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C. J. Barick, AED Class Officer

Date W. J. O'Leary and R. R. Herries visited BMI to review the progress
of subcontract research on extended surface fuel elements and on
the consolidation of thorium powder.

SUMMARY

1. Seven electrodes of Horizons' powder have been pressed and satisfactorily arc melted under various conditions.
2. A second lot of 18 to 20 lbs. of Horizons' metal has been received at BMI for melting.
3. Eighteen of the proposed 33 "half-dollar" uranium corrosion samples for investigation of higher bonding pressures have been prepared. Ten of these are on test in boiling distilled water.
4. Three ERL fluid-pressure-bonded uranium corrosion samples failed due to sheath rupture after 31-33 days on test; no "undercutting" was evident. These samples have shown satisfactory corrosion resistance.

DISCUSSION

A. Uranium

1. Mechanical Hot Die Pressing

"Half-dollar" size uranium corrosion samples for the purpose of evaluating the effects of higher bonding pressures are being press-clad with 30-mil aluminum at BMI.

DPW-55-24-2

SR/H-797

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Trip Report
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Specimens of nickel-plated uranium, 1" in diameter X 0.180" thick, are being bonded using 10 and 15 thousand psi at 950°F (510°C) for 5 minutes. After pressing, the assemblies are pinch-welded around the edges of the aluminum sheath and are "pinholed" with a 15-mil hole. Samples bonded similarly at 6000 psi are being corrosion tested in boiling distilled water to serve as a basis for comparing the behavior of the samples prepared under the higher pressures when tested under the same conditions.

2. Electroplating of Nickel on Uranium

In conjunction with the press-cladding of uranium, a discussion of electroplating nickel on uranium was held with BMI personnel.

Since uranium cleaning and electroplating techniques may greatly affect the quality and corrosion resistance of uranium-nickel-aluminum bonded systems, it is necessary that those procedures used for the preparation of test specimens be standardized with the procedures in use by the operating groups. For this reason, the BMI and SRL cleaning and nickel electroplating procedures were discussed and compared.

In earlier work on press-cladding of nickel-plated uranium, bond strengths of hot pressed specimens were found to be inconsistent. This was attributed in part to poor adherence of the nickel plate. Consequently, it was thought desirable to roughen the uranium surface to provide better mechanical adherence of the nickel electroplate. This was accomplished in part by sandblasting at BMI; subsequent mild anodic treatment at BMI did not appreciably increase the surface roughness of the core. Since the SRL procedure uses hot nitric acid instead of sandblasting to remove oxide scale, it was considered at SRL that a more severe anodic treatment was required to produce a surface of approximately the same degree of roughness as that achieved with the BMI method. This more severe pickle, however, results in a correspondingly heavier oxide layer to be removed from the hills and valleys of the core surface. The nitric acid pickle (8N, 60-70°C for 30-40 sec.) must completely remove this oxide to insure proper nickel-plating. Therefore, it is necessary that this step be closely controlled and standardized.

It was further agreed that the present pressing techniques warrant a review of the uranium surface roughness now necessary to achieve strong, corrosion-resistant bonds. If uranium-nickel-aluminum bonds of high strength can be attained with much smoother uranium surfaces, several advantages would be realized, i.e., (1) more continuous bonds, (2) easier cleaning, (3) easier electroplating of nickel. Items (1) and (2) above would be especially beneficial to increase the resistance of press-clad fuel elements to undercutting corrosion.

3. Extrusion Cladding

Due to lack of funds, no further work has been done on this program during the last two weeks. A BMI report covering the work to date is being prepared showing that with the present die and mandrel tip, an extrusion cladding $5/32$ " thick can be made. Past work was discussed, as well as tentative designs of equipment for extrusion cladding of plates by the porthole technique which is being proposed as an extension of the present program.

4. Corrosion

The three ERL fluid pressure bonded samples were removed from test after 744 to 792 hours (31 to 33 days). These 1" X 8" X 0.180" nickel-plated uranium cores, clad with 30-mil aluminum, had been drilled with a 15-mil pinhole and placed in boiling distilled water. Pimples which appeared at the pinholes after 9 to 11 days grew in diameter until they had proceeded over the edges of the 1" wide samples and ruptured the aluminum sheaths. The fact that no undercutting corrosion occurred was attributed to the continuous bond obtained with the uniform pressure (5000 psi) exerted by this method of press-cladding, and to the benefits of degassing or dewatering the assemblies before pressing.

Corrosion test results from twelve 3" X 5" X 0.180" aluminum-clad uranium samples, coated with nickel by vapor decomposition of nickel carbonyl at the Mound Laboratory, were inconclusive. As previously reported (DPW-55-24-1), the 4 to 5 weeks' delay between nickel-coating and press-cladding resulted in several non-bonded areas as well as in areas of questionable bond. On corrosion testing, all but one specimen failed by undercutting after 2 to 14 days.

The group of 10 "half-dollar" samples, press-clad at 6000 psi as controls for the "high bonding pressure" samples, have been in boiling distilled water for 144 hours with one failure. This sample undercut from the edge at a defective pinch-weld. This group of samples will evaluate the theory that press-cladding at a higher average pressure than has previously been standard will approximate the more uniform pressure obtained by fluid pressure bonding.

One as-pressed sample from each pressure range will be sectioned for metallography.

B. Thorium

1. Consolidation of Thorium

Seven electrodes, compacted from Horizons' metal, have been arc melted by BMI as their first attempt to consolidate and purify the powdery cathode material. Five of the 1" X 1" X 6" thorium electrodes, cold pressed at 50 tsi, had

been sintered for either 15 or 90 minutes at 1250°C for melting, although the two initial melts were made with unsintered (green) electrodes. The conditions for each melt varied, as shown in the following data:

<u>Melt Number</u>	<u>Electrode</u>	<u>Atmosphere</u>	<u>Crucible Size</u>
1	Green	Less than 100 microns	4"
2	Green	20 inches He	4"
3	Sintered (90 min.-1250°C)	20 inches He	4"
4	Sintered (15 min.-1250°C)	20 inches He	4"
5	Sintered " " "	Less than 100 microns	4"
6	Sintered " " "	Less than 100 microns	4"
7	Sintered " " "	20 inches He	2½"

Considerable "splattering" occurred during each melt although the arc was fairly stable even at the lower pressures. With the exception of the last melt (2½" crucible), the resulting ingots were coarsely spongy with more or less adhering globules. Very little difference was noted between melts from green or from sintered electrodes, although more splatter was experienced from both types of melt at the lower pressures. Melt No. 7, using the 2½" crucible, appeared fairly sound since the smaller diameter resulted in more heat input into the metal. Very little non-metallic sublimate was found in the furnace following the melts.

The minus 250-mesh material, which amounted to 4-5% of the total as-received metal, had been removed by 40 minutes of screening in order to determine the effects of fines on the oxide content of the melts. A screen analysis of the remaining metal showed a normal distribution of particle sizes. Three chemical analyses made on the powder prior to compacting gave a carbon content of 0.03%, and HCl insoluble values of 0.88, 0.89, and 0.75%. Vacuum fusion results have not yet been received. Analyses of an unknown grey deposit found in the vacuum sintering furnace are also being made.

A shipment of 18 to 20 pounds of Fernald thorium has been received at BMI.

2. Diffusion of Thorium into Aluminum

Diffusion couples of aluminum (99.99%) and of an aluminum alloy containing 0.5% thorium have been prepared for determining the amount of diffusion of thorium into aluminum that takes place beyond the limit which can be

detected by metallography. Two couples, bonded at 1125°F (607°C) under a pressure of 6000 psi, were sectioned and found to be well bonded. Since a 1" aluminum cylinder is placed between two alloy cylinders, each sample will provide an extra couple for metallography or for a recheck. Annealing will be carried out at temperatures of 600°C and lower, to that lowest temperature at which measurable diffusion takes place within one month's time. Chemical analyses will be made on 2-mil cuts through the interface, and on 5 and 10-mil cuts farther from the interface, in order to determine the amount of diffusion that occurs through solid solution.

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