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ANALYSIS OF PT-684-A HOT DIE SIZE PROCESS PARAMETERS EVALUATION

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ANALYSIS OF PT-684-A
HOT DIE SIZE PROCESS PARAMETERS
EVALUATION

by:

W. Bowie
Product Engineering Unit
Fuels Engineering Operation
Production Fuels Section - IPD

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INTRODUCTION

Fuel elements manufactured by the hot die size process for initial production tests experienced an unforeseen diameter growth during irradiation. This growth was considered undesirable and in some cases resulted in "stuck charges" during reactor discharge. In order to develop a more dimensionally stable fuel, the Process Development Unit scheduled four production tests aimed at evaluating certain process and feed site variables. The first of these tests, PT-665, compared two end bonding processes (resistance and induction). The purpose of this second test was to determine the effects of end bonding pressure and machined core diameter on irradiation-induced diameter changes.

Four groups of hot die sized fuel elements with combinations of high and low end bonding pressure, and standard and small diameter cores, were irradiated with AlSi control elements for this test. Details of the test are outlined in the production test document.(1) The dimensional data were analyzed by Applied Mathematics Operation-Battelle, and are reported below:

SUMMARY

The analysis of dimensional data showed that there was no significant difference between any of the hot die sized parameters. The differences between the hot die sized fuels and AlSi control fuels were much the same as those seen in previous tests. The means of the total hot die sized group and the AlSi control group are listed with their differences in Table I.

TABLE I

<u>Characteristic</u>	<u>AlSi Mean</u>	<u>Hot Die Size Mean</u>	<u>Difference</u>	<u>Significant Difference at Five Per Cent Level</u>
ΔOD_1	5.95	7.35	1.40	NO
ΔOD_2	7.87	13.10	5.23	YES
ΔOD_3	6.41	11.32	4.91	YES
TFC	19.58	23.42	3.84	YES
Warp	5.72	5.45	-.27	NO
ΔID_2	5.45	6.78	1.33	NO

DISCUSSION

The test design called for the following six treatments:

1) AlSi Brazed Control Elements (Standard "F" Process)	} No Difference
2) AlSi Brazed Control Elements (Standard "F" Process)	

(1) Hladek, K. L., "Production Test IP-684-A, Hot Die Sized Parameters Evaluation," July 16, 1964, HW-82472, [REDACTED].

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- 3) Hot Die Sized Standard Diameter Cores - High End Bond Pressure
(4.25 Tons/In.²)
- 4) Hot Die Sized Standard Diameter Cores - Low End Bond Pressure
(3.75 Tons/In.²)
- 5) Hot Die Sized Small Diameter Cores - High End Bond Pressure
(4.25 Tons/In.²)
- 6) Hot Die Sized Small Diameter Cores - Low End Bond Pressure
(3.75 Tons/In.²)

In this test, the standard ALSi cores had an OD of 1.406 inches compared to the standard hot die sized OD of 1.432 inches, and the small diameter hot die sized OD was the same as the standard ALSi cores. Fuel elements used in this test were C5NS ALSi controls and CDB2N hot die sized, all with self-supports. Induction end bonding was used for all hot die sized cores.

The six treatments were randomly charged in four banks of six tubes each with only positions 5 through 28 being used for test material. The remaining upstream and downstream positions were charged with ALSi filler pieces. The sixth tube of the fourth bank was not charged. The test was irradiated for 84 days to an average exposure of 770 MWD/T. Reactor operating conditions for each column in the test are shown in Table II.

TABLE II

Irradiation Conditions for PT-684-A

<u>Tube</u>	<u>MWD/Ton</u>	<u>Average ΔT</u>	<u>Tube</u>	<u>MWD/Ton</u>	<u>Average ΔT</u>
1069-C	821	94.5	3661-C	761	89.5
1076-C	798	94.5	3662-C	739	85.5
2264-C	794	94.5	3671-C	747	87.5
3479-C	811	95.5	3672-C	717	87.5
3560-C	764	88.6	3673-C	759	88.5
3562-C	754	87.5	3678-C	765	89.5
3574-C	790	93.5	3679-C	759	88.5
3584-C	779	91.5	3681-C	758	87.5
3586-C	768	89.5	3869-C	791	92.5
3587-C	780	89.5	3873-C	777	94.5
3656-C	688	80.5	3874-C	781	93.5
3660-C	752	86.5			
AVERAGE				767.5	90.0

Although the test design called for four banks of six tubes each, only 23 tubes were charged. This made it necessary to analyze the test as having three banks rather than four. The data from the fourth bank was used to fill in missing values in the other three. The design of the test was such that the loss of one bank did not effect the validity of the test; however, it did reduce the test's discriminatory power.

Two statistical models were used in analyzing the data. One was a four-way analysis of variance with main factors: banks, rows, pressure, and core size. There were three banks of six tubes each, 24 rows corresponding to positions

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5 through 28 in a tube, two pressure levels--high and low, and two core sizes--standard and small. The other model was a three-way analysis of variance with main factors banks, rows, and treatments. There were three banks, 24 rows, and six treatments.

The effects of the six treatments on six fuel element dimensional characteristics (ΔOD_1 , ΔOD_2 , ΔOD_3 , ΔID_2 , Warp, and TFC) were analyzed with the following results:

- 1) There was no significant difference between the high pressure and low pressure end bond fuels for any of the six characteristics.
- 2) There was no significant difference between standard size cores and small cores for five of the characteristics. The data indicated a difference in the TFC characteristic at the 10 per cent significance level, but not at the five per cent significance level. The over-all average TFC measurements for the two core sizes were:

Standard Size Cores

24.38

Small Cores

22.46

It is not felt that any practical significance can be attributed to this difference.

- 3) There was no significant end bond pressure core size interaction effect for any of the six characteristics.
- 4) The average values for each of the six characteristics for the ALSi mean and the hot die size mean were as shown in Table I.

There was a significant difference between rows (positions along the tube) for ΔOD_1 , ΔOD_2 , ΔOD_3 , and TFC. No significant row effect was observed in the warp or ID_2 characteristic. There was a significant difference between bank effect on ΔOD_1 or ΔOD_3 , or ID_2 . These row and bank effects were anticipated since there are flux differences along the tubes and between tubes in the reactor. The test was designed to remove any influence that the row and bank effects might have on the difference in averages for the maximum effects of interest.

The row and bank differences seen in this test reaffirm the necessity for adequate test design. They also point out the hazards involved in trying to draw inferences from individual fuel element differences or differences between small groups of fuel elements. If the test is designed, as this one was, to randomize these effects, they will not have an influence on the averages of large groups of fuel elements; however, individual fuel elements within a group may, and in this case did, vary considerably from the average.

W. Bowie

W. Bowie
Standards Technician
Fuels Engineering Operation

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