MASTER

NYO-3906-6

ULTRASONIC THERMOMETRY IN LMFBR SYSTEMS

Sixth Quarterly Progress Report

Contract AT(30-1)-3906

Covering the Period Ending March 1969

Work performed for

Development Contracts Division
U. S. Atomic Energy Commission
New York Operations Office
New York, New York

March 1969

by

S. Fam.
L. C. Lynnworth
E. H. Carnevale

This report was prepared as an account of work sponsored by the United States Government. Neither the United States nor the United States Atomic Energy Commission, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness or usefulness of any information, apparatus, product or process disclosed, or represents that its use would not infringe privately owned rights.

PANAMETRICS, INC.
221 Crescent Street
Waltham, Massachusetts 02154

647 6000

This document is

PUBLICLY RELEASABLE

Larry E. Williams
Authorizing Official

Date: 05/31/2007

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency Thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

SUMMARY

The progress achieved during the sixth quarter, January-March, 1969, may be summarized as follows:

1) A model of a complete ultrasonic/thermocouple composite sensor was presented to GE at a meeting held on Jan. 7, 1969 at GE-NPS (Evendale). Two composite probes were subsequently received and tested. The two probes fell short of expectations primarily because of construction details at the hot and cold joints. The ultrasonic signals exhibited pronounced signal "roll" and interference, which made the identification of sensor weld and end echoes impractical (Figs. 1-5). Consequently, a new test geometry (Fig. 6), which allows the ultrasonic probe and W/Re thermocouple to perform independently of each other, was submitted to GE-NPS. Another possibility is a smaller dia. (0.005") wire properly positioned tie-on at the cold junction.

2) Anodized aluminum coils were tested at 500° F for 120 hrs., 600° F for 114 hrs., and 700° F for 100 hrs, with no significant signal degradation.

LABORATORY TEST PROGRAM

Two composite W-Re thermocouple/ultrasonic composite probes were tested in the laboratory and found to be unsatisfactory. The thermocouples consisted of a beryllia-insulated W-25 Re leg which doubled up as the ultrasonic lead-in, and a W-3Re side leg welded to it at the hot end. In the first thermocouple, however, the W-25Re lead-in wire and the W-3Re side leg were twisted around each other to preserve the integrity of the hot junction at high temperature (Figs. 1-4). This type of joint had not previously been envisioned for the test probe and, upon testing in the laboratory, yielded a pronounced signal "roll" which made the identification of sensor weld and end echoes impossible (see Fig. 5b). Furthermore, a sizable reflection was obtained from the cold junction weld (Fig. 5a). The amplitude of this reflection was greater than any of the weld reflections obtained in the sample geometries tested so far, and subtracted from the sensor signal amplitudes which were on the order of 200 mV.

The second, reworked, thermocouple exhibited similar characteristics although this time the W-25Re lead-in wire and the W-Re side leg were not twisted around each other. The sensor signals exhibited some "roll" and were on the order of 200 mV. These effects were due to the fact that the cold junction tie-on was placed approximately 3/8" downstream from the remendur - W/25Re weld, and that the hot junction tie-on was ~1/4" up from the W/25Re to Re sensor weld. Ultrasonic considerations require that both knots be as close to the respective welds as possible, within ~1/32" to 1/16". Furthermore, the rhenium sensor appears to have been slightly crimped at the weld area for added structural integrity.

While recognizing the difficulties inherent in the construction of the probe, it appears that the present compromise design may unnecessarily handicap the performance and reliability of the ultrasonic thermometer. Consequently, a new test geometry was conceived which allows the ultrasonic probe and the W/Re thermocouple to perform independently of each other (Fig. 6). The heart of the new design is a 3-hole hafnia insulator. This design apparently may be difficult to fabricate.* Another possibility is a smaller dia (0.005") wire properly positioned tie-on at the cold junction. Preliminary tests with this geometry were successful.** While water transport problems necessitated the use of larger diameter wire (0.010") at the hot junction, the cold junction apparently could still operate with a 0.005" dia tie-on.

A copy of the accompanying sketch (Fig. 6) was mailed to GE-NPS for evaluation and delivery estimates. Owing to experimental difficulties in the ORTC tests, it was not possible to agree to a detailed schedule of operations.

Short term tests were performed to determine the behavior of the anodized aluminum coils at high temperature under both thermal shock and steady state conditions. The coils were placed in an air-atmosphere oven and heated to a temperature of 500° F as measured by

* W. C. Kuhlman, GE-NPS - Private communication

** NYO-3906-5, Fifth quarterly progress report, Dec. 1968.

a type K thermocouple placed alongside the coil. Continuous monitoring of the signals for the full duration of the tests (2 hours) revealed no significant changes in amplitude due to the coil. The coils were then abruptly removed from the oven and exposed to air at room temperature, simulating thermal shock conditions. No signal degradations were observed. Subsequent long term tests were performed using a similar arrangement. Seven anodized aluminum coils were tested at 500°F for 120 hrs, two coils at 600°F for 114 hrs, and two coils at 700°F for 100 hrs. No significant signal degradation was observed for the full duration of the tests. A 1000 hr test on 4 coils at 500°F is expected to terminate April 10th at 0340 hrs.

ACKNOWLEDGMENT

The assistance of W. C. Kuhlmann, W. G. Baxter and others at GE Company, Evendale, Ohio in the construction of the composite sensor, and their continuing cooperation, is gratefully acknowledged.

Figure 1. Composite thermocouple/
ultrasonic sensor. Top: portion of
line including hafnia-insulated W/Re
lead-in legs, and 2" Re sensor ex-
tending from thermocouple junction.
Bottom: ultrasonic magnetostrictive
transducer attached to thermocouple
line. Photos courtesy General Electric.

← Figure 2. Transducer coil wound of 0.006" dia anodized aluminum wire, and fixed onto alumina tube bobbin with Sauereisen cement. A more recent design uses alumina cement.

Figure 3. Thermocouple twist provides secure connection near rhenium sensor, but interferes with sensor echoes if contact is too massive, lengthy or if twist distorts lead-in.

0.023" dia
Nickel transducer

← Figure 4. Thermocouple twist and brazed joint near transducer end interferes with sensor echoes if it is too massive or lengthy.

Weld echo near transducer

(a) 20 $\mu\text{sec}/\text{cm}$, 200 mV/cm

(b) 10 $\mu\text{sec}/\text{cm}$, 200 mV/cm

Figure 5. Signals obtained from composite probe constructed by GE-NPS.

Figure 6. Rough sketch of proposed test geometry (partially exploded for clarity)