COO-2781-12

FUEL COOLANT THERMAL INTERACTION PROJECT

UC 79P

Massachusetts Institute of Technology
Department of Nuclear and Mechanical Engineering

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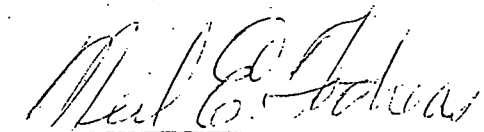

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DISCLAIMER

Reports and Papers Published under
MIT Fuel-Coolant Interaction Project

(This project was funded until June 30, 1975 by ANL and reports issued as 31-109-38-2831-XX; starting July 1, 1975 reports were issued as COO-2781-XX)

Progress Reports (Available from National Technical Information Service, U.S. Department of Commerce, Springfield, Va. 22151)

W.F. Lenz, G. Shiralker and N. Todreas, Fuel Coolant Thermal Interaction Project UC 79P, COO-2781-1, Nov. 1975.

W.F. Lenz, G. Shiralker and N. Todreas, Fuel Coolant Thermal Interaction Project UC 79P, COO-2781-2, Feb. 1976.

G. Shiralker, W.F. Lenz and M. Corradini, Fuel Coolant Thermal Interaction Project UC 79P, COO-2781-3, April 1976.

G. Shiralker, W.F. Lenz and M. Corradini, Fuel Coolant Thermal Interaction Project UC 79P, COO-2781-5, Oct. 1976.

G. Shiralker, W.F. Lenz and M. Corradini, Fuel Coolant Thermal Interaction Project UC 79P, COO-2781-10, Dec. 1976.

M. Corradini, Fuel Coolant Thermal Interaction Project UC 79P, COO-2781-12, Jan. 1977

Reports Issued under this Contract

Topical Reports (Available from National Technical Information Service, U.S. Department of Commerce, Springfield, Va. 22151)

Mujid S. Kazimi, "Theoretical Studies on Some Aspects of Molten Fuel-Coolant Thermal Interaction," 31-109-38-2831-1TR, MITNE-155, May 1973.

Charles E. Watson, "Transient Heat Transfer Induced Pressure Fluctuations in the Fuel-Coolant Interaction," 31-109-38-2831-2TR, MITNE-156, August 1973.

Trond A. Bjornard, "An Experimental Investigation of Acoustic Cavitation as a Fragmentation Mechanism of Molten Tin Droplets in Water," 31-109-38-2831-3TR, MITNE-163, May 1974.

Glen Bjorkquist, "An Experimental Investigation of the Fragmentation of Molten Metals in Water," 31-109-38-2831-4TR, June 1975.

Roland B. Knapp, "Thermal Stress Initiated Fracture as a Fragmentation Mechanism in the UO_2-Sodium Fuel-Coolant Interaction," 31-109-38-2831-5TR, May 1975.

Michael Corradini, "Prediction of Minimum UO_2 Particle Size Based on Thermal Stress Initiated Fracture Model," COO-2781-4TR, August 1976.

M. Kazimi, C. Watson, D. Lanning, W. Rohsenow, N. Todreas, "Acoustic Cavitation as a Mechanism of Fragmentation of Hot Molten Droplets in Cool Liquids," COO-2781-6TR, November 1976.

Gautam S. Shiralkar, "An Investigation of the Fragmentation of Molten Metals Dropped into Cold Water," COO-2781-7TR, November 1976.

William F. Lenz, Jr. "Mixing Requirements for the Limiting Fuel-Coolant Interactions in Liquid Metal Fast Breeder Reactors," COO-2781-8TR, November 1976

M. Corradini, A.A. Sonin, N. Todreas, "A Proposed Heat Transfer Model for the Gas-Liquid Heat Transfer Effects Observed in the Stanford Research Institute Scaled Tests," COO-2781-9TR, December 1976.

M. Corradini, W.M. Rohsenow, N.E. Todreas, "Application of Spontaneous Nucleation Theory to Tin-H_2O Interactions," COO-2781-11TR, January 1977.

Reports Issued under this Contract

Papers and Summaries

M.S. Kazimi, N.E. Todreas, D.D. Lanning and W.M. Rohsenow, "A Criterion for Free-Contact Fragmentation of Hot Molten Materials in Coolants," Transactions of the American Nuclear Society, Vol. 5, No. 2, p. 835, November 1972.

M.S. Kazimi, N.E. Todreas, W.M. Rohsenow and D.D. Lanning, "A Theoretical Study of the Dynamic Growth of a Vapor Film Around a Hot Sphere in a Coolant," Fifth International Heat Transfer Conference, Tokyo, 1974.

T.A. Bjornard, W.M. Rohsenow and N.E. Todreas, "The Pressure Behavior Accompanying the Fragmentation of Tin in Water," Transactions of the American Nuclear Society, Vol. 19, pp. 247-248, 1974.

R. Knapp and N. Todreas, "Thermal Stress Initiated Fracture as a Fragmentation Mechanism in the UO_2-Sodium Fuel-Coolant Interaction," Nuclear Engineering and Design 35, pp. 69-85, 1975.

I. Mechanisms Responsible for Fragmentation in Molten Metal Droplet Experiments (Michael Corradini)

The work in this area has been submitted in a topical report COO-2781-11TR, "Application of the Spontaneous Nucleation Model to Tin Water Experiments". The major thrust of the report is to:

i) Review the large amount of experimental data accumulated for the tin-water system. A number of independent variables have been identified which affect the degree of interaction (extent of fragmentation and peak pressure generation) for tin-H_2O; initial fuel temperature, initial coolant temperature, size of mass, shape of the mass of tin, and the effects of external triggers on the interaction.

ii) Review the theories advanced to explain this behavior with special emphasis on the spontaneous nucleation model.

iii) Compare the tin-water results to the four criteria of the spontaneous nucleation model.

Specifically it has been observed in the UCLA tin dropping experiments that the tin noticeably deforms in shape before the interaction occurs. In fact the interaction begins at these

extended projections from the bulk and then proceeds to rest on the tin mass. One of the criterion of the sponteneous nucleation model for an energetic FCI is to have the fuel-coolant interface temperature above the sponeaneous nucleation temperature and below the critical temperature of the coolant. The upper bound of this criterion was compared to tin-water results by performing a transient cooling analysis on the tin mass. The projections were idealized as cooling fins. The results indicated that the tin-water interface does cool below $T_{critical}$ for water before the interaction was initiated at the fin projection. The origin of these projections appear to be caused by either drop deformation due to inertial forces or tin-oxide surface formation, subsequent cracking and drop deformation.

Based on this short analysis it appears that the set of necessary criterion for an energetic FCI from the spontaneous nucleation model are consistent with tin-H_2O data.

II. Thermal Stress Initiated Fracture

No additional work is planned in this area.

III. Possible Mechanisms of Heat Transfer to Cold Walls and Fluid in Reactor Vessel

(Michael Corradini)

No additional work has been done in this area during this reporting period.