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SUPPORT BLOCK AND TIE ROD INTERACTION
FLOW TESTS WITH TRANSPARENT PLEXIGLAS MODEL
(Title Unclassified)

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SUMMARY

A plexiglas model which essentially duplicated the geometry of the bottom support block in the immediate vicinity of the tie rod support cone was used to obtain preliminary information on the flow patterns at the exit of the tie rod channel. Water was used in place of hydrogen, with hot water simulating the tie rod channel flow and cold water simulating the fuel element channel flow. The position of the tie rod support cone was varied over a range above and below the original design location and measurements were made on the temperatures of the tie rod tip (T_t), the tie rod channel flow (T_c), and the fuel element channel flow (T_p).

The effectiveness of the center channel flow in cooling the tie rod button was represented by the dimensionless temperature ratio

$$\tau = \frac{T_t - T_c}{T_p - T_c}$$

Reynolds numbers were varied from 2000 to 4000 (compared with 15,000 in the reactor) with flow ratios (hot/cold) of 0.1 and 0.2. It was concluded that the tie rod tip would obtain maximum cooling if it were recessed approximately 0.2 inches below the face of the support block.

INTRODUCTION

The bottom support block and tie rod are part of a complex structural system which retains all of the fuel elements in the core. Optimization of these critical items is required in order to insure a successful power run on the NRX-A designs. The purpose of the support block flow tests is to determine the inter-relation of the tie rod support system with the unfueled center element in order that their structural integrity be assured under operating conditions.

Figure 1 shows a cross-section of the support block end of a typical seven-element cluster. Approximately six percent of the total hydrogen flow through each cluster is directed through the center channel for the purpose of keeping the tie rod temperature below a maximum of about 1000°R . The design temperature of the gas leaving the tie rod channel is about 800°R . After passing through the support cone, this gas is mixed with the propellant gas which is at a design temperature of 4300°R . Since the final temperature of the mixed gas is 4090°R , it is important that the flow patterns in this mixing region be such that the tie rod tip is adequately cooled by the low temperature gas. The purpose of the tests reported herein was to obtain preliminary information on the flow patterns around the tie rod tip and to determine its optimum longitudinal position.

TEST APPARATUS AND PROCEDURE

Plexiglas Model

The test apparatus is shown in Figure 2. It is constructed of a clear thermal plastic, methyl methacrylate, and essentially duplicates the geometry in the immediate vicinity of the tie rod support cone, including the coolant channel around the tie rod and the eighteen propellant channels immediately adjacent to the center hexagonal element. The hydrogen flow is simulated by hot and cold water, with hot water, at a temperature T_c of approximately $120-140^{\circ}\text{F}$, representing the coolant flow in the tie rod channel and cold water, at a temperature T_p of approximately $60-70^{\circ}\text{F}$, representing the propellant flow in the fuel element channels. In the reactor the propellant temperature is, of course, higher than the tie rod coolant temperature. The temperatures were reversed in this experiment, however, so that the test apparatus would not be overheated. Methyl methacrylate tends to distort at temperatures only slightly greater than the highest water temperatures used. Since the propellant flow rate was somewhat greater than the tie rod coolant flow rate, the mean temperature of the apparatus could be kept lower if cold water were used to simulate the propellant.

Instrumentation

Tap water was used for both the propellant and coolant streams, with the flow rates determined from Fisher "Flowrators" installed on the inlets. The tip temperature (T_t) was measured with a thermocouple directly attached to the tie rod button while the tie rod coolant (T_c) and propellant (T_p) temperatures were measured with thermocouples in the inlet streams. The thermocouples used were iron-constantan and were read by means of a selector switch and portable potentiometer.

Test Procedure

The position of the tie rod tip with respect to the exit plane of the support block was varied by means of spacers placed directly beneath the support cone. A range of positions from approximately 5/16-inch recession to 1/8-inch protrusion in 1/16-inch increments was used.

The mean mass flows in the reactor are 0.0177 pps through the tie rod channel and 0.0436 pps through the eighteen adjacent fuel element channels, a ratio of 0.4. The actual ratio in different locations in the core, however, varies considerably from this mean, and the ratios of 0.1 and 0.2 used in this experiment represent the more severe conditions, since a low ratio will provide the least amount of cooling for the tie rod. Reynolds numbers of 2000 to 4000 were used for flow in the fuel element channels. These values were limited by the available water source and are lower than the expected exit Reynolds numbers of about 15,000 in the reactor.

A dye was added to the tie rod coolant stream during part of the testing. This permitted visual observation of the flow patterns during the mixing of the two streams. No conclusive deductions, however, could be made from the flow patterns.

Data Utilization

From the three measured temperatures, the following dimensionless variable was calculated:

$$\gamma = \frac{T_t - T_c}{T_p - T_c}$$

From the two measured volume flow rates, the ratio of mass flow rates was calculated without considering the small correction for variation of density with temperature. This ratio is W_1/W_2 where:

W_1 = mass flow rate through tie rod coolant channel (lb_m/sec)

W_2 = mass flow rate through eighteen fuel element channels (lb_m/sec)

RESULTS AND CONCLUSIONS

The results of the experiment are summarized in Figure 3. The most important conclusion is that for either mass flow ratio or any Reynolds number, a maximum cooling of the tie rod tip is accomplished if the tip is recessed about 0.2 inches below the exit plane of the support block. It can also be seen that an increase in the mass flow ratio W_1/W_2 decreases the dimensionless temperature considerably. This result justifies the use of the low flow ratios. The effect of a low Reynolds number appears to be to reduce the dimensionless temperature but the effect is neither constant nor strong. Hence, it is expected that these results would substantially apply to the actual application despite higher Reynolds numbers.

Only the first row of holes in each fuel element was simulated in this experiment. There will be some effect from flow in the holes further away from the tie rod, but it is considered that this effect will result in flow patterns not substantially different from the patterns set up around the tie rod tip by the configuration used.

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The results obtained will be checked using hydrogen at reactor temperatures. This will be done in the A 4.2 tests using eighteen fuel element holes, the same as in this test, and in the A 10 tests using a complete cluster.

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FIGURE 1 SUPPORT BLOCK END OF SEVEN-ELEMENT CLUSTER

FIGURE 2 EXPERIMENTAL SET-UP

FIGURE 3 VARIATION OF DIMENSIONLESS TEMPERATURE WITH POSITION