography, and X-ray cine. Jet breakup lengths are determined from motion pictures; the mechanisms by which the jets are fragmented may be inferred from radiographs.

At the end of the last reporting period, eight experiments had been completed. In each experiment, a single jet of molten Cerrobend (a Bi-Pb-Sn-Cd alloy, melting point 70 °C) was poured into a pool of room-temperature Freon-11 at roughly atmospheric pressure. Breakup lengths in those experiments were in good agreement with the empirical relation obtained from earlier experiments with water jets in Freon-11 and liquid nitrogen by Saito et. al. Preparations were underway for X-radiography using a flash X-ray system.

## Objectives and Accomplishments

Our objectives for this year have been:

1) Obtain additional breakup length data to confirm agreement with the correlation of Saito et. al.;
2) Observe the breakup of an array of three jets;
3) Evaluate the efficacy of X-radiography by using a flash X-ray system;
4) Observe the dynamics of jet fragmentation using the X-ray cine system.

A breakup length correlation applicable to high jet/coolant density ratio systems is obviously a useful benchmark for validation of fragmentation models. It was therefore important to obtain additional breakup length data. This year, 23 experiments with single jets were completed. Breakup lengths were determined for 17 of these. The data are in general agreement with the Saito correlation.

Our interpretation of the physical basis of this correlation suggested that the breakup lengths for an array of jets would be comparable to that of a single jet. In order to test this interpretation, 17 experiments were conducted using three jets placed 1.5 to 20 diameters apart. No correlation of breakup length with jet spacing was detected. Breakup lengths were comparable to those of the single jets.

X-radiography using a flash X-ray system has been used in most experiments this year, with some success.

Frequently, the X-ray beam is too much attenuated by the liquid Freon-11 to provide recognizable images. However, in the few experiments where the path of the beam was highly voided at the time of exposure, the fragmenting jet was shown on 8x10 inch X-ray film with excellent resolution. The radiographs suggest that erosion of the vertical surfaces of the jet, due to Kelvin-Helmholtz instability, is the dominant fragmentation mechanism.

The flash X-ray system was utilized in more experiments than was originally anticipated, because it allowed simultaneous motion picture photography (and hence breakup length determination), which is not possible with the X-ray cine system.

The results of the experiments completed to date are summarized in the attached draft paper, "Breakup of Metal Jets Penetrating a Volatile Liquid," submitted for NURETH-5.

## Work Planned

Our experience with the flash X-ray system indicates that useful images should be obtainable from the X-ray cine system, although the resolution possible with high speed 16 mm motion picture film is not comparable to that of the 8x10 inch X-ray film. However, it is anticipated that X-ray cine film will show the dynamics of fragmentation, which will complement the high resolution still images already obtained.

A small number of experiments using this system are planned for the balance of this research program.

## Summary

The experiments with single jets and related analysis are to be published in a Ph.D. thesis. The three-jet experiments are the subject of an M.S. thesis (in preparation).

The present experiments have concentrated on the breakup of a jet enshrouded by a large diameter vapor counterflow. However, the breakup of a jet separated from the coolant only by a thin vapor film is also of interest. This type of breakup may occur if the reactor coolant is under high pressure and/or is highly subcooled. Investigation of this breakup regime would be the logical extension of the work completed to date.

# END

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