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Metallurgy and Ceramics

General Electric Company
KNOLLS ATOMIC POWER LABORATORY
Schenectady, New York

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Final Report

Brazing Type 304 to Type 304 Stainless Steel With High Temperature Brazing Alloys

Shop Order 31-071-421-433

by

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September 13, 1956

Operated for the US Atomic Energy Commission by the General Electric Company under Contract No. W-31-109 Eng. 52

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876-001

Introduction

The use of high temperature brazing alloys rather than fusion welding would be advantageous in certain S3G applications. Full penetration and a reduction of distortion could be obtained in cases where welding would be very difficult.

A few brazing alloys are known to have good corrosion resistance in 680°F water. However, no information is available on the mechanical properties of brazed joints made with these alloys after corrosion.

Objectives

The purpose of this work was to determine the mechanical behavior of four brazing alloys on type 304 stainless steel in the as-brazed condition, after stress-relief annealing and after exposure to 680°F water corrosion.

The brazing alloys listed in Table Ia were included in this investigation.

Conclusions

1. The 82% Au-18% Ni brazing alloy yielded better mechanical properties than the other alloys tested.
2. The ANP-81 alloy was found to be cracked in all samples examined metallographically.
3. None of these alloys were corroded to an appreciable amount in 680°F water.
4. Brittle alloy phases were observed in the joints brazed with ANP-81 and Coast Metals NP.
5. An improvement in the mechanical properties of the ANP-81 braze was apparent after a post heat treatment of 1950°F for 2 hours. This is believed to be the result of the reduction of brittle phases by diffusion. The Coast Metals NP and copper brazes were essentially unaffected by this heat treatment.

Procedure

The specimens used in this investigation consisted of 1/2 inch diameter cylindrical plugs of type 304 stainless steel brazed into a hole in a 1/8 inch thick type 304 stainless steel disc. A clearance of 0.002 inch was provided all around the joint for the brazing alloy.

The static shear strength of the braze was evaluated by measuring the force required to push a 1/2 inch long plug from the hole in the 1/8 inch thick sheet. Impact shear strength of the braze was evaluated by measuring the energy in ft-lb required to pull a 1 1/2 inch long plug from a hole in 0.080 inch thick discs. The plug was threaded at one end to screw into an adapter on the impact machine pendulum. The thickness of the discs brazed to the impact specimens was reduced to 0.080 inch because thicker 1/8 inch discs brazed with some of the stronger brazing alloys could not be broken in the impact testing machine.

All sample joints were furnace brazed in a dry hydrogen atmosphere, the time and temperature for brazing with each alloy are given in Table Ib. Groups of samples brazed with each alloy except the Au-Ni alloy were stress relieved at 1950°F for 2 hours in a vacuum furnace. The Au-Ni alloy was not included in the stress relief treatment because its melting point was below 1950°F.

The copper and gold-nickel brazing alloys were applied to the joints as a single turn of 0.027 inch diameter wire.

The ANP-81 and Coast Metals NP brazing alloys were supplied to the joints in powder form because both are too brittle to work into wire form.

Metallographic samples were prepared from representative samples of joints brazed with each alloy. These were examined for porosity, completeness of the joint, cracking in the braze and the shape of the fillet.

Results

Visual examination and metallographic examination of sections of representative samples of these joints revealed no indication of corrosion attack on any of the brazing alloys. Metallographic examination also indicated that both the ANP-81 and Coast Metals NP brazes alloyed considerably with the stainless steel. However, alloying was not sufficient to eliminate completely a brittle alloy phase usually present in these brazes. With a reduced joint clearance, these

Table Ia

Composition of Brazing Alloys

Alloy	Composition - Wt. %										Melting Temperature °F
	Ni	Cr	Au	Si	Mo	Fe	Mn	P	Cu	Other	
ANP 81 (G.E.)	66	19	--	10	--	4	1	--	---	---	2150
Coast Metals NP	49	--	--	12	4	28	--	5	---	2	2050
Copper	--	--	--	--	--	--	--	--	100	---	1981
Gold-Nickel	18	--	82	--	--	--	--	--	---	---	1740

Table Ib

Alloy	Brazing Temp, °F	Brazing Time, min.
ANP 81	2246	40
CM NP	2156	45
Copper	2057	25
Au-Ni	1850	40

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brittle phases would probably not be present after brazing. The Au-Ni braze alloyed to a somewhat smaller extent than the ANP-81 or CM-NP brazes, but since the Au-Ni is a single phase alloy, a ductile joint results with only a small amount of alloying. Very slight alloying occurred between the copper and the stainless steel so that the strength of these joints would be essentially that of a layer of pure copper in the joint.

Results of mechanical test and metallographic examination of these brazed specimens are summarized in Table II. The results show that there was no significant lowering of the static or impact shear strength by exposure to 680°F water for 1200 hours.

There was quite a large spread in the results of the ANP-81 and the CM-NP brazements. These deviations may be attributed to variations in the amount of brazing alloy used for each specimen resulting in variations in the thickness of the fillets. These two alloys are extremely brittle and necessarily must be supplied in a powdered form to provide flexibility in applying to the brazed joints. In most cases, a greater amount of powdered braze was placed around the joints than was necessary. Large fillets resulted from limited braze alloy flow over the exposed surfaces, whereas smaller fillets occurred when the excess braze alloy spread widely over the exposed surfaces.

A comparison of the brazes and fillet sizes may be seen by referring to Figs. 1 and 2 which represent the ANP-81 and the Au-Ni brazes respectively. The Coast Metals NP braze appeared similar to the ANP-81 braze, except that in general there was no cracking. The copper-brazed joint is presented in Fig. 3, in which it can be seen that no observable alloying occurred with the base metal.

Discussion

The type of specimens employed in the work may be considered satisfactory for evaluating the relative performance of various brazing alloys in a joint representative of a typical application. In order that the comparison be valid, it is necessary that the specimen dimensions and fillet size and shape be the same for all specimens. A great superiority of the gold-nickel alloy over the copper braze was shown consistently by these tests. However, when the fillet size varies as with the ANP-81 and CM-NP alloys the test results vary widely and no valid comparison can be made with the other brazes.

The results listed in Table II show that the stress relieving heat treatment of 1950°F for 2 hours raised the static shear strength of the ANP-81 brazed joints considerably from an average of 47,500 psi up to 67,400 psi. This improvement was believed to be the result of the reduction of the amount of brittle phases because of alloy diffusion into the stainless steel at the high temperature of 1950°F.

It seems reasonable that the effects of post heat treatments on the properties of brazed joints could be determined with these type specimens. In these particular cases, however, the results are obscured by the variation in fillet for the ANP-81 and CM-NP alloys. Since no response to post heat treatment would be expected for the copper braze and no difference was observed in the mechanical properties, there is no concrete proof of the sensitivity of this test to heat treatment.

The sensitivity of this test to corrosion of a brazing alloy is questionable. This is obvious, because an observable amount of braze would have to corroded away before any changes in the mechanical properties would be apparent. Since a visual examination or penetration measure could indicate corrosive attack with equal accuracy and is simpler than the mechanical tests, the mechanical-corrosion tests seem to be unwarranted.

Table II

Results of High-Melting Brazing Alloy Tests

Alloy	Static Shear Load-Pounds		Impact Shear Energy - ft-lb		Metallographic Examination
ANP-81 As brazed	5800 6200 3800	5270 av. (26,800 psi)	34.0 40.5 45.0	39.8 av.	Excess fillet Cracked in joint
Stress Relieved	11750 11100 16800	13220 av. (67,400 psi)	65.0 78.0 42.5	61.8 av.	Excess fillet Cracked in joint
After Corrosion	8200 5000 14800	9330 av. (47,500 psi)	37.5 46.0 31.0	38.2 av.	Excess fillet Cracked in joint No apparent attack
Coast Metals NP As brazed	15050 9200 16900	13720 av. (70,000 psi)	61.0 50.0 90.5	67.2	Excess fillet Small crack in joint
Stress Relieved	8200 16600 10100	11630 av. (59,200 psi)	68.0 88.5 50.0	68.8 av.	Excess fillet No cracking
After Corrosion	24500 20500 26500	23830 av. (121,500 psi)	46.0 84.5	65.2	Excess fillet No cracking No apparent attack
Copper As brazed	7700 9000 8600	8430 av. (42,900 psi)	44.0 45.0 43.5	44.2 av.	Normal fillet No cracking
Stress Relieved	8700 8400 8200	8430 av. (42,900 psi)	39.5 43.0 43.5	42.0 av.	Normal fillet No cracking
After Corrosion	8500 9200 8600	8770 av. (44,600 psi)	48.0 50.5 66.5	55.0	Normal fillet No cracking No apparent attack
Gold-Nickel As brazed	18900 17400 18100	18130 av. (92,400 psi)	194 125 126	145 av.	Normal fillet No cracking
After Corrosion	15900 16700 13700	15430 av. (78,600 psi)	120 113 207	143 av.	Normal fillet No cracking No apparent attack

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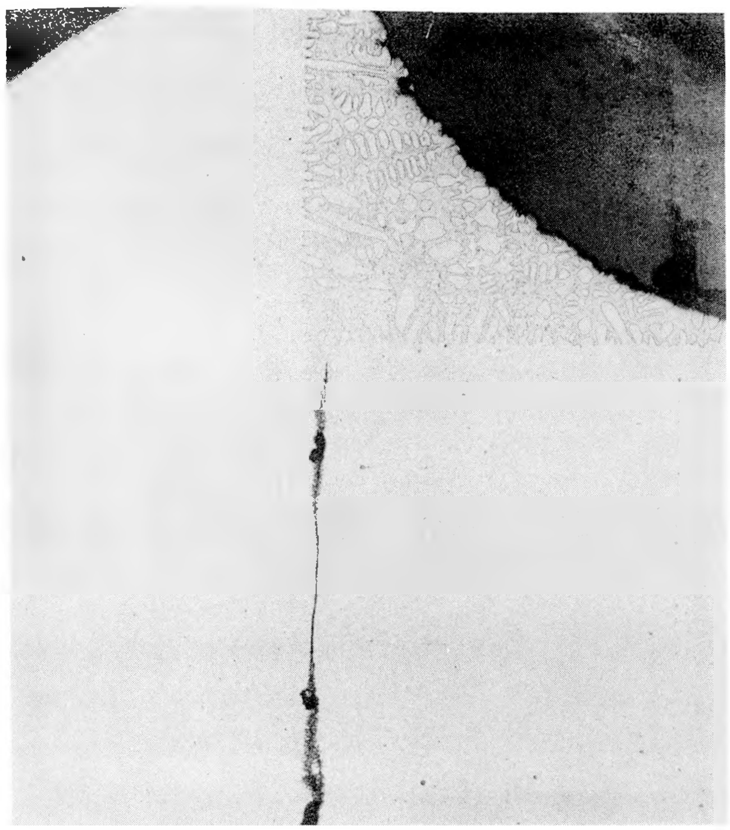

Fig. 1 - ANP 81 Brazing Alloy

Sample 6200 Mag. 50X

Note crack and hard brittle alloy phase (gray) in braze region and alloying along interfaces.

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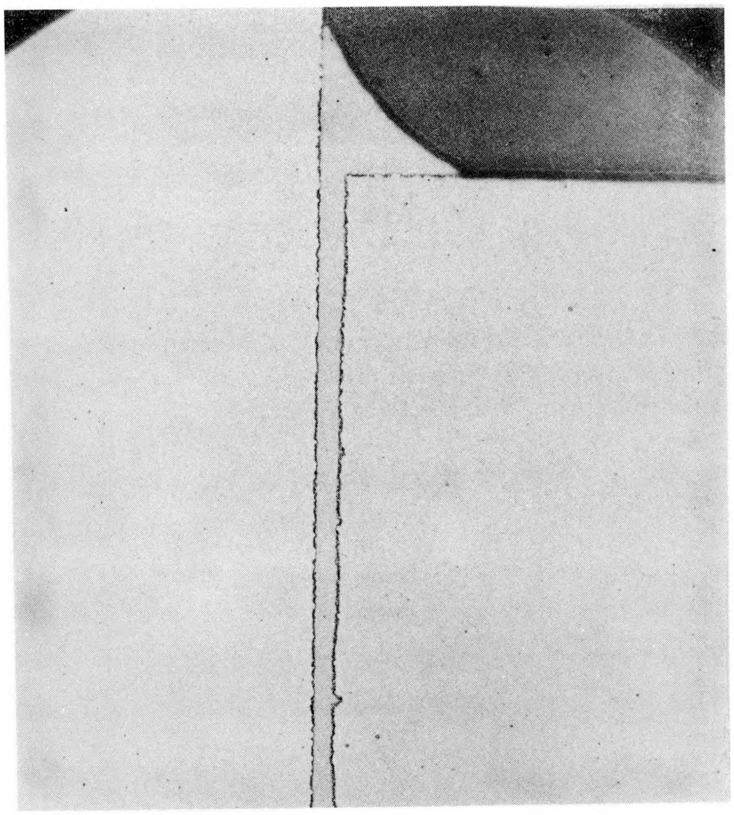

Fig. 2 - 82%Au-18Ni Alloy

Sample 6197 Mag. 50X

Note single phase brazing alloy, and alloying along interfaces.

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Fig. 3 - Copper Braze

Sample 6199 Mag. 50X

Note essential lack of alloying along interfaces.