CASTING SMALL SPECIMENS OF REFRACTORY METALS

Description of a method of preparing small laboratory specimens of a refractory alloy by casting an arc-melted button directly into a chill mold.

by M. T. Hepworth

In a recent dilatometric study of the titanium-oxygen system, it was found necessary to produce small cylinders of titanium-oxygen alloys having a high degree of homogeneity. This paper describes a method for producing such alloys by casting an arc-melted button directly into a chill mold.

Initially, master alloy buttons were produced by arc melting with a water-cooled tungsten electrode on a chilled copper hearth under an inert gas atmosphere. The range of oxygen contents of the alloys was such that the solubility limit of oxygen was not reached; however, the resulting alloys were extremely brittle, and thus could not be mechanically worked. The buttons were also found to be rather inhomogeneous because of the segregation of oxygen which occurred during cooling.

In order to overcome these difficulties, a subsequent step in alloy preparation was developed. A mold was designed which served both as a mold and a melting hearth. The mold, shown in the accompanying figure, consisted of a copper bar 10.2 cm in diameter and 8.5 cm long split longitudinally along its axis. A cup was machined on one face, and a cylindrical hole 0.25 in. diameter by 2 in. long was drilled along the axis. A vent was cut at the base of the cylindrical hole.

A 50-g button of master alloy was placed on the cup of the assembled mold which was clamped together and put into a vacuum furnace. The furnace enclosure was then evacuated and back-filled with argon at a pressure of 14 cm of Hg. A water-cooled $\frac{3}{8}$ -in. tungsten electrode and a high-frequency starting circuit made up the furnace. The first melting of the master button was accomplished in 1.5 min with a direct cur-

rent of 400 amp and a closed-circuit voltage of 20 v. Although the large copper block was not water-cooled, it did not rise appreciably in temperature. Upon cooling, the furnace was opened and the button removed from the cup. At this power level the rate of heating was too low to provide sufficient superheat to cause the alloy to flow into the cylindrical hole; therefore, only a shallow nipple was formed over the hole. This nipple was ground off and the button was again placed into the cup.

After evacuating and back filling, an arc was started with 1200 amp and 20 v power. This power level was maintained for about 1 min. Again the mold underwent very little heating, but the button melted and a portion of it flowed into the cylindrical mold. The mold was taken apart and the button with attached cylinder removed.

Three master alloys had been previously prepared, analyzing 0.01, 0.25, and 4.66 wt pct oxygen. The

cylinder made from the 0.25 wt pct button was analyzed by sectioning into four lengths and subjecting the sections to vacuum fusion analyses. The four analyses for oxygen made on the cylinder gave a variation in oxygen level of less than 0.02 wt pct in the total length.

The geometry of the mold, power levels, and inert gas pressure were all determined by trial and error. Two meltings were required, the first was necessary to conform the button shape to the mold cup, and the second to produce the cylinder.

After the first melting, the nipple which was formed could not be melted by increasing the power input or length of time during which power was supplied. When the nipple was ground off and the button replaced in the cup of the mold, the button-mold interface represented a good heat transfer path; whereas, the small region of the button over the cylindrical hole could not lose heat readily to its surroundings. The application of a sudden intense power source caused the button to melt rapidly and achieve a high degree of superheat, except immediately adjacent to the button-mold interface. Violent stirring of the button was accomplished by the intense arc. Within a minute, the bottom of the button over the cylindrical opening melted, and the mold was filled with alloy. Freezing of the cylindrical section was probably very rapid, hence the low degree of longitudinal segregation.

The pitch of the cup, length and diameter of the cylindrical hole, mass of alloy, power level, and argon pressure are all rather critical factors. The exterior surface of the copper mold was contoured in order to prevent arcing to the rim.

Although this process is a rather specialized one, it is probably applicable to a number of refracting metals for which chill casting in an inert atmosphere is necessary, and where a high degree of homogeneity is needed.

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