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Analysis of Dimensional Distortion Data
From Initial 24 Quality Certification
Tubes

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ANALYSIS OF DIMENSIONAL DISTORTION DATA FROM
INITIAL 24 QUALITY CERTIFICATION TUBES

Introduction

This is the second report issued summarizing post-irradiation results from IP-216A. In the first report^[1], data from seven tubes were analysed. This report includes data from 17 additional tubes.

Summary

A control chart technique is introduced to routinely monitor fuel element performance with respect to dimensional changes experienced during irradiation. As the effects of reactor variables become better known, these charts can be modified to subtract out such known effects, and hence permit a direct evaluation of fuel element quality as such.

The effects of fuel element position (or more exactly, fuel element power, exposure, and/or temperature) on dimensional distortion were evaluated. Upon grouping results from tubes having similar flux characteristics, the data strongly suggest that when

[1] HW-64031, "Analysis of Data From Initial 7 Tubes Discharged Under IP-216A," Secret, J. L. Jaech - 2-24-60.

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IBM machine utilization permits an analysis of the data on an individual fuel element basis, it will be possible to determine expressions relating distortion to these reactor variables. This will permit us to predict such distortion under different sets of conditions, which will enable us in turn to predict the frequencies of such things as stuck charges, and, possibly hot spots.

Discussion

Table I lists the pertinent data included in this analysis:

Table I

<u>Tube #</u>	<u>Canning Date*</u>	<u>Exposure</u>	<u>Power Factor</u>	<u>Ave. Warp</u>	<u>ΔOD Ends</u>	<u>ΔOD Center</u>	<u>TFC**</u>
3065F	5385	540	1.21	12.5	-2.6	2.1	11.8
0979DR	5386	740	1.24	11.5	3.4	3.3	15.3
1970DR	5386	750	1.16	9.5	3.3	2.8	12.8
3785F	5390	560	1.26	7.6	-2.8	0.8	6.4
2054KE	5397	550	1.18	9.7	-6.0	-1.6	5.9
2072KE	5398	590	1.28	7.9	-5.0	-1.0	4.9
2460F	5405	560	1.25	13.4	-1.3	2.1	13.4
2661D	5405	820	1.23	11.8	-6.0	2.9	10.6
2276H	5405	730	1.11	9.6	-3.4	0.1	8.9
1272D	5407	650	1.20	11.0	-1.6	2.1	10.6
3084D	5408	820	1.25	8.9	-4.5	2.6	8.1
2687D	5412	830	1.25	11.3	-4.3	1.6	9.4
2062B	5418	720	1.23	9.6	-4.4	0.6	7.6
1967B	5419	640	1.26	8.5	-4.3	0.8	6.5
1877B	5419	640	1.25	5.9	-3.9	-0.3	4.3
3874KW	5421	810	1.16	15.9	-3.7	4.3	15.4
2078B	5435	660	1.27	7.1	-4.1	-0.6	5.1
3670DR	5436	610	1.21	7.5	-5.3	-0.8	4.5
4179H	5441	700	1.07	8.0	-2.3	2.6	8.8
1872KE	5442	590	1.27	8.7	-4.0	-0.3	6.1
3153KE	5446	570	1.21	8.1	-4.2	1.9	6.3
2275KW	5470	620	1.29	4.9	-2.0	2.9	5.9
1863KW	5475	630	1.26	8.9	-3.3	2.2	9.1
4978KE	?	690	1.19	13.0	-3.8	3.4	13.2

* HAPO Date5385 => 6-24-59

** Tube Filling Capacity

The flux profiles were computed for each of these tubes using weasel data. These are shown in Figure (1). In analysing these data, the tubes were divided into 3 groups:

- A: Old reactors with dips in the flux profile.
- B: Old reactors with roughly cosine flux profiles.
- C: K reactors

This was a rough attempt at removing the effects of reactor variables. Note, however, that the flux profiles within each group still differ by a considerable amount, as do

the tube powers and exposures, and the grouping can only be construed as a first order removal of the effects of reactor variables. What is required to do a complete job is an analysis of the data on a slug by slug basis as will be possible when IBM machine utilization becomes an accomplished fact.

The analyses showed that reactor variables, as associated with position of the fuel element in the reactor, significantly affect the amount of warp. This is shown in Figure (2) where the various dimensional distortion data, averaged over 8 tubes in each case, are plotted as functions of position. In each case, the polynomial required to adequately describe the position effects is found. Note that a second degree polynomial appears to be adequate except for tubes in group A (old reactors, dip flux profile). This indicates that when it becomes possible to analyse these data on an individual fuel element basis, there is real reason to anticipate that well-defined relationships will result. Note also from Figure (2) that for Δ diameter at the fuel element centers, a second degree polynomial appears to be adequate. It should, of course, be kept in mind that as more data are accumulated, results may differ somewhat. There are no discernible position effects on Δ OD at the fuel element ends.

There are a number of reasons why it is desirable to be able to express the amount of distortion experienced as a function of reactor variables. For one thing, the relationships can be used to predict the frequency of stuck charges as a function of reactor conditions. Another potential benefit is the possibility of using such relationships to predict the frequencies of hot spots. Not to be overlooked is the desirability of being able to remove the effects of reactor variables on observed results such that a direct evaluation can be made of fuel element quality as such on a routine basis.

To indicate the type of approach that can be used in connection with this latter point, Figure (3) has been prepared. This presents individual tube averages plotted in canning date order. "Out of Control" points, indicative of real differences between tubes of metal, are circled. The limits shown are 3σ limits such that the probability of a point's being out of control due to chance alone is about .003. The effects of different irradiation conditions have not been removed from these averages, so some of the scatter may be due to these different conditions. It is impossible to remove these effects at the present time because of lack of quantitative knowledge as to their magnitude.

It is recommended that the control chart technique be used to monitor fuel element distortion data. Its value will be increased when it becomes possible to remove effects of reactor variables. Trends and cycles in quality will be readily apparent using this technique. Further, if it becomes evident that the situation remains well in control over long periods of time, it will indicate that attempts to predict warp on the basis of pre-irradiation measurement are futile, since in this case, the post-irradiation results are the same for all fuel elements. On the other hand, if real differences appear, it will spur on efforts to locate and remove the causes of such differences, or at least be able to predict beforehand which fuel elements are likely to behave poorly in this respect.

It should be recognized that in order for the program to be effective in this respect the time lag between discharge and analysis must be minimized. Observe from these data that we have no results for lots canned after September, 1959. Part of this delay represents a delay in analysis of data, which source of delay will shortly be virtually eliminated with the use of IBM machine calculations. This leaves as the greatest source of delay the time lag between discharge and measurement. It seems that the incentive is there to reduce this lag as much as possible.

J. L. Jaech
J. L. Jaech

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Figure (2)

Average Warp

Figure 3

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