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LABORATORY DETERMINATION OF NORMAL OPERATING FLOW RATES
WITH THE 105-F REAR FACE FLOATING NOZZLE

MASTER

By J. A. Findlay

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LABORATORY DETERMINATION OF NORMAL OPERATING FLOW RATES
WITH THE 105-F REAR FACE FLOATING NOZZLE

By J. A. Findlay

INTRODUCTION

A new rear nozzle has been developed by Mechanical Development (A), IPD to alleviate the stuck gun barrel problem on the process tubes at F reactor. This nozzle is called the 105-F rear face floating nozzle (RFFN) and is shown in Figure 4.

The purpose of this study was to determine the hydraulic operating characteristics of this nozzle and to compare these characteristics with those of the standard nozzle assemblies. This report is essentially an addendum to HW-63756 1 (4)* which presented energy loss data for various outlet fitting assemblies for possible use on the BDF type reactors.

The experimental data for this study were obtained with the use of the hydraulics mockup in the 189-D Thermal Hydraulics Laboratory.

SUMMARY AND RESULTS

Pressure drop - flow relations were found experimentally for the 105-F rear face floating nozzle (RFFN) with three combinations of pigtails and rear Parker fittings.

- (A) 105-F RFFN, small pigtail and 0.469" Parker fitting
- (B) 105-F RFFN, large pigtail and 0.469" Parker fitting
- (C) 105-F RFFN, large pigtail with Parker fitting and slip nut reamed to 0.610"

The pressure drop-flow relations for the combinations operating under all liquid phase flow are shown in Figure 1. Figure 2 shows similar data for operating conditions of steam-water mixtures where critical flow is encountered. Figure 3 shows reactor operating conditions for all three combinations in comparison to the standard nozzle with a helical type pigtail. It may be seen that use of the new RFFN nozzle alone will result in slightly increased flow rates as compared with the standard nozzle and that greater flow increased are possible with a larger pigtail and reamed Parker fitting.

It should be pointed out that flow characteristics of the outlet fittings can affect reactor operating limits and new fittings should be used only after a careful analysis of operating limits. Such an analysis was not carried out in this study.

* Numbers in parenthesis refer to references listed at the end of the report.

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HW-63756 3

RESULTS

The tests were run on the standard BDF mock-up in the 189-D Hydraulics Laboratory. The only changes made were the substitution of the test nozzle assemblies for the standard nozzle assembly. The three assemblies tested were supplied by C. E. Frantz and G. F. Howden and were designated: (A) 105-F RFFN with small pigtail and standard 0.469" outlet Parker fitting, (B) 105-F RFFN with large pigtail and standard 0.469" outlet Parker fitting, and (C) 105-F RFFN with large pigtail, with slip nut and outlet Parker fitting reamed to 0.610" (see Figure 4 and Drawings H-1-1882 and H-1-12024).

The results of the experiments are given in the following figures:

Figure 1 - Single Phase Pressure Drop (non-critical flow)

The non-critical flow pressure drop from the "end of active section" to the rear header is given as a function of flow rate in gpm metered at 10°C. These pressure drop measurements were made with 10°C, 110°C and 140°C water flowing through the assembly. Located upstream of the nozzle assembly was a standard dummy column made up of 3 - 8" thin wall perfs, 9 - 8" tubulars, 1 - 5" thin wall and 1 - 8" thin wall. The pressure drop was then measured across this dummy column and the nozzle assembly.

These data can be represented empirically by the following expression:

$$\Delta P = K Q^{1.9}, \text{ psi (Q given in gpm)}$$

where

$$\begin{aligned} K_A &= .0690 \\ K_B &= .0438 \\ K_C &= .0312. \end{aligned}$$

Figure 2 - Critical Flow Data

In this figure, the critical flow rate data are given in terms of the "end of active section" pressure minus the saturation pressure (corresponding to the tube outlet temperature). These data can be represented by a modified "cavitation number",

$$C = \frac{(P_{EOAS} - P_v)}{Q^2}$$

based on a water density at 10°C. There is a slight density correction for other water temperatures which will be mentioned in the "Discussion". For the geometries tested, the results are:

$$\begin{aligned} C_A &= .0680 \text{ psi/(gpm)}^2 \\ C_B &= .0575 \\ C_C &= .0252 \end{aligned}$$

Figure 3 - Supply and Demand Curves

"End of active section" pressure versus flow rate - The supply curve is for 34 O-II-N I&E fuel elements, CG-558 front fittings with 0.310 venturi, an average coolant temperature of 60°C and a front header pressure of 575 psig. The demand curves are for the rear nozzle assemblies designated A, B and C and for a rear header pressure of 30 psig and a tube outlet temperature of 110°C. The demand curve for the "standard helical

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HW-63756 3

pigtail" is also shown (5/8" pigtail, 0.469 nozzle and cross header Parker fittings and standard BDF nozzle assembly). The demand curve for the "standard J-2 pigtail" falls on top of the curve designated "A". The dotted portion of the curves is to be ignored when determining the system flow at the conditions given. See the "Discussion" for the explanation of the dotted portion of the curves.

From the "Supply and Demand Curves", the operating point for each of the assemblies under the given conditions may be determined.

	Flow Rate gpm	% Increase
Standard Helical Pigtail	46.8	0
A	47.8	2.1
B	48.4	3.4
C	52.3	11.5

It will be noted that of the different assemblies only C is operating in non-critical flow.

DISCUSSION

Single Phase Non-Critical Flow

Under single phase, non-critical flow conditions, the pressure loss through a system consists of frictional losses which are proportional to $\rho Q^2 / \text{Re}^{0.2}$, in the turbulent region, and the momentum type loss which is proportional to ρQ^2 . At a given temperature, then, the combined losses may be represented by $\Delta P = K_1 Q^{1.8} + K_2 Q^2$ or within a limited range of flow rates by $\Delta P = K Q^n$ where $1.8 \leq n \leq 2$ depending on what per cent of the losses are frictional and what per cent are momentum. For assemblies such as the 105-F RFFN, the single phase pressure loss may be represented over the range of interest by the latter expression.

Single Phase Critical Flow

The critical flow phenomena observed at the conditions under which these assemblies were tested might be termed a "single-phase critical flow". That is, the liquid in the system is everywhere subcooled except at the critical flow point. At this point the liquid is at saturated conditions. Phenomena of this nature are correlated against the cavitation number

$$C' = \frac{P - P_v}{\rho \bar{V}^2 / 2g} \quad (1)$$

Using P_{EOAS} (end of active section) as a representative system pressure and referring the density to some reference temperature a modified cavitation number,

$$C = \frac{P_{EOAS} - P_v}{Q^2} \quad (1)(2)$$

may be used to correlate the critical flow data (see Figure 2). A slight density correction of $\frac{C}{C_{10}} = \frac{\rho_{10}}{\rho}$ is then obvious.

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HW-63756 3

Determination of the Operating Conditions

The operating point for a process tube is determined by the intersection of the supply curve ($P_{FH} - P_{EOAS}$ vs Flow) and the demand curve ($P_{EOAS} - P_{RH}$ vs Flow). When the supply curve is plotted on P_{EOAS} vs Flow coordinates, the result is a family of curves with front header pressure as a parameter. For the comparison of the assemblies 575 psig front header pressure was used. The demand curve is made up of a non-critical flow portion and a critical flow portion (see Figure 3). The extension of these two portions of this curve beyond their point of intersection is shown dotted in Figure 3. The non-critical flow portion of the demand curve is a function of the rear header pressure when plotted on P_{EOAS} vs Flow coordinates (Figure 3). The critical flow portion of the demand curve is a function of the temperature. Thus a particular demand curve (for a given geometry) can be determined only after the rear header pressure and the tube outlet temperatures are specified.

John A. Findlay
Thermal Hydraulics Operation

J.A.Findlay:ag

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HW-63756 3

Nomenclature

T = Temperature, °C
P = Pressure, psi
C = $(P_{EOAS} - P_v)/Q^2$; Modified Cavitation Number
Re = Reynolds Number
Q = Flow rate, gpm
K = Loss coefficient

Subscripts

EOAS = End of active section
RH = Rear header
FH = Front header
v = Saturation condition
i = Inlet
o = Outlet

References

1. Findlay, J. A., HW-SA-1713, Results of Preliminary Studies of Critical Discharge Phenomena, November 18, 1959.
2. Waters, E. D., HW-57946, Methods for Investigating Critical Discharge Phenomena with Saturated Water, August 29, 1958.
3. Waters, E. D., HW-63756 1, Laboratory Determination of Normal Operating Flow Rates with Enlarged Outlet Fittings - BDF Reactors, February 2, 1960.
4. Waters, E. D., HW-63756 2, Laboratory Determination of Normal Operating Flow Rates with a Flexible Outlet Connector - BDF Reactors, February 16, 1960.

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FIG. 1

SINGLE PHASE PRESSURE DROP
(NON-CRITICAL FLOW)

PRESSURE DROP - END OF ACTIVE SECTION - REAR HEADER, PSI

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HW-63756 3

FIG. 2
CRITICAL FLOW DATA

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HW-63756 3

FIG 3
SUPPLY AND DEMAND CURVES

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HW-63756 3

FIGURE 4 - 105-F REAR FACE FLOATING NOZZLE

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