Technical Note:

Parametric Modification of Weld Microstructure in Iridium

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ABSTRACT. A gas tungsten arc weld made in an iridium container for a radioisotopic heat source occasionally failed under certain test conditions. These failures were attributed to columnar grain structures in the weld which frequently displayed a single grain extending through the entire thickness of the weld. The metallurgical properties of the weld were enhanced by modifying the welding parameters to achieve a finer, more equiaxed grain structure. A significant contribution to improving the weld microstructure was made by oscillating the welding arc under precisely controlled conditions.

Introduction

The metallurgy and joining properties of iridium are not well understood although it has been used for various commercial applications, for example, as a catalyst. Gas tungsten-arc (GTA) welds made in 0.025 in. thick (nominal) iridium containers which encapsulated a radioisotopic fuel occasionally failed under test conditions of impact, vibration, and shock. Some failures in early production welds were attributed to columnar grain structures which frequently displayed a single grain extending through the entire thickness of the weld. A development program was therefore undertaken to enhance the mechanical properties of the GTA welds.

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Initial Weld

The iridium heat source capsules were GTA welded in a glovebox containing a helium atmosphere. Initial welding parameters were developed from technology with other noble metals since iridium had not heretofore been precision welded. The major welding parameters initially used were:

Electrode — ⅛ in. diam, EWTh-2 with a special tip geometry
Arc gap — 0.040 in.
Welding current — 41 A dcsp
Welding speed — 12 in./min
Torch gas — helium

Figure 1 shows a photomicrograph of a transverse cross-section through a weld, indicating the type of microstructure which was frequently obtained when the initial weld parameters were used. The primary objective of this development effort was to eliminate the single columnar grain extending through the entire 0.025 in. thickness of the weld and replace it with a finer, more equiaxed weld grain structure.

Parametric Studies

A three-dimensional metallographic examination was performed

Fig. 1 — Photomicrograph of a transverse cross-section through a weld made with initial weld parameters. X40, reduced 31%

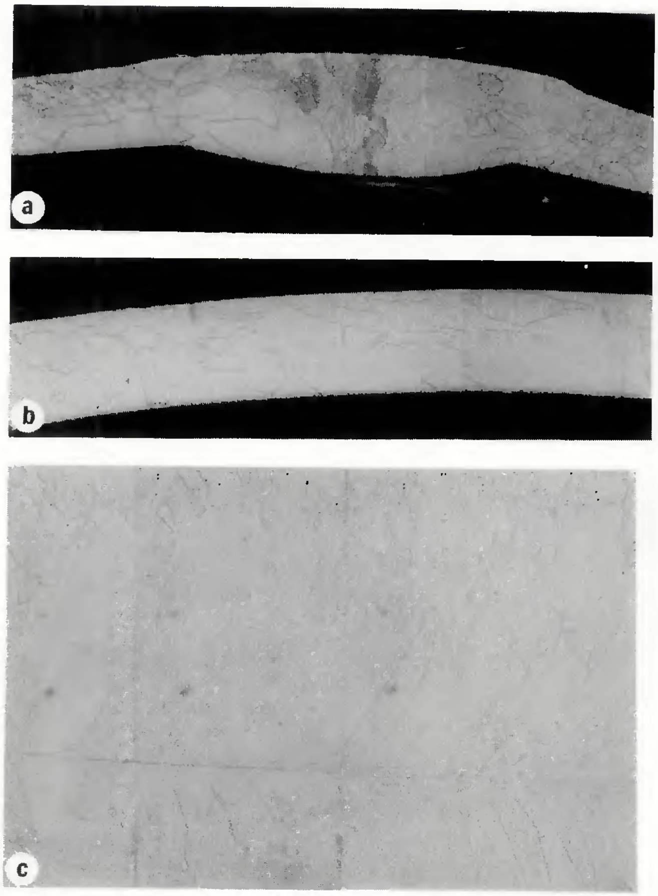

Fig. 2 — Photomicrographs showing effects on weld microstructure of 30 in./min welding speed. (a) Transverse section; (b) longitudinal section; (c) top section, X40, reduced 46%

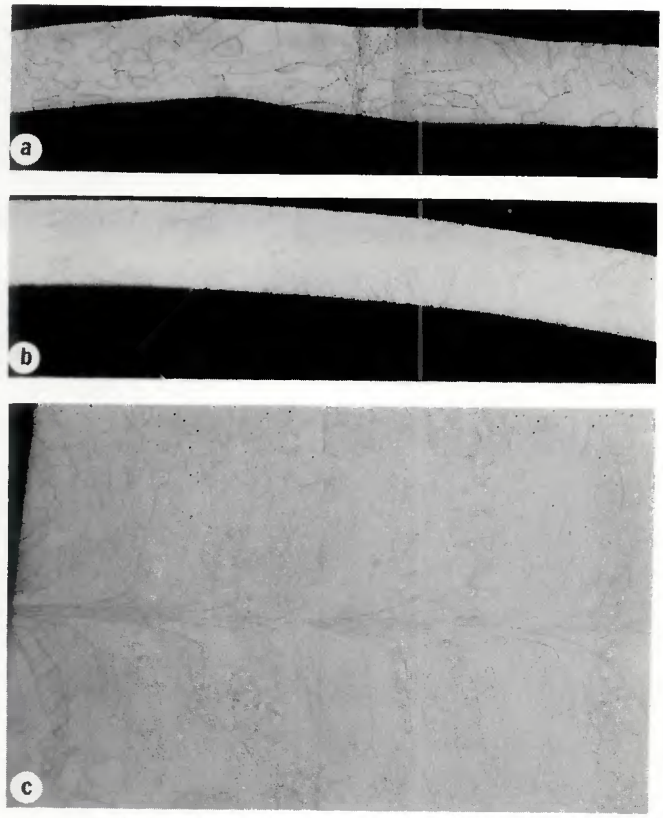

Fig. 3 — Photomicrographs showing effects of oscillating the welding arc at 192 cycles per minute; 30 in./min welding speed. (a) Transverse section; (b) longitudinal section; (c) top section. X40, reduced 48%

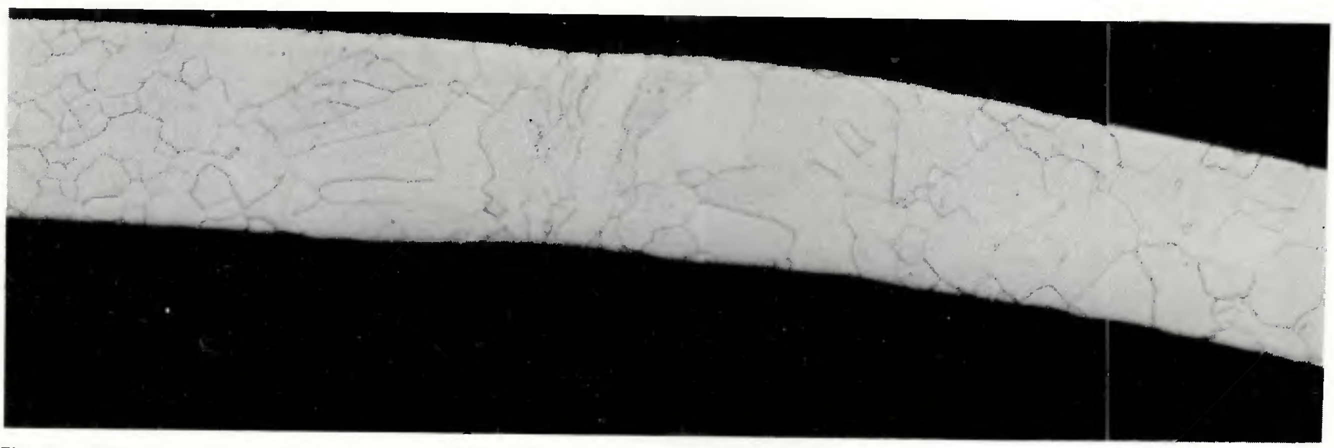

Fig. 4 — Photomicrograph showing effects of 30 in./min welding speed, oscillation, and trailing chill gas. X40, enlarged 25%

on each of the development welds in order to obtain a detailed analysis of the effects of each weld parameter change. Specimens were taken transverse to the weld, longitudinal to the weld along its center line, and at the top face of the weld. Transverse sections were found to be less informative than the other two sections for evaluating the overall effects of the parameter changes.

The following changes in welding parameters were evaluated:

1. Increase in welding speed
2. A trailing helium chill gas
3. Oscillation of the welding arc

Figure 2 shows the effects on the weld microstructure of increasing the welding speed from 12 to 30 in./min with a corresponding increase in welding current from 41 to 65 A. The welding current was increased to maintain the same weld bead width. It can be seen that there is a significant modification of the weld microstructure.

Figure 3 shows the effects of oscillating the welding arc at the 30 in./min welding speed. Some further improvement in weld microstructure can be seen in these photomicrographs. The arc oscillator was a "door bell" type made in the laboratory and it oscillated the arc in a sinusoidal pattern at 192 cycles per minute.

Figure 4 is a photomicrograph of a weld made with 100 cfh of helium gas directed on the weld immediately behind the weld cup at the 30 in./min welding speed and with arc oscillation. Only the transverse section is shown for comparison. The gas flow could not be increased above 100 cfh without perturbing the welding arc. It can be seen that this trailing chill gas

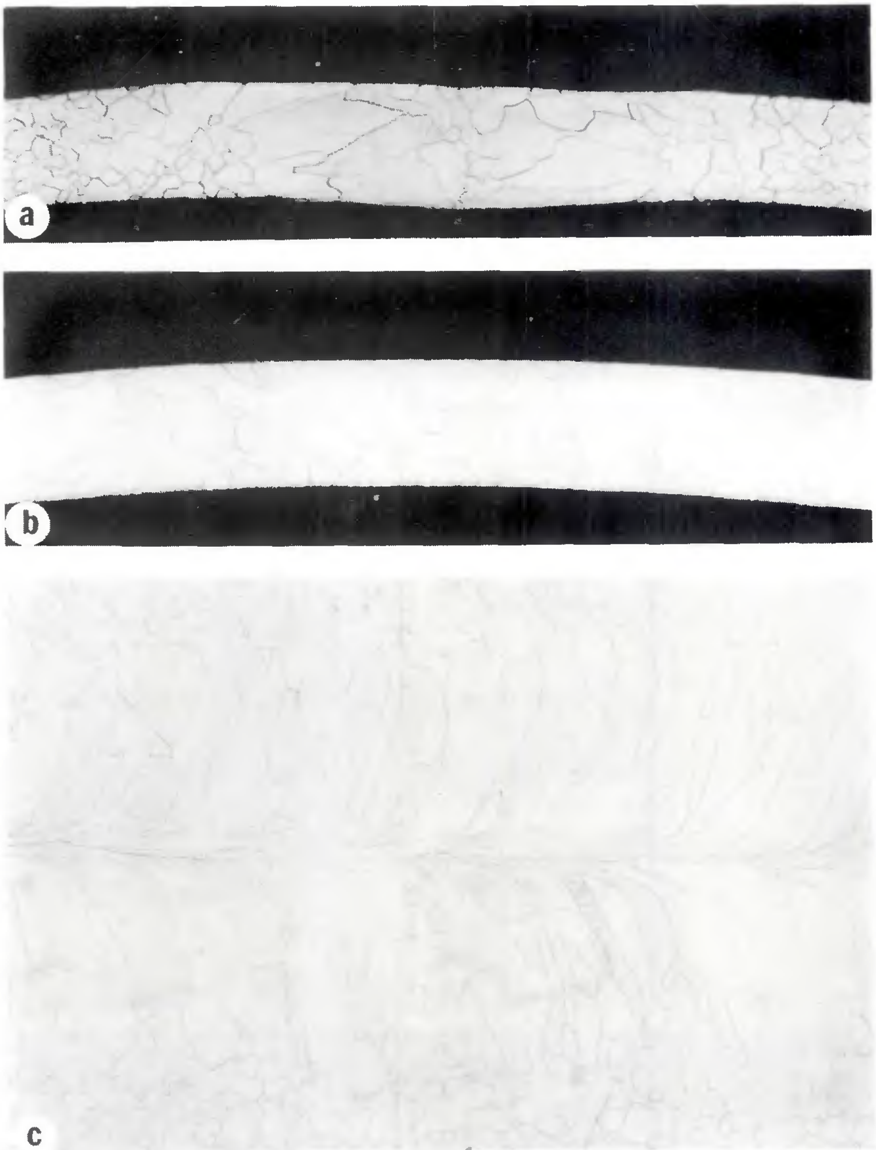

Fig. 5 — Photomicrographs showing effects of oscillation at 375 cycles per second and a welding speed of 30 in./min. (a) Transverse section; (b) longitudinal section; (c) top section. X40, reduced 27%

did not materially affect the weld microstructure. Consequently, the chill gas concept was dropped from further consideration during subsequent work.

At this point in the development effort, the "door bell" oscillator was replaced with a commercial unit which provided a means of independently adjusting the arc sweep rate across the weld center line and the arc dwell time at each edge of the weld. A series of welds was made at the 30 in./min welding speed to optimize the sweep rate and dwell time with respect to the weld microstructure. Final oscillation parameters were a 5 msec sweep rate and a 75 msec dwell time at each edge of the weld. These oscillation parameters result in an arc pattern which is essentially a square wave with a frequency of 375 cycles per minute. Figure 5 shows the typical weld microstructure which was achieved, i.e., a finer, less columnar microstructure with no single grains extending through the entire thickness of the weld.

Conclusions

The microstructure of GTA welds in thin iridium was significantly improved by increasing the welding speed and by oscillating the welding arc. A trailing chill gas was ineffective under the conditions tested. The arc oscillator with independently adjustable oscillation parameters was a significant contributor to obtaining a weld having smaller, more equiaxed grains. This type arc oscillator has a high potential for improving the microstructure of welds made in other materials.

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