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STATUS OF CANNING CYCLE OPTIMIZATION STUDY

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OPTIMIZATION STUDY

by

T. W. HUTTON
Process Control Unit
Fuels Engineering Operation
Production Fuels Section
Irradiation Processing Department

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INTRODUCTION

A concentrated study of the present manufacturing process was initiated in the Process Engineering Unit, the purpose of the study being to optimize the present operations, procedures, and methods of the AlSi canning process. It is the purpose of this document to report the findings and accomplishments for that portion of the study concerned with the optimization of component preparation and fabrication within the canning furnace. To date, this study has consisted mainly of heating rate studies of the various components used in the fuel element fabrication with some work being done on the optimization of the heating cycle for these components. This work necessarily serves as the basis for further optimization study.

SUMMARY AND CONCLUSIONS

Generally, heating rate studies completed to date indicate that in almost all cases, changes can be made in the heating cycles for components which will make for more optimum operation. It was observed that in some cases components were preheated or submerged longer than necessary whereas it appeared that other components did not receive sufficient preheat or submerge time before fabrication.

Heating studies of the spire-caps for all models revealed that each model very closely approached the canning bath temperature in the normal preheat time. Further, it was observed that the C6N spire-cap which now has a preheat two (2) to three (3) seconds longer than normal, reached the same temperature after the normal preheat time as did the other models.

Results of heating studies for cans with the standard contoured-bases showed that generally the eight (8) inch models heat faster than do the four (4) or six (6) inch models. During the normal 47 second preheat time for the cans in the AlSi bath, the temperature reached by the various can models varied from 550 to 565 C. However, following normal preheat, it was observed that after submersion for 19 to 21 seconds, the normal time before core insertion, the cans of all models reached the required canning temperature, regardless of the temperature at submersion.

Based on the average temperature that the cans reach before core insertion after normal preparation, a test conducted on the O3N model can proved that by increasing the normal preheat to about 55 seconds and decreasing the submerge time before core insertion to approximately five (5) seconds, the can would reach the required canning temperature faster than by any other combination of preheat and submerge times. The result is that the heating cycle for the cans and thus the canning cycle can be decreased by seven (7) to eight (8) seconds. Further, canning tests proved that the quality of fuel elements fabricated using this reduced heating cycle for the cans was comparable to those fabricated using the normal cycle. In a similar study made for the O5N model, an optimum preheat time was developed, but the total heating cycle time required remained the same as in the present cycle.

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To study the effect can-base design has on the heating rate, stepped-base O3N cans were compared with the standard contoured-base model. Results showed that after 47 seconds of preheat the stepped-base can reached a temperature five (5) degrees greater than did the contoured-base model. Moreover, canning tests conducted to compare the two can models showed that the quality of those fuel elements fabricated using the stepped-base cans was better than those fabricated using the contoured-base models.

By altering the eight (8) inch O3N stepped-base cans four (4) inch stepped-base cans were made. Heating studies for this model showed that the stepped-base can heated faster and after 47 seconds reached a temperature three (3) degrees higher than did the contoured-base model. Hence, it was concluded that the stepped-base cans for the models tested do have better heating rates than do the standard contour-base cans.

DISCUSSION

Heating Rate Studies

Initially, heating rates of the components of various models were determined by monitoring the temperature of each throughout the normal heating cycle before assembly. For both the can-sleeve assemblies and spire-caps, the temperatures were monitored by a one-sixteenth (1/16) inch O.D. stainless steel sheathed chromel-alumel thermocouple insulated with magnesium oxide. For the can-sleeve assemblies, thermocouples having a mercury-weld exposed junction were embedded in the can base in a hole one-sixteenth (1/16) inch in depth located one-sixteenth (1/16) inch from the spire well. (See Figure 1) The heating rates for the spire-caps were likewise monitored by embedding exposed junction thermocouples in a hole drilled into the top of the cap one-sixteenth (1/16) inch in depth located one-eighth (1/8) inch from the inside surface of the spire. (See Figure 2)

The spire-caps and can-sleeve assemblies of the various models tested were preheated in pairs in the normal preheat position in the canning furnace, with the spire-caps being pulsed, until each reached bath temperature. The heating rates of the can-sleeve assemblies after submersion into the ALSi bath were then determined by allowing the assemblies to heat in the preheat position for 47 seconds and then submerging them into the bath. Again, each assembly was heated until it reached bath temperature.

During all heating tests, the ALSi canning bath was maintained at approximately 587 C. In all tests, however, the maximum corrected temperature recorded exceeded that of the canning bath. This apparent discrepancy may be due to the difference in position of the furnace controller-thermocouple and the component thermocouples. Tests show as much as a 3 C gradient throughout the canning furnace.

Spire-Caps

Heating studies of the spire-caps for all present production models revealed that each model very closely approaches bath temperature in the normal pre-

heat time of 21 ± 2 seconds. It appears, therefore, that no change is warranted at this time for the preparation of spire-caps. Further, it was observed that the C6N spire-cap which now has a preheat time of 27 ± 1 seconds, reached the same temperature in the normal preheat time as did the other models. (See Figure 3) It therefore appears that the preheat time for the spire-cap should be the same as for the other models. Heating curves for each model are found in Figures 3 through 13.

Can-Sleeve Assemblies

The heating studies of the contoured-base can-sleeve assemblies showed that generally the longer model cans heat faster than the shorter models. After 47 seconds of preheat in the AlSi bath, the eight (8) inch models, excluding the C6N and C5N models, reach 558 to 565 C, whereas the six (6) inch models reach 550 to 560 C, and the four (4) inch model reaches approximately 553 to 555 C. Of course, the temperatures reached by some six (6) and eight (8) inch models fall in the lower limits of the range of comparison given above. For the eight (8) inch models, the K5N can model is of the most concern for after 47 seconds preheat, this model reaches only 558 C. All other eight inch models reach at least 561 to 565 C. For the six (6) inch models, two models reach temperatures greater than 555 C after 47 seconds preheat; however, the C3E and K4E models reach only 551 C. Nevertheless, following a preheat of 47 seconds, measurements of the can temperature during submersion showed that at the normal time for core insertion, all model cans reach the required canning temperature, regardless of the temperature at submersion.

In comparing the can models above, the eight (8) inch C6N model was excluded because of its large diameter and mass as compared to other eight (8) inch models. Normally, the C6N can model has a preheat of 75 seconds. However, after preheating for 75 seconds, it was observed that the can reached 573 C, a temperature five (5) to ten (10) degrees higher than other eight (8) inch models reach after a 47 second preheat. (Figure 14) It therefore appears that a shorter preheat time could be used. Examination showed further that after a preheat of 55 to 65 seconds, the C6N can reaches 560 to 565 C, temperatures very close to those reached by other eight (8) inch models in 47 seconds. It is recommended, therefore, that the heating cycle for this model be studied closely for possible improvements.

The C5N model can was excluded from the comparison above of other eight (8) inch models because its base differed from all other models. At the beginning of these heating tests, a flat-base can was being used with the C5N model, whereas all other models had contoured bases. Initial heating studies showed that after a preheat of 47 seconds, this model reached only 545 C. (See Figure 15) During the tests, however, a stepped-base can was adopted for this model. Subsequent heating studies using the stepped-base can showed that a great improvement in the heating rate of this model had resulted since the can reached approximately 571 C after 47 seconds of preheating. (See Figure 16) It is noted that this is a temperature five (5) to ten (10) degrees greater than most other eight (8) inch models reach during preheat.

Another model which to date has a longer-than-normal heating cycle is the four (4) inch O5N model. At present, this model has a special 40 second

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canning cycle consisting of a preheat of 55 to 65 seconds before submerge. From the heating studies, it was found that this four (4) inch model required a preheat time greater than two of the six (6) inch models and all of the eight (8) inch models. Nevertheless, after 47 seconds of preheat, this four (4) inch can reached approximately 554 C, a temperature two (2) to four (4) degrees greater than two of the six (6) inch models now used in production reach in the same preheat time. It therefore appears that this can model could be prepared using the normal heating cycle. It is noted that during preheat of this model for as long as two (2) minutes, bath temperature was never reached. (See Figure 17) This is probably caused by rapid heat radiation and convection to the air. Complete heating curves for each can model are found in Figures 14 through 25.

Optimization Study of Heating Cycles

As the above heating study was progressing, it appeared that even though each can model reached the required canning temperature after the normal preheat and submerge time, it might be possible to reach the required temperature faster by varying the preheat or submerge time. Therefore, a test was designed to measure the heating rate of O3N model can-sleeve assemblies while varying the preheat and submerge times independently. From previous O3N can preheat and submersion tests, it was determined that after normal preparation the can reaches approximately 585 C before core insertion. Therefore, the search was for a combination of preheat and submerge times which would allow the can to reach 585 C in a minimum of time. A plot of preheat time versus total time required to reach 585 C, Figure 26, shows that this minimum occurs at a preheat of about 55 seconds and a submerge time before core insertion of five (5) seconds. From Figure 26, it appears that this is an optimum heating cycle for that model since the total heating cycle for the can-sleeve assembly was only 60 seconds as compared to the 67 seconds required by the normal heating cycle. Using the above heating cycle for O3N can-sleeve assemblies, a canning test was designed for the Pilot Plant to test the quality of fuel elements canned using the shorter over-all heating cycle. The total canning cycle, however, was kept constant by adjusting the load-unload time; thus nothing was changed from the normal cycle except the preheat and submerge times for the can-sleeve assembly. The results of the quality tests showed that by using the shorter heating cycle, O3N fuel elements could be fabricated with quality which is comparable to those fabricated using the normal heating cycle. The total internal and external bond count values for pieces fabricated using the shorter cycle differed little from those fabricated using the normal cycle. Furthermore, analysis of the data showed that the UE-1 total external bond count and the UT-4 total internal bond count actually decreased with the increased preheat-decreased submerge time. The UT-4 total external bond count, however, increased with increased preheat-decreased submerge time. This was probably due to mild oxidation at the mouth of the can during the long preheat time. With apparent success in the pilot plant tests, it was recommended that a large-scale O3N production test be conducted utilizing the reduced can-sleeve heating cycle, to further verify the pilot plant results.

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From the results of the optimized heating cycle study of the O3N model, there seemed to be promise for further studies of this type. Because of the special heating cycle given to the four (4) inch O5N model and the problems involved in its fabrication, a study was conducted for the purpose of optimizing the heating cycle of this can model. Similar to the test made for the O3N model, this test consisted of varying the can-sleeve preheat and submerge times in order to find the combination which would allow the can-sleeve to reach 585 C in a minimum of time. From Figure 27, it is apparent that the optimum is indefinite, however, it appears to be in the range of about 45 to 55 seconds preheat. Since with the heating cycle now used the preheat time for this model is 55 to 65 seconds, this indicates that the preheat time could be reduced by as much as ten seconds. It is pointed out, however, that the total time required to reach 585 C was found to be approximately 58 to 87 seconds, whereas in the present 85 to 87 cycle the total time required to reach this temperature is approximately 85 seconds. Therefore, it is evident that no over-all time savings can be realized because a longer submerge time of 32 to 42 seconds is required with the shorter preheat time. Since the over-all cycle time will not be altered by the shorter preheat time, the only possible advantage of the shorter preheat time might be in fuel element quality. From this, it is recommended that a canning test be conducted to prove the feasibility of canning the O5N model with a heating cycle having a preheat of 45 to 55 seconds and a submerge time before core insertion of 32 to 42 seconds. Of major concern should be the effects that the changed cycle has on fuel quality.

Evaluation of Stepped-Base Cans

Even before the start of the concentrated study of optimized heating cycles for the various models, work was being done for the purpose of improving the heating rates of the cans by changing their design. It was at this time that the O3N stepped-base can was introduced. Heating tests were then required to determine whether or not these had better heating rates than did the standard contoured-base can models. Subsequent tests of the O3N model revealed that the stepped-base can did heat faster than the contoured-base model and, in fact, after 47 seconds of preheat, the stepped-base can reached a temperature five (5) degrees greater than did the contoured-base model. (See Figure 28) Further, canning tests which followed showed that the quality of fuel fabricated with stepped-base cans was superior to the quality of fuel fabricated with contoured-base cans. The UT-4 total internal bond count of the fuel fabricated using stepped-base cans was almost one-half that of the fuel fabricated using contoured-base cans.

To further evaluate stepped-base cans, several eight inch O3N stepped-base cans were cut to four (4) and seven (7) inch lengths. It was noted that the standard O5N four (4) inch model can has the same diameter and base thickness as the standard O3N model. Heating studies of the four (4) inch stepped-base model showed that it had a faster heating rate than did the standard model. (See Figure 29) In fact, after 47 seconds of preheating, the stepped-base can reached 557 C, a temperature three (3) degrees greater than did the contoured-base model.

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The seven (7) inch stepped base cans were made because of the prospect of the new O3D depleted fuel elements. Heating studies of this model showed that its heating rate initially was identical to the eight (8) inch stepped-base model, but that after 47 seconds of preheating, the can reached only 566 C, whereas the eight (8) inch model reached 570 C. Comparison of the above stepped-base cans to the four (4) inch stepped-base cans in Figure 30 shows that the heating rates of each can are apparently dependent on can length, especially after the cans reach about 550 C. By comparison, after 47 seconds of preheating the eight (8) inch model reaches 570 C, the seven (7) inch reaches 566 C, and the four (4) inch reaches 557 C. This may be due to the fact that there are greater heat radiation losses to the atmosphere with short cans than with longer cans.

From the work that has been done on the stepped-base can models, it can be concluded that the stepped-base model cans do heat faster than the contoured-base models. Also, the canning tests of the O3N model show that the quality of those elements fabricated with stepped-base cans is equal to or better than those fabricated with contoured-base cans. Therefore, from this standpoint, it is recommended that the present contoured-base cans be replaced with stepped-base cans.

J. W. Hutton

Engineer, MTP
Process Control Engineering
Fuels Engineering Operation
Production Fuels Section, IPD

TW Hutton:skc

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REFERENCES

1. Summary of Process Work Request No. 65-38, T. W. Hutton 8/20/63
 2. Summary of Process Work Request No. 73-42, T. W. Hutton 12/63
 3. Summary of Process Work Request No. 85-49, T. W. Hutton 11/4/63
 4. Summary of Process Work Request No. 90-52, T. W. Hutton 10/9/63
 5. Summary of Process Work Request No. 102-59, T. W. Hutton 12/4/63
 6. HW-47029, "Process Specifications, Aluminum-Silicon Canning Bath," August 20, 1963.
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FIGURE 1

10-300/0

CT/H

FIGURE 2

THERMOCOUPLE ASSEMBLY
FOR SPIRE-CAP

CTH

K-E 10 X 10 TO THE INCH 359-5
KEUFFEL & ESSER CO. MADE IN U.S.A.

359-5

10 X 10 TO THE INCH
KEUFFEL & ESSER CO.

K&E

S. A. 13

FIGURE 1 BATH THERMISTOR KILLER

6-11-62

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TRANSFORMER K5E-67 C-5-13

K.E. 10 X 10 TO THE INCH 359-5
KEUFFEL & ESSER CO. MADE IN U.S.A.

OPTIMIZATION OF
HEATING RATES OF
0.5N 4-INCH CAN -
SLEEVE ASSEMBLIES

FIGURE 27

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TEMPERATURE (°C)

FIGURE 28

0.3N STEPPED-BASE
 CONTROLLED-EFFECT CAN
 COMPARISON

TEMPERATURE

47 SEC

CONTROLLED-BASE
 STEPPED-BASE

TIME (SEC)

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FIGURE 29
HEATING RATE OF CSN
STEPPED-BASE CAN
ANAL

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