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SUBJECT: Compatibility Tests of Various Materials in Molten Sodium

TO: W. D. Manly

FROM: R. Carlander and E. E. Hoffman

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Introduction

The compatibility of various materials in molten sodium is important in determining their high-temperature applications. The solid-solid diffusion occurring between two materials when in contact at high temperatures may have adverse effects on their structural properties depending upon the extent of the bonding or compound formation that may result. In order to determine the nature of the alloying occurring in such a system, the diffusion couples Inconel-beryllium, molybdenum-beryllium, molybdenum-INOR #8 (Nom Comp wt %: 15-17 Mo, 6-8 Cr, 4-5 Fe, Bal Ni) and type 316 stainless steel-INOR #8 have been studied.

Summary

Several compatibility tests of various materials in contact in sodium under 500 psi pressure were conducted for 716 hr at 1500°F. Of the diffusion couples studies, the Inconel-beryllium system showed the largest amount of alloying. The reaction between molybdenum and beryllium resulted in the formation of two compounds, both of which were severely cracked in several areas. The molybdenum-INOR #8, and the INOR #8-type 316 stainless steel interfaces showed little if any alloying.

Procedure

A compatibility test system was prepared by placing 1/4 x 1/2 x 1 in. specimens of Inconel, beryllium, molybdenum, INOR #8, and type 316 stainless steel together in sodium. (Figure 1) In addition, a groove (0.010 x 0.250 in.) was machined in each specimen in order to determine the extent of diffusion occurring across a stagnant sodium layer. The assembly (Figure 2) was then tested at 1500°F for 716 hr--when failure of the bellows occurred. The specimens were then removed from the test system and examined metallographically.

Results

Inconel-Beryllium

A reaction layer 36 mil deep was formed at the Inconel-beryllium interface. (Figures 3 & 4) Two compounds formed, BeNi and $Be_{21}Ni_5$, which had hardnesses of 894 and 1656 DPH, respectively. (Table I) No analysis of the diffusion across the stagnant sodium layer was possible because the beryllium was "extruded" into the Inconel groove. The large amount of alloying found in this system is deleterious and experiments are being performed to determine the suitability of chromium as a diffusion barrier between the two materials.(1)

Molybdenum-Beryllium

A reaction layer, 5 mil deep, composed of the two compounds $MoBe_2$ and $MoBe_{13}$, formed at the molybdenum-beryllium interface. (Table I) The two compounds were similar in appearance to those formed in the previous static tests. Both compounds

(1) E. E. Hoffman, et. al., ORNL-2106, ANP Quar Prog Rep June 10, 1956, p. 148.

were severely cracked in many areas (Figure 5). No analysis of the diffusion across the stagnant sodium layer was possible because the beryllium was "extruded" into the molybdenum groove. The alloying between molybdenum and beryllium is deterimental because of the brittle nature of the reaction layer.

Molybdenum-INOR #8

No apparent compound formation was observed at the reaction interface. No alloying occurred across the stagnant sodium layer. (See Table I)

Type 316 Stainless Steel-INOR #8

No apparent compound formation was observed at either the reaction interface or across the stagnant sodium layer, although the two specimens did bond during the test. Diffusion voids were formed to a depth of 1 mil in the INOR #8. A depleted zone approximately 1/4 mil deep appeared at the surface of the type 316 stainless steel. (Figure 6) The hardness of this zone did not differ significantly from either of the parent materials (see Table I).

R. Carlander

R. Carlander

E. E. Hoffman

RC/dp

E. E. Hoffman

Table I

Metallographic Examination of Interfaces of Diffusion Couples Tested in Sodium Under 500 psi Pressure for 716 Hr at 1500°F.

Interface	Compounds	Hardness (DPH)	Depth of Reaction Layer	Metallographis Notes
Inconel-Beryllium	$Be_{21}Ni_5$ BeNi	1656 894	35 1	Beryllium compressed into 10 mil groove. Slight alloying observed in groove.
Molybdenum-Beryllium	$MoBe_{13}$ $MoBe_2$	2575 1545	2-1/2 2	$MoBe_{13}$ was pink in appearance and similar to that found in previous Mo-Be static tests in sodium. Severe cracking of reaction layer occurred in several areas. Beryllium compressed into 10 mil groove.
Molybdenum-INOR #8	-	-	None	No apparent compound formation. No alloying observed in 10 mil groove.
Type 316 Stainless Steel-INOR #8	-	-	1 Mil	No apparent compound formation. Specimens bonded during the test. Diffusion voids to depth of 1 mil in surface of INOR #8. Depleted zone, 1/4 mil deep, on surface of type 316 stainless steel. No reaction observed in 10 mil groove.

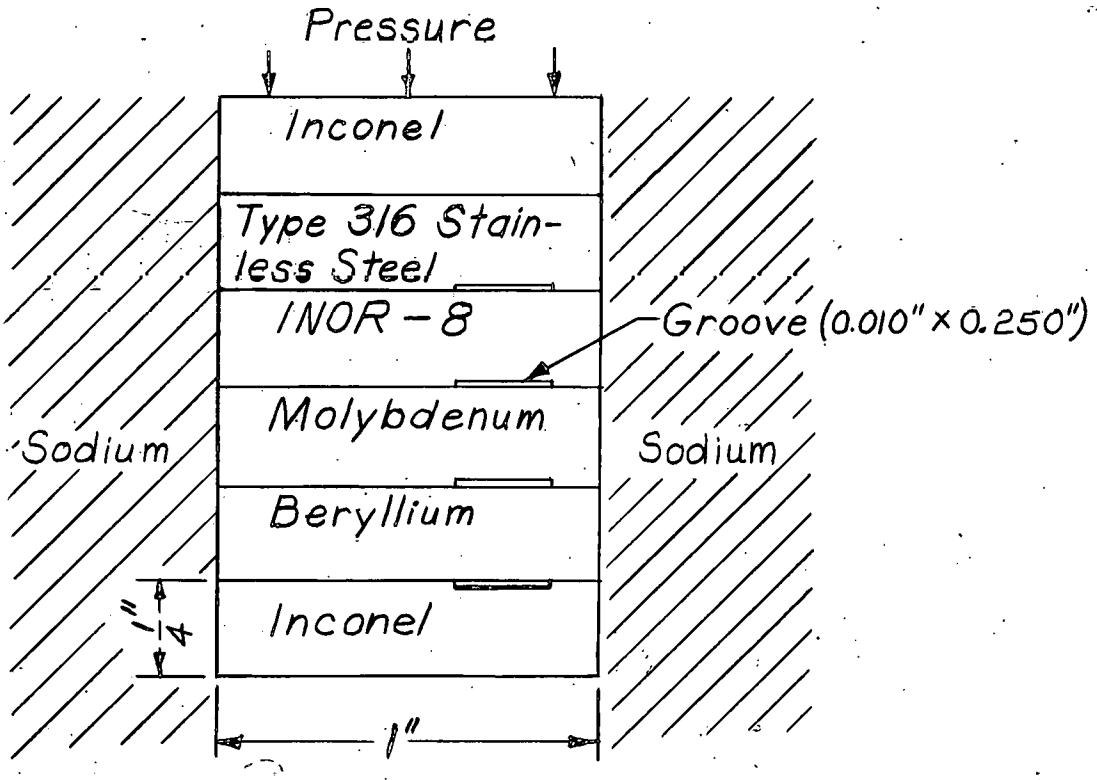

Fig 1
Specimen Positions in Sodium Compatibility Test