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HYDRAULIC TEST OF ORR DUMMY FUEL ELEMENT

E. S. Bettis

Introduction:

Since the fuel element proposed for use in the ORR differs slightly from elements used in the MTR it was decided to run a hydraulic test on the element to determine the pressure drop and flow distribution in the various channels.

The fuel element tested was the nineteen plate Mark 11 Type described in Drawing No. D-24078. The purpose of the test was to check experimentally the pressure drop calculations reported by Sanders in ORNL-CF-54-3-57 and by Binford in ORNL-CF-55-5-157.

These experiments were conducted in Building 9201-3 in Y-12 with hydraulic facilities existing there. The attached Drawing No. E-16875 shows the location and arrangement of pressure taps, impact tubes and gauges as they were applied to the test element.

Procedure:

Small stainless steel tubes (.080" O.D.) were located in the center channel and the two channels nearest each side face of the fuel element. A pair of these tubes were used for each channel, one tube was inserted in the end of the channel so as to register total pressure (static plus impact); the other tube was brought into the side of the channel so as to register static pressure alone. Static pressure taps were also located in the inlet and outlet boxes. Pressure measurements were made by connecting these pressure taps to mercury "U" tube manometers.

In addition to the "U" tube manometers, Bourdon gauges were connected to the water inlet pipe, the outlet pipe and at pressure tap 6 (inlet box pressure).

The experiment was first run by connecting a static pressure tap of one channel to one end of a mercury manometer and the total pressure tap of the same channel to the other end of the same mercury manometer. With this arrangement the manometer read the impact head from which the velocity of the flow in the channel in ft. per second could be computed by

$$V^2 = \text{inches of Hg} \times 1.134 \times 64$$

It was found that some of the static pressure taps did not give a true static pressure because the taps did not terminate exactly smoothly on the inside surface of the channel. Accordingly a streamlined pressure probe was inserted in the end of the fuel element channels to measure static pressure. This pressure was then read on the manometer against atmospheric pressure and this static pressure was subtracted from the total pressure reading taken with respect to atmospheric pressure.

The experiment was run repeatedly and a series of data was taken for different flow rates through the apparatus. The experimental arrangement is shown schematically in Fig. 1. A centrifugal pump was used to circulate water from a reservoir tank through the test element and back into the tank at flows of from approximately 200 to 600 gpm. Flow was controlled by means of the setting of the by pass valve shown in Fig. 1. An orifice plate in the 4" feed line to the element was used to indicate flow as a gross check on the operation of the experiment.

Flow in the five measured channels was relatively uniform. Channels 1 and 5, (the channels adjacent to the sides of the fuel element) had a slightly lower flow than the other channels. However the difference is not large and it is felt that the flow is sufficiently uniform to provide adequate cooling of all portions of the element in use in the ORR.

Table I summarizes the data taken. These points represent the mean values of some six different experimental runs. All runs were consistent and values did not change between runs by more than about 10%.

Figure 2 is a plot of the pressure drops across the total element, the inlet and outlet end boxes, and the fuel plate section against the flow rate in feet per second water flow through the narrow fuel passages. The pressure drops had previously been computed for two flow rates (20 and 32 ft./sec.) and these computed values are shown for comparison on the experimental plots.

From the test data obtained on the hydraulic test of the fuel element it appears that the design of the element is satisfactory for the use proposed in the ORR. Since the remainder of the ORR cooling circuit was computed in the same manner and by the same person as was the fuel element, the agreement between computed and measured pressure drops in the fuel section constitutes reasonable circumstantial evidence that the calculations of the other parts of the cooling circuit can be expected to be correct.

Conclusions:

Since the maximum difference in flow between any two channels encountered in any isolated measurement amounted to 17% it was concluded that the flow distribution in the element as designed was satisfactory and the elements as designed will be used in the ORR. Corroboration of the calculated values of pressure drop was given by the experimental checks.

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TABLE I

P _{line}	P _{fuel inlet}	ΔP_{inlet}	ΔP_{fuel}	ΔP_{outlet}	Avg. Flow ft/sec.	Measured Flow in Channels ft/sec.				
						1	2	3	4	5
						Pounds Per Sq. In. Gauge				
10.75	8.35	2.4	7.12	1.23	19.6	16.6	19.	20.	19.4	18.
14.9	11.6	3.3	9.95	1.65	24.38	21.8	25.2	26.4	25.4	23.2
19.15	14.95	4.2	12.9	2.06	28.1	25.6	29.4	30.8	29.	28.3
23.35	18.43	4.9	15.9	2.47	31.6	29.9	34.1	36.	31.	31.1
27.57	21.77	5.8	18.87	2.9	34.6	30.8	36.2	38.	34.	32.5
31.77	25.07	6.7	21.7	3.3	37.4	34.2	39.	41.	36.1	35.2

Two points were calculated for pressure drop at different flow conditions. Comparison of these calculated points with measured values is shown.

	Pressure in Pounds / Sq. In. Gauge				Flow ft/sec.
	P _{line}	ΔP_{inlet}	ΔP_{fuel}	ΔP_{outlet}	
Computed	27	6.5	16.4	4.1	32
Measured	24.17	5.2	16.3	2.67	32
Computed	11	4.	5.1	1.9	20
Measured	11.15	2.55	7.3	1.3	20

Comparison with MTR Element

MTR	37	14	18	5	30
ORR	21.5	4.65	14.5	2.35	30

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Fig. -1

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