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STRUCTURES OF URANIUM EXTRUDED HIGH IN THE ALPHA PHASE

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Conditions were explored for extruding uranium at temperatures high enough in the alpha phase for at least the core of the extruded rod to be transformed into the beta phase as it leaves the die. This uranium then is similar in grain size and texture to uranium conventionally subjected to a separate post-extrusion beta treatment.

Les conditions de l'extrusion de l'uranium aux températures assez élevées du domaine α ont été étudiées de telle façon qu'au moins le cœur du barreau extrudé soit transformé en phase beta quand le barreau sort de la filière. Cet uranium est alors semblable du point de vue de sa grosseur de grain et de sa texture à l'uranium soumis de manière classique à un traitement distinct en phase β postérieur à l'extrusion.

Es wurden die Bedingungen untersucht, unter denen man Uran in einer so hohen Temperatur der α-Phase strangpressen kann, dass mindestens der innere Teil des Presslings sich in die β-Phase umwandelt wenn er die Strangpressform verlässt. So bearbeitetes Uran gleicht in der Korngrösse und Textur dem konventionellen Uran, welches nach dem Strangpressen einer besonderen β-Behandlung unterzogen wurde.

1. Introduction

For dimensional stability under irradiation, the grains of metallic uranium should be both randomly oriented and fine: preferred orientation causes anisotropic growth; coarse grains lead to rough surfaces (bumping, wrinkling, dimpling). Fine grains and random orientation are somewhat incompatible objectives since the means of improving one property is likely to impair the other: working to reduce grain size also increases the preferred orientation; heat treatment to randomize the structure by transforming the uranium into the beta phase coarsens the grains. In practice, primary consideration is given to achievement of a random structure through beta treatment of material worked in the alpha phase; reduction of grain size is sought by controlling the rate of cooling and by alloying. Although rapid cooling is desirable for grain refinement, excessively rapid cooling can introduce preferred orientation.

The program reported here was undertaken to explore the possibility of obtaining novel structures, possibly combining random structure and fine grains, by extruding uranium at temperatures high in the alpha phase. The texture (and hence the irradiation growth) of uranium is known to be strongly dependent on the temperature of alpha working [1]). In the

† The rise in the transus is of course associated with the volume increase in the phase change. Calculation of the magnitude of the temperature increase from the Clausius-Clapeyron equation ($\Delta P/\Delta T = \Delta H/T\Delta V$) gives $\Delta P/\Delta T = 3460$ psi/°C. Thus, under a stress of 100 000 psi, the transformation to beta uranium requires a temperature higher by about 30° C. The heat generated in extrusion is certainly capable of effecting such a temperature increase in the uranium. The exact temperature increase depends on dissipation of heat to the tooling. Higher temperatures are expected along the axis of the billet and the extruded rod.

In 1944 Creutz and Gurinsky [3]) cited the possibilities of the increase of the uranium temperature by extrusion work and the raising of the alpha-beta transus by the extrusion pressure. Their Clausius-Clapeyron calculation gave a $\Delta P/\Delta T$ of about 4000 psi/°C. The value of 3460 given above is in excellent agreement because of cancellation of the effects of downward revision of both ΔH and ΔV from the values available in 1944.