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AUTHOR

E. D. Waters
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HYDRAULIC DEMAND CURVES FOR K-REACTOR
GEOMETRY AT LOW TUBE POWERS

By
E. D. Waters
and
D. E. Fitzsimmons

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HYDRAULIC DEMAND CURVES FOR K-REACTOR
GEOMETRY AT LOW TUBE POWERS

INTRODUCTION

The outlet water temperature limits for the Hanford production reactors are based, among other things, on the ability to prevent excessive fuel temperatures during or following inadvertent flow losses or power surges. The analyses involved in the determination of the limits are dependent upon laboratory heat transfer experiments which closely simulate actual reactor conditions in a single process tube. The heat transfer experiments are quite complex in that they involve the recording of rapid changes in pressure, temperature, flow, and heat generation rates. As a preliminary to these transient heat transfer experiments, selected steady state experiments are performed to better plan the experimental program and to aid in the analysis of the problem.

This document presents the results of some steady state experiments performed at low tube powers for K reactor. The results are reported separately from the transient experiments because the data are useful for reactor problems involving shutdown cooling and are also of value to people interested in pressure drop of two phase mixtures.

SUMMARY

Experiments were conducted with the Low Pressure Heat Transfer Apparatus of Thermal Hydraulics Operation to determine the pressure-flow relationships for a K-reactor process channel at very low heat generation rates. Hydraulic demand data were obtained for steady state heat transfer conditions with tube powers of 50, 100, 200 and 300 KW. The experiments utilized a test section simulating a 38 piece K-III I & E fuel charge in a standard K process tube with a standard K outlet fitting assembly. Inlet water temperatures of 20 to 24 C and a rear header pressure of 15 psig were used during the experiments.

Tube inlet pressure demand data are presented on Figures 1 and 2. Data which show the pressure drop across the active (heated) section are presented on Figure 3. These data will be useful in the analysis of laboratory data from transient heat transfer experiments which involve low heat generation rates. They will also be useful in determining the adequacy of reactor coolant supply pressures during shutdown conditions.

EXPERIMENTAL METHOD

The experiments were conducted with the 189-D heat transfer apparatus with nuclear heat being simulated by d.c. electrical heating in a metal "rod." The heater rod dimensions (1.447 inch O.D. by 0.391 inch I.D.) were selected to be approximately midway between those of K-III-N and K-III-E I & E fuel elements after a 0.010 inch reduction of the O.D. as an allowance for the "Heresite" electrical insulation coating on the inside of the standard K process tube. The heater rod had a stepped cosine power distribution with a peak power to

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average power ratio of 1.43. The outlet fitting assembly utilized standard K reactor rear fittings. The entire assembly is a prototype of an actual reactor channel except that the downstream dummy section of the process tube is offset from the active (heated) section to allow the necessary electrical connections.

A series of data points were obtained for each tube power by recording data for steady state conditions at various flow rates. For each tube power, at least two data points were obtained with the flow rate low enough to cause film boiling on the heater rod surface, as indicated by a large increase in the heater rod metal temperature with small flow reduction.

DISCUSSION OF RESULTS

Data are presented on Figure 1 for 50 and 100 KW and on Figure 2 for 200 and 300 KW tube powers. These figures show tube inlet pressure as a function of the square of the flow rate. The curves illustrate the increased pressures which are necessary to sustain flow as the flow rate is reduced and boiling occurs along the heated section and flashing occurs in the outlet fittings. The change in scale between Figures 1 and 2 tends to conceal the large variations in tube inlet pressure which result from a change in tube power or flow rate. However, if one were to plot maximum tube inlet pressure versus tube power, this difference would be apparent. Such a plot would also allow interpolation to maximum pressures for intermediate tube powers.

Data on Figure 3 show flow rate versus the pressure drop from the tube inlet to the dummy (support charge) inlet--that is, the ΔP along the heated length of the simulated fuel charge. By combination of these data with data of Figures 1 and 2 and a rear header pressure of 15 psig, one can determine the loss across the dummy charge and outlet fittings. By so doing, one finds that this loss is very small for the all liquid cases or for all conditions with 50 KW tube power. However, with increasing tube powers the outlet losses increase in significance until at 300 KW and maximum tube inlet pressure requirements, the ΔP from dummy section inlet to rear header is about equal to the ΔP across the active (heated) charge length.

The present hydraulic demand data may be compared with data which were reported in HW-42273, "Low Power K Reactor Boiling Curves," (1956). The previous data were for a simulated solid fuel element charge of 23.5 foot length while the present data are for a K-III I & E fuel charge of 28.5 foot length. Comparison of these two sets of data shows very good agreement for the non-boiling pressure drop across the simulated active charge when allowance is made for the above mentioned differences in geometry. The present data also show good agreement with liquid pressure drop measurements made in the 189-D Hydraulics Laboratory and reported in HW-54590 and HW-56989 for actual canned solid and K-III fuel elements, respectively. These comparisons give added assurance that a good simulation of a reactor process channel has been made.

Since equilibrium reactor tube powers are well above 300 KW, the present data are not generally useful for normal reactor operation. (Laboratory data for this geometry at tube powers of 500 to 2,000 KW have been published in HW-64029.) However, at the reduced flow rates associated with low or shutdown power levels, the data are useful to select supply pressures which will assure adequate coolant flow to prevent excessive fuel temperatures.

E. R. Waters - D. E. Fitzsimmon
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Figure 1. Steady State Tube Inlet Pressure Demand
(K-Reactor with K-III I & E's and STD Rear Fittings)

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Figure 2. Steady State Tube Inlet Pressure Demand
(K-Reactor With K-III I & E's and STD Rear Fittings)

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Figure 3. Steady State Pressure Drop Data
(K-Reactor with K-III I & E's and STD Rear Fittings)

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