NON-UNIFORM HEAT GENERATION
EXPERIMENTAL PROGRAM

Quarterly Progress Report No. 3

January - March 1964

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AEC Contract No. AT(30-1)-3238
B&W Contract No. 59-3090

Submitted to
THE UNITED STATES ATOMIC ENERGY COMMISSION
by
THE BABCOCK & WILCOX COMPANY
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PREFACE

The Babcock & Wilcox Company and the United States Atomic Energy Commission acting for the Joint U.S.-Euratom Research and Development Board signed an agreement for a non-uniform heat generation experimental program.

The program includes experimental and analytical investigations to determine how non-uniformly distributed heat flux along lengths of tubular and annular channels affects the onset of burnout (departure from nucleate boiling). The experimental program is being conducted on the 1.8-MW heat transfer facility at B&W's Research Center, Alliance, Ohio. The analytical program is being conducted by the Atomic Energy Division, Lynchburg, Virginia.

The third calendar quarter of this program has been spent designing, procuring, fabricating, and modifying the heat transfer facility. Sufficient design work, procurement, and facility modification have been completed so that test work can begin and experimental data can be obtained.

ABSTRACT

The Babcock & Wilcox Company, as part of the Joint U.S.-Euratom Research and Development Program, is conducting experimental and analytical investigations to determine the effects of irregular heat flow through reactor channels on the operating conditions that cause burnout (departure from nucleate boiling). This program seeks to improve design correlations that will be suitable for direct use by reactor designers. Tubular specimens having four axial power shapes and annular specimens having five power shapes will be used, and an effort to correlate the experimental data with empirical and analytical models will be made.

The third quarter of this program has been spent designing, procuring, fabricating, and formulating plans in preparation for the initial test work. The instrumentation, bus bars, piping, and Test Section No. 1 are complete for the first test and installed except for the final connections, which will be made when the loop is shut down. Also, after failing to obtain a satisfactory outside bid for the work, machine work on the non-uniform test sections was started.

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1. INTRODUCTION

Nuclear reactors and modern boilers require more and more knowledge about the limitations on the transfer rates of heat from channel walls to flowing liquids. Burnout (departure from nucleate boiling) is a very serious design problem still facing the reactor designer. The result of this phenomenon is that the heat transfer conductance is reduced considerably, causing the metal and fuel temperatures to rise and initiate failure of the fuel element. Although considerable attention has been given to this problem in recent years, the predictability of the occurrence of burnout conditions is quite uncertain. In fact, there is still much disagreement on the effect of the channel geometry and operating conditions upon burnout.

In an effort to clarify some of the areas of disagreement, Babcock & Wilcox (B&W), as part of the Joint U.S. -Euratom Research and Development Program, is conducting an experimental and analytical program to determine the effects of non-uniform heat generation rates in tubular and annular flow channels on the operating conditions causing burnout under experimental conditions representative of water reactor systems. The objective of the program is to seek improved design correlations suitable for direct use by reactor designers. The technical approach to the work emphasizes the development of an improved understanding of the physical phenomena involved and their relation to design variables.

The experimental program, which was discussed in the first quarterly report (BAW-1287)*, will be conducted on a B&W heat transfer facility at its Research Center in Alliance, Ohio. The controlled variables

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* D. F. Judd et al, Non-Uniform Heat Generation Experimental Program, Quarterly Technical Report No. 1, The Babcock & Wilcox Company, BAW-1287, Lynchburg, Virginia, July - September 1963.

for the tests are pressure, inlet subcooling, and mass velocity. These variables will be investigated over the ranges of from 1000 to 2000 psia pressure, 0.5×10^6 to 2.5×10^6 lb/hr-ft² velocity, and 20 to 150 F subcooling. The tests will be performed in 6-foot-long tubular and annular test sections having both uniform and non-uniform axial heat flux distributions. The analytical program will then be conducted by the Atomic Energy Division in Lynchburg, Virginia.

Problems that developed in the power supply have not been completely remedied; however, the power supply is operating satisfactorily for the start of this test work. Early in the next quarter, the test facility will be shut down for final modifications and installation of the test section.

2. PROGRAM

2.1. Test Facility Modifications

All modifications to the test facility are complete except for the final connections. The loop is scheduled to be shut down early in the next quarter for final installation and the start of the test work.

2.2. Test Sections

The dimensions of the tubular and annular test sections were reported in the second quarterly report (BAW-1291)*.

Since acceptable outside bids could not be obtained, fabrication of the non-uniform tubular test sections was started. The non-uniform heat generation shape is being formed by machining a series of conical surfaces based on the test section dimensions referenced in BAW-1291*. The primary problem is the tolerance of $2-1/2\%$ on the azimuthal wall variation. To find the cheapest method of achieving this $2-1/2\%$ tolerance, the Alliance Research Center is using two measuring and machining techniques in machining the first test section.

The design of the tubular test sections has been modified by placing a tube connector in the inlet piping joining the heated section. This modification facilitates machining and handling ease and enables the test section to be removed from the test facility, reversed, and then used for subsequent testing. This modification also suggests additional investigations on the effect of an approach section formed by installing tubes having different diameters in the $3-1/2$ -foot section. Figure 1 shows the voltage tap spacing to be used on all tubular test sections. This arrangement will locate the burnout position within ± 3 inches.

Detailed design work on the annular test sections has been started.

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* D. F. Judd, et al, Non-Uniform Heat Generation Experimental Program, Quarterly Technical Report No. 2, The Babcock & Wilcox Company, BAW-1291, Lynchburg, Virginia, September - December 1963.

Figure 1. Schematic of Tubular Test Sections

3. PROGRAM SCHEDULE

The schedule in Figure 2 indicates the work to be done during the next two quarters.

Figure 2. Schedule of Non-Uniform Heat Program

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