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DEVELOPMENT AND EVALUATION OF SPIRE PULSE FOR ALSI LEAD-DIP CANNING

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DEVELOPMENT AND EVALUATION

OF SPIRE PULSE FOR ALSi LEAD-DIP CANNING

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SYNOPSIS

Some of the I&E reactor failures have resulted from porosity and non-wetting associated with the cap wafer. The spire pulse, which involved pulsing of the cap-spire in the ALSi bath during preheating, was introduced to alleviate this problem. Significant improvements in fuel quality and in assembly yield were accomplished through the use of spire pulse.

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DEVELOPMENT AND EVALUATION OF SPIRE PULSE FOR ALSi LEAD-DIP CANNING

In the ALSi process, the I&E fuel element is assembled in a two-piece aluminum container consisting of an outer cylindrical shell and an inner tube containing an integrally impacted cap wafer which forms the top end and cap during canning. Both autoclave failures and reactor failures have been attributed to porosity in the ALSi and non-wetting of the aluminum wafer with ALSi. Porosity and non-wetting in the area of the cap closure provides a pathway for water to penetrate through to the uranium from small defects in the weld which are not detected by visual weld inspection or radiography. These quality deficiencies are caused from two apparent fuel problems, (1) the disparity in mass between the spire and cap wafer which results in uneven pre-heating rates for spire and cap wafer and freezing of gas bubbles under the cap wafer, and (2) the heavyoxide and lubricant contamination on the underside and side of the wafer which causes non-wetting and outgassing. In December, 1958, an additional cleaning step was introduced in the 313 Manufacturing process to improve cap wetting. This change involved degreasing followed by a caustic etch to remove imbedded lubricants in the cap wafer. It was effective in reducing cap wetting, although it did not completely resolve the problem.

The spire-pulse concept was conceived on or about June, 1959⁽¹⁾ as a possible means for further reducing spire and cap-wafer non-wetting, cap-braze voids, and, in addition, for reducing cap-wafer heating rates. This innovation involved vertical pulsing of the cap-spire during the pre-heating stage to promote additional dissolution of metal from the underside of the cap wafer. The spire-pulsing unit, Figure 1, consists of a motor-driven cam which raises a spring-loaded capping-tong holder and allows it to fall at a rate dependent upon the spring tension.

SUMMARY OF RESULTS

Significant improvements, both in quality and in assembly yield, were accomplished by the introduction of spire pulsing equipment in the canning step. Conversion costs for spire pulse amounted to \$5,700 for all canning lines. Average yield improvements predicted by production testing amounted to approximately one percent (this yield improvement is worth approximately \$50,000 annually), and porosity and non-wetting in the cap area were reduced by an approximate factor of 2.8. A comparison of the autoclave failure frequency rate and the Relative Metal Performance Level (RMPL)

(1) Personal communication with C. A. Burgess, ALSi Product Engineering, FPD, November 30, 1961.

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with respect to closure failures for pre-and post-pulsing periods, Figures 2 and 3, revealed a significant improvement in fuel performance. It cannot be assumed that all of the improvement in closure failures resulted from the use of spire pulse; however, it is likely that a portion of the quality gains can be credited to it.

The optimum conditions established for spire pulsing were a pulse rate of 1.4 pulses per second with an amplitude of $3/4$ inch when using a pre-heat time of 21 seconds. Higher pulse rates produced better wetting; however, it was found that a spire-bending problem imposed a limitation on the frequency of pulsing. If the spire-bending tendencies could be overcome, further gains could be realized by increasing the frequency of pulsing.

DEVELOPMENT AND PROTOTYPIC PERIOD

Exploratory work was carried out during the last half of 1959 to determine the feasibility of using spire pulse. During this period it was found that the concept was valid and resulted in improved wetting of the spire and cap wafer. The mechanical development of the prototype was initiated in December, 1959,⁽²⁾ and various cam designs (these controlled the raise and drop rates of the cap-spire) were investigated as well as various pulse frequencies. The development of the prototype was completed on or about March, 1960, and experimental work with this unit was continued through May, 1960. The experimental development work involved the canning of approximately 1600 fuel elements in addition to wetting tests on 3000 spire-caps. During the development period, it was found that a spire-bending problem imposed a limitation on the frequency and the amplitude of spire-pulsing. This was particularly true for the downward acceleration of the spire. The efficiency of this method for wetting the face wafer was also found to be a function of the downward acceleration imparted to the spire-cap and, as a result, cap wetting was to some extent compromised to alleviate the problem of spire bending. It was found that good vertical alignment of the spire during pulsing was an important factor in reducing spire bending. The optimum conditions established for spire pulsing were a pulse rate of 1.4 pulses per second with an amplitude of $3/4$ inch when using a pre-heat time of 21 seconds.⁽³⁾

(2) HW-68982, Completion Report, Cap-Spire Pulser, G. Miller, March 27, 1961, (U).

(3) HW-65800, Cap-Spire Pulsing, C. A. Burgess, June 15, 1960, (C).

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The data from the experimental work⁽³⁾ revealed no significant differences in reject rates between spire pulse and normally pre-heated elements. Destructive examination of canned elements, however, showed a 4 to 1 reduction in cap voids, a 5 to 1 reduction in non-wetting on vertical surfaces, and a 51 to 1 reduction in face wafer non-wetting with spire pulse. Significant improvements were also noted for cap-wafer heating rates. Based on the results of these tests, recommendations were made in June, 1960, to install spire-pulse units on all canning lines in the 313 Building production facility.

PRODUCTION EVALUATION AND CONVERSION

The first production evaluation of spire pulse was performed with the prototype during July 6 through 20, 1960, to determine the operational capability and quality effects of the spire pulse.⁽⁴⁾ During this period, one-half of canning line No. 5 was spire pulsed and one-half was not, and a sample of approximately 1700 fuel elements were destructively examined to determine quality differences. The following quality improvements were found to exist for the spire pulsed elements:

- 1) Cap wafer non-wetting was reduced by a factor of 4.
- 2) Cap wafer braze porosity was reduced by a factor of 1.4.
- 3) Cap braze-line porosity was reduced by a factor of 2.5.

An examination of the reject rates for this period of time (approximately 16,000 fuel elements were involved in the test) revealed a reduction in bond layer contamination rejects by a factor of 2.4 for the spire-pulsed elements. With regard to operational capabilities, it was found that the spire pulse afforded a higher degree of control and was considerably quieter than the standard spire preheating technique. Since these tests corroborated earlier experimental tests, conversion of the production canning lines was initiated.

The production conversion was performed in a stepwise fashion starting on November 30, 1960, and continuing through to completion of all lines on January 6, 1961. One line was converted in November, three lines in December, and two lines in January.⁽⁵⁾ Approximate costs for the conversion were

(4) HW-66299, Production Evaluation of Spire Pulse Preheating Technique, H. G. Powers, August 2, 1960, (C).

(5) Personal communication, G. Miller, Facilities Engineering, November 30, 1961.

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\$3000 for parts and \$2700 for installation which totaled \$5700 for all six lines. (6) The second production evaluation of spire pulse was performed during the installation of the production units to determine the effect on yield. Data representing approximately 250,000 fuel elements were used for this analysis and the following yield improvements were noted for spire pulse: (7)

- 1) Assembly rejects reduced by a factor of 1.3.
- 2) Bond Layer Contamination rejects reduced by a factor of 1.3.
- 3) Internal Bond rejects reduced by a factor of 1.7.
- 4) Radiograph rejects reduced by a factor of 2.0.
- 5) Internal thin wall rejects reduced by a factor of 2.1.

The operational problems encountered with spire pulse were as follows:

- 1) Minor difficulties with keeping the capping tongs properly formed and aligned to prevent lateral whipping of the spire during pulsing. This problem was resolved by modification of the capping tongs.
- 2) Minor difficulties with wearing of pulser bars and supports. This was felt to cause some spire bending. The standard ball slides were replaced by high precision ball slides which essentially eliminated this problem.
- 3) Minor difficulties in keeping tong holders in the vertical position. This was also felt to contribute to spire bending. This problem was alleviated by periodic checking of the tong holder positions.

All of the spire bending problems have apparently been resolved and it is no longer considered to be a problem. In the past, spire bending was detected at the internal penetration tester and by visual examination of the internal bore for wrinkles.

GR Hanson

Engineer
ALS¹ Product Engineering

GR Hanson:skc

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- (6) Personal communication, L. F. Reilly, Facilities Engineering, November 30, 1961.
 - (7) HW-68688, Supplementary Production Evaluation of the Spire Pulse Preheating Technique, B. K. Boyd, February 28, 1961, (C).

FIGURE 1
Assembly View of Spire-Pulse Unit

FIGURE 2 -- AUTOCLAVE FAILURE FREQUENCY RATES
PLOTTED BY SIX MONTHS INTERVALS

FIGURE 3 - REACTOR FAILURE FREQUENCY RATES (CLOSURE FAILURE)
CORRECTED FOR SEVERITY OF SERVICE AND PLOTTED BY SIX MONTH
INTERVALS

FIGURE 4 -- TIME TAELE OF DEVELOPMENT AND
INSTALLATION OF SPIRE PULSE

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