CONF-751101--39

Self-Welding Evaluation of Reactor Materials in Flowing Sodium

(Ji Young Chang, P. N. Flagella, S. L. Schrock)

Summary Paper for Presentation at the 1975 Winter Meeting of the American Nuclear Society, San Francisco, California. November 16-21, 1975

The objective of this program is to provide experimental information on the self-welding characteristics of fast breeder reactor materials which will be in static contact, under load, for extended periods while immersed in high temperature sodium.

Various material combinations have been tested at temperatures from 800 to 1100°F for time periods up to six months and at constant contact stresses from 2 to 148 ksi on a contact area ranging from 0.08 to 1.9 inch square. In addition, three interface geometries have been used (flat-on-flat, flat-on-curved, and curved-on-curved) with subsequent separation performed in either tensile or shear modes. A summary of the testing conditions is presented in Table 1.

Testing procedures consist of allowing high-temperature sodium to flow freely between the specimen surfaces for several days until the oxygen content of the sodium attains a level between 0.5 - 1.0 ppm. Sodium, being a strong reducing agent, removes the surface oxides normally present on most potential reactor materials. These oxides prevent or inhibit self-welding in non-reducing environments. After the surfaces have been cleaned by the sodium they are mated and remain in static contact under load for the duration of the test. Separation is also performed with the specimens immersed in sodium normally at the same temperature level as that maintained during the test.

Stresses required to separate the surfaces at the completion of the tests are also summarized in Table 1. Thus far, self-welding has only been observed at temperatures of 1050°F and above. The maximum self-welding tendency is encountered with a flat-on-flat geometry. Other geometries also show some self-welding tendencies but require longer times to achieve the same bond strength.

This is felt to be caused by elastic deformations on curved surfaces which break the self-weld bond when loads are removed.

Breakaway data for a Stellite 156 couple at 1050°F under a compressive stress of 16 ksi could be correlated quite accurately by the following equation.

$$S = 1800\ t^{1/2}$$

where S is the tensile stress in psi required to break the bond and t is the test duration in month.

One self-weld couple of Type 304/Type 304 SS was not separated but rather was removed intact from the test apparatus and examined in cross section. Scanning electron micrographs of the contacted area showed that portions of the original interface were no longer discernable.

In no instance has the stress required to break the self-weld bond approached the force capability of the reactor component being simulated in the test.

Table 1. Materials, Test Conditions and Results for In-Sodium Self-Welding Tests

Material Combination	Contact Temp. °F	Contact Stress, ksi	Contact Time, Months	Separation Temp. °F	Separation Shear(d) Friction Coef.,μ	Separation Stress, ksi
Type 304 SS/Type 304 SS (a)	800	2	6	400	---	0
	800	2	6	400	---	0
	800	2	6	400	---	0
	800	10	6	400	---	0
	800	10	6	400	---	0
	800	30	6	400	---	0
Type 304 SS/Type 304 SS (a)	1100	12	3	300	>13.9	-
Cr Plated Type 304 SS/ Type 304 SS (a)	1050	12	3	310	3.6	-
Type 304 SS/A286 (a)	800	15	6	400	---	0
	800	15	6	400	---	0
	800	30	6	400	---	0
Type 304 SS/A286 (a)	1060	12	3	320	0.9	
Type 304 SS/Inconel 718 (a)	1100	4	3	1050	---	1.10
Inconel 718/A286 (a)	1100	5	3	310	2.0	
Stellite 156/Stellite 156 (a)	850	6	1	850	---	0
	850	6	3	850	---	0
	850	6	4	850	---	0
	1000	6	1	1000	---	0
	1100	6	3	1050	---	2.24
	1100	16	1	1050	---	1.84
	1100	16	3	1050	---	3.08
	1100	16	6	1050	---	4.48
Inconel 718/Inconel 718 (b)	850	148	1	850	---	0
	850	148	3	850	---	0
	850	148	4	850	---	0
	1000	148	1	1000	---	0
	1050	148	1	1050	---	0
	1050	148	3	1050	---	0
	1050	148	6	1050	---	0
Inconel 718/Inconel 718 (c)	1050	16	1	1050	---	0
	1050	16	3	1050	---	0
	1050	16	6	1050	---	0.57
Stellite 6/Stellite 6 (c)	850	12	1	850	---	0
	850	12	3	850	---	0
	850	12	4	850	---	0
	1000	1	1	1000	---	0
	1050	12	1	1050	---	0
	1050	12	3	1050	---	0
	1050	12	6	1050	---	0.64

(a) Flat-on-Flat
(b) Curved-on-Flat
(c) Curved-on-Curved

} Geometry of Contacted Surfaces

(d) Separation measured under partial load. Values given are based on when motion initiated