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Applications of Solid-Phase Bonding to Refractory Metals

By P. J. GRIPSHOVER,
Battelle Memorial Institute, Columbus, Ohio

Synopsis

The refractory metals possess special fabrication problems because of their high melting points and poor oxidation resistance. Modifications of standard primary and secondary working techniques, welding, and brazing have been found suitable to some but not all of the refractory metal alloys being considered. Experiments conducted at the Battelle-Columbus Laboratories have shown that many fabrication problems can be overcome by the application of the gas-pressure-bonding process to refractory metals and their alloys.

The gas-pressure-bonding process has been used for both solid-phase joining and powder-metallurgical applications. In this paper, techniques are discussed for solid-phase bonding columbium, molybdenum, tantalum, rhenium, tungsten, and their alloys to themselves and to other refractory metals. Bonding parameters, surface preparations, and microstructural interpretation of the resulting bonds are discussed. Examples are presented of practical applications of this joining process to refractory metal structures. An analysis of the relative advantages and limitations of the solid-phase-bonding technique is also presented.

Introduction

The primary property of refractory metals which makes them useful is their structural strength at very high temperatures. This provides construction materials for such applications as furnaces, reactors, aircraft, missiles, and chemical processing equipment.

However, to be successfully employed in structural applications, it is necessary to have available satisfactory joining methods which will permit full utilization of the high-temperature capabilities that refractory metals possess.

A number of properties common to these materials complicate joining them to themselves and to other materials. These include poor oxidation resistance, high ductile-brittle transition temperatures, sensitivity to interstitial elements, and tendency to form compounds when in contact with more common materials. Because of these properties, it is necessary to control atmospheres, grain size, and the use of foreign materials if severe degradation of base metal properties is to be avoided. In spite of these limitations, varying degrees of success have been achieved by welding, braz-