Atomics International Division
Rockwell International

U

CLASSIFICATION LEVEL
(S, C OR U)

DOCUMENT NO.

TI-759-240-016

COVER SHEET

DOCUMENT TITLE

Effect of Cladding Wall Thickness and Gas Gap Width on
Circumferential Temperature Gradients and Film
Coefficients for Rod Bundles having a P/D = 1.00

AUTHOR

A. R. Marchese

NOTICE
This report was prepared as an account of work sponsored by the United States Government. Neither the United States nor the United States Energy Research and Development Administration, 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.

THIS IS AN INTERNAL WORKING
DOCUMENT AND MAY BE
EXPANDED, MODIFIED, OR
WITHDRAWN AT ANY TIME.

~~IT IS INTENDED FOR
INTERNAL USE ONLY.~~

CLASSIFICATION TYPE
(RD OR DI)

~~THIS REPORT MAY NOT BE PUBLISHED WITHOUT THE APPROVAL OF THE PATENT BRANCH, AEC.~~

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.

U

CLASSIFICATION LEVEL
(S, C OR U)

MASTER

DO NOT REMOVE THIS SHEET DISTRIBUTION OF THIS DOCUMENT UNLIMITED

CB

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.

Atoms International
Full Service Bureau

SUPPORTING DOCUMENT

NUMBER

TI-759-240-016

REV LTR/CHG NO

SEE SUMMARY OF CHG

PROGRAM TITLE

ZrH Core Test Reactor Program

DOCUMENT TYPE

Technical Information

KEY NOUNS

SNAP, Liquid Metal Heat Transfer

DOCUMENT TITLE Effect of Cladding Wall Thickness and Gas Gap Width on Circumferential Temperature Gradients and Film Coefficients for Rod Bundles having a P/D = 1.00.

ORIGINAL ISSUE DATE October 29, 1970

GO NO.

7759

S/A NO.

13420

PAGE 1 OF

TOTAL PAGES 6

REL. DATE 10/30/70

PREPARED BY DATE

A. R. Marchese

DEPT

731-134

MAIL ADDR

LB29

APPROVALS

DATE

10/21/70

SECURITY CLASSIFICATION

(CHECK ONE BOX ONLY)

UNCL

☒

CONF.

☐

SECRET

☐

AEC

DOD

RESTRICTED

DATA

DEFENSE

INFO.

☐☐

AUTHORIZED CLASSIFIER

E. Donovan

DATE

10/21/70

DISTRIBUTION

ABSTRACT

* NAME	MAIL ADDR
J. G. Asquith	LB02
A. Baumgartner	LB25
J. Brunings	LB41
W. Dauterman	LB25
E. J. Donovan	LB25
L. D. Felten	LB25
L. M. Maki	LB03
E. Moody	LB25
D. K. Nelson	LB29
C. A. Rice	LB25
G. L. Schmidt	T006
R. P. Varnes	LB14

For the case of NaK flowing in-line through a rod bundle with P/D = 1.00, calculations are presented showing the effect of cladding wall thickness and gas gap width on the azimuthal temperature gradient and convective film coefficient. Calculations are given for a typical set of test reactor conditions.

RESERVED FOR PROPRIETARY, LEGAL NOTICES

* TITLE PAGE ONLY

I. INTRODUCTION

The effect of cladding wall thickness and gas gap width on the circumferential temperature gradient for a SNAP type fuel element at $P/D=1.00$ has been examined. The results, which have been extracted from Tables 10 and 11 of TI-568-24-054,¹ are shown plotted in Figures 1 and 2. Because of the dimensionless presentation, these results are valid in any core region for both S8DR and the Test Reactor provided the conditions listed in Figures 1 and 2 are satisfied. For Test Reactor Conditions corresponding to the current design, center element, $Z/L = 0.5$; calculations are presented in Figure 3 showing the variation of maximum circumferential temperature gradient and film coefficient with the cladding wall thickness.

II. NOMENCLATURE

- D_h = hydraulic diameter, ft.
- $\bar{h}$ = rod-average film coefficient, Btu/hr-ft² - °F.
- k_{Clad} = cladding thermal conductivity, Btu/hr-ft-°F.
- $\bar{q}_{Clad}$ = circumferential average heat flux at cladding outer surface, Btu/hr-ft².
- R_{Clad} = outer radius of cladding, ft.
- ΔR_{Clad} = cladding wall thickness, ft.
- $\Delta R_{Gas\ Gap}$ = gas gap width (radial), ft.
- $\Delta T(\theta)_{max.}$ = maximum circumferential temperature difference $[T(\theta=0^\circ) - T(\theta=30^\circ)]$, °F.

III. RESULTS

A. Figure 1

Variation of Non-Dimensional Circumferential Cladding Temperature Gradient and Nusselt Number with Dimensionless Cladding Wall Thickness

$$\begin{aligned} \text{For: } k_{Fuel} &= 12.0 \text{ Btu/hr-ft-}^\circ\text{F} \\ k_{Gas} &= 0.25 \text{ " } \\ k_{Barrier} &= 1.00 \text{ " } \end{aligned}$$

- 1) Marchese, A. R., "Analytical Study of Heat Transfer to Liquid Metals Flowing Parallel Through Tightly Packed Fuel Rod Bundles", TI-568-24-054, April 20, 1970

$$\begin{aligned} k_{\text{NaK}} &= 14.9 \text{ Btu/hr-ft-}^{\circ}\text{F} \\ \Delta R_{\text{Gas Gap}} &= 0.0035 \text{ in.} \\ \Delta R_{\text{Barrier}} &= 0.0020 \text{ in.} \end{aligned}$$

B. Figure 2

Variation of Non-Dimensional Circumferential Cladding Temperature Gradient and Nusselt Number with Dimensionless Gas Gap Width.

For:

$$\begin{aligned} k_{\text{Fuel}} &= 12.0 \text{ Btu/hr-ft-}^{\circ}\text{F} \\ k_{\text{Gas}} &= 0.25 \text{ " } \\ k_{\text{Barrier}} &= 1.00 \text{ " } \\ k_{\text{NaK}} &= 14.9 \text{ " } \\ \Delta R_{\text{Barrier}} &= 0.002 \text{ in.} \\ \Delta R_{\text{Clad}} &= 0.0113 \text{ in.} \end{aligned}$$

C. Figure 3

Variation of Maximum Circumferential Temperature Gradient and Average Film Coefficient with Cladding Wall Thickness for a Typical Set of Test Reactor Conditions:

$$\begin{aligned} \overline{q''}_{\text{Clad}} &= 47,800 \text{ Btu/hr-ft}^2 \\ k_{\text{Fuel}} &= 12.0 \text{ Btu/hr-ft-}^{\circ}\text{F} \\ k_{\text{Gas}} &= 0.25 \text{ " } \\ k_{\text{Barrier}} &= 1.00 \text{ " } \\ k_{\text{Clad}} &= 12.6 \text{ " } \\ k_{\text{NaK}} &= 14.9 \text{ " } \\ \Delta R_{\text{Gas Gap}} &= 0.006 \text{ in.} \\ \Delta R_{\text{Barrier}} &= 0.002 \text{ in.} \\ R_{\text{Clad}} &= 0.304 \text{ in.} \end{aligned}$$

Figure 1. Variation of Non-Dimensional Circumferential Cladding Temperature Gradient and Nusselt Number with Dimensionless Cladding Wall Thickness

NO. 17555N

Figure 2. Variation of Non-Dimensional Circumferential Cladding Temperature Gradient and Nusselt Number with Dimensionless Gas Gap Width

NUSSELT NO. $(h D_h / k_{N_2 K})$

Figure 3. Variation of Maximum Circumferential Temperature Gradient and Average Film Coefficient with Cladding Wall Thickness for a Typical Set of Test Reactor Conditions

$P/D = 1.00$
TURBULENT FLOW