Development of Metal-Ceramics

POSSIBILITIES OF THE PLATINUM METALS IN SILICIDE CERMETS FOR HIGH TEMPERATURE SERVICE

The possibility that one of the platinum metals might meet all the exacting requirements of a metallic binder for a silicide cermet having strength, stability, and oxidation resistance at high temperatures is put forward by Dr. Alan W. Searcy, associate professor of ceramic engineering in the Division of Mineral Technology of the University of California, as a result of a theoretical survey he has just published on "Predicting the Thermodynamic Stabilities and Oxidation Resistances of Silicide Cermets" (1).

Cermets, which have been the subject of a great deal of intensive—and for the most part disappointing—research during the past ten or fifteen years, are essentially composite bodies made by incorporating particles of some refractory (usually silicide, oxide, boride or nitride) in a continuous, ductile, metallic network. The familiar cemented carbides, made by bonding particles of tungsten and other carbides with cobalt, are the prototypes of all cermets.

The most optimistic seeker after the perfect cermet hardly hopes that he will ever develop a kind of super heat-resisting alloy, capable of being hammered home in a force fit or adjusted to shape after installation; what is needed is a highly refractory body, almost certainly destined to be ground to shape, but resistant to the blows of normal service.

The number of combinations possible is obviously enormous, and in recent years many scores have been made and tested experimentally. Dr. Searcy now suggests that the area of investigation can be very appreciably narrowed down by choosing those combinations which are most likely, from thermodynamic considerations, to be (*a*) resistant to oxidation and (*b*) chemically stable—the refractory and the metal must not react at high temperatures. He has therefore collected the available thermodynamic data and applied it to the problems of those cermets incorporating, as a refractory, the high-melting silicides.

Among the known silicides, molybdenum disilicide is outstanding in its resistance to oxidation, and this is attributed to the formation on the surface of the particles of a closely-adherent layer of nearly pure silica glass, the MoO_3 which is formed at the same time escaping by volatilisation. Very protective silica coatings also form on silicon carbide and silicon nitride by a similar reaction. In general, therefore, Dr. Searcy suggests that investigation of further silicides should be confined to those of high silica content which on oxidising form silica glass together with a volatile metal oxide. He concludes that "the only uninvestigated silicides that appear to meet this requirement are the disilicides of rhenium, ruthenium, rhodium, palladium, osmium, iridium and platinum". The stability of none of these, however, seems likely to be better than that of molybdenum disilicide.

The bonding metal must similarly be resistant to oxidation and must not react with the silicide. Here again, the platinum metals appear to have attractive properties and are well worth further consideration. At first sight, therefore, molybdenum sulphide bonded with platinum would seem to have promise, but two American investigators, De Vincentis and Russell (2), have recently reported that reaction takes place between these materials at 1425°C. Dr. Searcy and his collaborators are now investigating the behaviour of the remaining platinum metals with molybdenum disilicide, but apparently have little hope of finding a stable combination. There seems greater hope in bonding silicon carbide or silicon nitride with one of the platinum metals, since the latter do not form stable carbides or nitrides, and Dr. Searcy writes that "cermets of platinum metals with silicon carbide or silicon nitride seem to be well worth investigating".

Dr. Searcy concludes his review with these words: "Unfortunately the materials that seem to have the greatest promise are rare and expensive. In certain areas of critical needs, such as in high-temperature engine parts, the high costs of such materials would not bar them, however, from limited application if they prove to be really satisfactory."

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References

1 A. W. Searcy .. .. *J. Amer. Ceram. Soc.*, 1957, **40** (12), 431–435

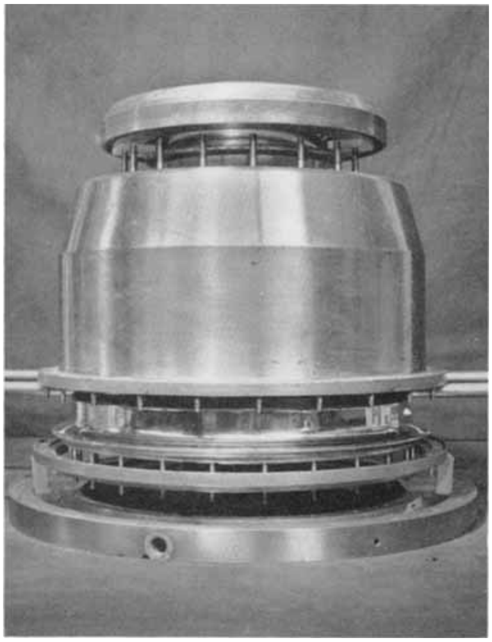
2 H. A. De Vincentis and W. E. Russell .. .. *Nat. Advisory Comm. Aeronaut. Research Memo.*, 1954, E54B15

Rhodium Plating in a Homopolar Generator

Direct current electromagnetic pumps have been applied to the primary heat-transfer circuits of nuclear reactors cooled by liquid metals. They have substantial advantages for pumping liquid metals, but they require to be supplied with a very large direct current.

An experimental homopolar generator for this purpose has been designed at the Atomic Energy Research Establishment at Harwell (1) and made by A. Frazer-Nash and the Palatine Tool and Engineering Company (Surbiton) Ltd. The use of mercury collector rings in this machine has reduced the "brush drop" to a few millivolts, with a friction loss of about two per cent of the power output. These losses are remarkably small for a rating of 10,000 amp. at one volt.

The copper rotor and brush assembly is shown in the photograph, with the outer collector rings separated. When assembled and rotating, each outer collector forms a circular trough filled with mercury. The rim of each stationary inner collector is immersed in the mercury in the trough. The relative peripheral speeds of the outer and inner rings may be more than 40 feet per second, so that the hydrodynamic conditions in the channel between them are severe, and lightly protected copper rings suffered attack. A heavy electrodeposit of hard nickel, by Fescol Limited, provided resistance to erosion, and to this a deposit of 0.0001 inch of rhodium was applied by Johnson, Matthey & Co., Limited. The rhodium surface is quite inert to mercury and is free from tarnish, so that very high electrical conductivity is maintained.



Brush and rotor assembly of the homopolar generator

Reference

1 D. A. Watt .. .. The development and operation of a 10 kW homopolar generator with mercury brushes, AERE R/R 2375 (to be published in Part A, Proceedings I.E.E.)