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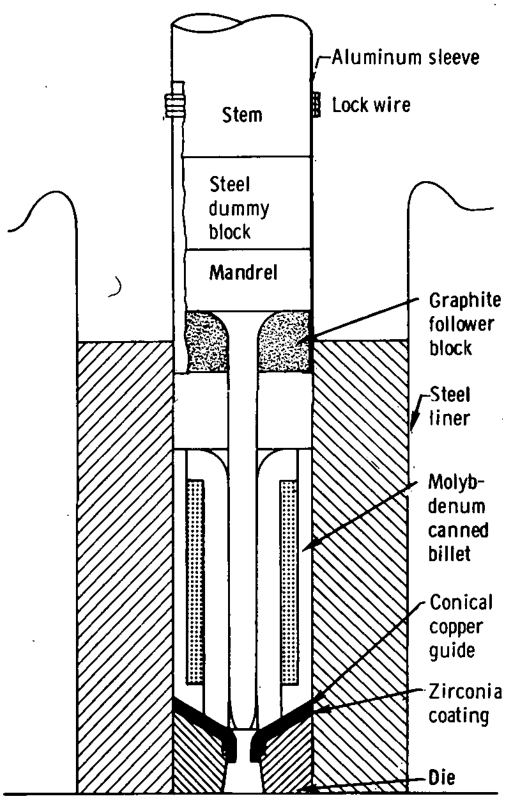
Extrusion of Small-Diameter, Thin-Wall Tungsten Tubing



Small-diameter, thin-wall seamless tubing of the refractory metal tungsten has been fabricated in lengths of up to 10 feet by hot extrusion over a floating mandrel. Successful extrusion of 0.50-inch-diameter tubing over 0.4-inch-diameter mandrels was accomplished at temperatures ranging from 3000° to 4000°F. Tubing of 0.375-inch diameter was extruded successfully over 0.3-inch-diameter mandrels at 3500° and at 4000°F.

Nominal wall thickness of the tubing produced by this modified floating mandrel technique was 0.020 inch. For the best 0.375- and 0.50-inch-diameter tubing specimens produced, wall thickness tolerances were within ±0.001 and ±0.002 inch, respectively. The diametrical tolerances were within ±0.005 inch. At 3500°F, the tensile strength of the extruded tubing, 8300 to 9600 psi, is comparable to that of wrought sintered tungsten.

One of the more promising experimental methods of fabricating seamless tungsten tubing is the filled-billet extrusion method. In this method, the starting billet consists of a tungsten tube with a molybdenum

(continued overleaf)

core and a molybdenum envelope (can). The entire billet is reduced to the desired dimensions by hot extrusion, and the tungsten tubing is obtained after selective dissolution (in acid) of the molybdenum core and can. This method is not fully practicable because of the difficulty of removing the core material from long lengths of tubing and the need for additional processing steps. The floating mandrel technique, which was shown previously to be feasible for extrusion of relatively large diameter (0.8 inch) thin-wall tungsten tubing, had received little attention for extrusion of small diameter thin-wall tubing before the present investigation.

With the modified floating-mandrel technique, billet canning procedures are utilized to lower the effective reduction required in the direct extrusion of thin-wall tubing. By this method, fully dense, wrought tungsten tubing of reasonable lengths can be extruded in one step. In addition, the central pilot hole remaining after withdrawal of the mandrel makes it easy to leach out the canning material (molybdenum shell) from the inside of the tubing. The components of the billet were fabricated by conventional powder metallurgy techniques. All billet components were dry machined to size, and a hole was provided through the center of the molybdenum core (to form a shell) for mandrel insertion. The billet was held together by tantalum pins (not shown) fused at 120° intervals along the can-shell interface.

The floating mandrel is made of tool steel and coated with zirconia for thermal protection. A copper guide may be used over the zirconia coated extrusion die to assure mandrel alinement. The mandrel is attached to the extrusion stem by an aluminum sleeve, which also contains a steel dummy block and a graphite follower. The billets, inductively heated to the desired extrusion temperature in a flowing hydrogen atmosphere, are transferred to the extrusion press in a rapid transfer device. During extrusion (in a 1020-ton vertical extrusion press), the billet is forced between the die orifice and the mandrel to form a molybdenum canned extrusion containing tungsten tubing of the desired reduced diameter and wall thickness. After cooling of the extrusion, the tungsten tubing is freed from the molybdenum by dissolving the latter in a solution containing 50 percent concentrated nitric acid, 10 percent concentrated sulfuric acid, and 40 percent water.

Notes:

1. This technique may be adaptable to the fabrication of similar size tubing from the stronger solid-solution or dispersion strengthened alloys of tungsten. With improved lubrication techniques, extrusion of smaller diameter and thinner wall tubing may be possible. Slight modification of the canning technique may permit extrusion at lower temperatures conducive to cold working. In addition to the enhancement of mechanical properties, a cold worked structure would be desirable for subsequent working operations, such as warm drawing for final sizing.
2. Details concerning this development are given in NASA TN D-3772, "Extrusion of 1/2- and 3/8-Inch-Diameter, Thin-Wall Tungsten Tubing Using the Floating-Mandrel Technique", by C. P. Blankenship and C. A. Gyorgak, available from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia 22151, price $1.00. Inquiries may also be directed to:

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Patent status:

No patent action is contemplated by NASA.

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