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HOT EXTRUSION OF FINE PLUTONIUM WIRE

by

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THE DOW CHEMICAL COMPANY
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ABSTRACT

Unalloyed plutonium wire with a diameter of 0.017 in. was extruded from a 0.170 in. diameter plutonium billet heated to about 230°C.

SUMMARY

1. Unalloyed plutonium wire with a diameter of 0.017 in. was obtained via extrusion at about 230°C.
2. The length of the wire produced was limited only by the extrusion setup.
3. The extrusion process did not appear to influence the ductility of the plutonium; i.e., the resulting alpha wire appeared brittle.
4. The grains in the wire did not appear to be elongated as a result of the extrusion process.
5. The surface condition of the wire was better than that of swaged wire.
6. It was observed that the wire was ductile near the exit of the die. This ductility was attributed to the probability that the wire near the exit was at least in the beta phase. This observation indicates that the wire could be coiled during extrusion if desired.

INTRODUCTION

An unalloyed plutonium wire with a diameter of about 0.020 in. was required for some experimental work. It was decided to attempt to obtain the wire by means of hot extrusion in air. To our knowledge, such work had not been accomplished previously.

EXPERIMENTAL WORK

A 0.017 in. diameter wire was extruded from an unalloyed plutonium billet with a diameter of 0.170 in. The plutonium used was electro-refined and had a total impurity content of less than 200 ppm. The extrusion was done at a temperature of about 230°C (in the gamma-phase region) and at a pressure of approximately 92,000 psi on the piston face. The load was applied using a small laboratory hydraulic press. A comparison of the plutonium billet and the extruded plutonium wire is shown in Figure 1.

Figure 1. COMPARISON OF PLUTONIUM BILLET AND EXTRUDED PLUTONIUM WIRE, Negative No. 308G3-1.

The extrusion die consisted of a 2-in. diameter cylinder of cold-rolled steel with holes of 0.175-in. and 0.020-in. diameters drilled into opposite ends (Figure 2). The piston was machined from hardened steel.

Figure 2. CROSS-SECTIONAL VIEW OF EXTRUSION DIE

Heating of the billet and die was accomplished by wrapping a strip heater around the extrusion die. The temperature was measured by placing a thermocouple on the top of the billet in the extrusion die. The thermocouple was removed just prior to extrusion. An attempt was made to hold the temperature constant by continued power input through the heating tape.

The plutonium wire was extruded into a steel chamber that was 3 in. in length. This was a limiting factor on the length of wire that we were able to extrude. The extrusion apparatus is shown in Figures 3 and 4.

The plutonium billet was dipped into silicone oil prior to being placed in the extrusion die in an attempt to lessen the friction between the die and billet.

After the pressure was applied, the wire was extruded at a rate of approximately 1/4-in. per minute.

The wire that we extruded exceeded the length of the pipe we were extruding into and was bent. However, the wire appeared to be surprisingly straight until this bending occurred.

Figure 3. EXTRUSION APPARATUS. Negative No. 308G1-1.

Figure 4. EXTRUSION APPARATUS IN OPERATING POSITION.
Negative No. 308G2-1.

The ductility of the cooled plutonium wire did not appear to be increased by the extruding operation. The wire broke upon bending, although no quantitative tests were made.

The grain structure of the extruded wire is shown in Figure 5. There is no apparent elongation of the grains as a result of the extrusion at 230°C.

Figure 5. PHOTOMICROGRAPH OF TRANSVERSE CROSS-SECTION OF THE EXTRUDED PLUTONIUM WIRE. Electro-polished, Approximately 90X, Negative No. 307G2-90.

The hardness of the wire was about 240-280 DPH (1000 g load).