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ENGINEERING RESEARCH - BRAZING

ALLOY - "DYNABRAZE B" -

COMPOSITION OPTIMIZATION OF -

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ENGINEERING RESEARCH - BRAZING ALLOY - "DYNABRAZE B" - COMPOSITION OPTIMIZATION OF -

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ENGINEERING DEPARTMENT

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I. SUMMARY

The object of this test was to establish the optimum manganese content in "Dynabraze B" brazing alloy (95% silver - 5% aluminum + manganese) to develop the best combination of crevice corrosion resistance, lap shear strength and braze-ability. Brazing alloys were made with manganese additions of .1, .2, .3, .5 and 1.0% from a master alloy of 95 silver -5 aluminum. Lap shear, corrosion and metallographic specimens were made from RS 140 titanium brazed with the various alloys.

The range of manganese content from .5 to 1.0% definitely appears to be the best of the groups studied, judging from the results of the corrosion tests and metallographic studies. Strength values as determined by the lap shear testing were indeterminate in direct comparison, due to the wide range of values obtained for each group. However, the shear strength values, when coupled with the results of the metallographic studies definitely indicates superiority in the manganese content of 1.0%

II. LIST OF FIGURES

Figure 1 on page 11 shows the salt spray flexure test specimens. Photomicrographs of C. P. (commercially pure) titanium core brazed to RS 140 titanium skin with the brazing alloy compositions under study are shown in the following list of figures.

III. LIST OF TABLES

IV. INTRODUCTION

The 95% silver - 5% aluminum braze alloy was developed under an Air Force Contract, AF33(600)-34392 by General Dynamics/Fort Worth. The alloy was developed for brazing titanium honeycomb sandwich panels. With a pressing need for the alloy at the time, accurate determinations were not made to establish the optimum manganese content. Numerous small shipments from two major brazing alloy producers were received with variations in manganese content. These variations in composition required adjustment in brazing temperature and produced variations in joint qualities. The contract was terminated before its completion and optimization studies for composition were not conducted.

This report describes an investigation performed to establish the brazing alloy composition in order to develop its best properties and thereby enhance its usage.

V. PROCEDURE

A 300 gram master alloy of 95 silver - 5 aluminum was made by melting together 999+ silver and 2S C. P. aluminum foil. The metals were induction melted in a graphite crucible under argon. While molten, the crucible was gently agitated to improve mixing of the metals. After cooling, the alloy button was flattened in a hydraulic testing machine, sectioned into four parts, and remelted as above. This procedure was repeated, the purpose being to assure uniformity in the finished alloy.

Twenty to twenty-five gram lots of the above master alloy were mixed with proportionate amounts of electrolytic manganese chips, 99.9+% purity, and melted in an identical manner as the master alloy described in the previous paragraph. All of the alloys were reduced to filings with a clean file.

Titanium specimens to be brazed were cleaned by immersing in a 15% nitric acid - 3% hydrofluoric acid solution at room temperature for 30 seconds, rinsing in tap water and drying. Brazing was accomplished in an electrically heated tube furnace equipped with a protective argon atmosphere. The argon was dehydrated by passing it through a tube coil immersed in acetone and dry ice at -100°F. The argon was further purified by passage over hot titanium chips within a retort. Brazing temperatures were monitored with a chromel-alumel thermocouple attached to the specimen holder. All of the specimens were brazed at 1650°F for 5 minutes.

Lap Shear Tests

Two pieces of .052" thickness RS 140 titanium, 4-1/2" x 1", were wired together with a 3/16" overlap and brazed. Three sets were brazed for each of the six braze alloys. After brazing, the strips were cut into 3/4" wide specimens to form individual lap shear specimens, 3/4" x 1-13/16". Shear values were determined by compressively loading the edges of the specimens in a jig which held the specimens vertical and prevented bending moments. The tests were conducted in a Baldwin Universal Test Machine of 5000 pounds capacity. Loading rate was 1000 pounds per minute.

Salt Spray Corrosion Flexure Tests

Corrosion specimens were made by brazing a 1" x 1" x 1/2" piece of C. P. titanium core to the center of a 1" x 4" x .010" strip of RS 140 titanium. The brazed specimens were bent over a 5 inch diameter mandrel as an indication of the soundness of the braze. The relatively inflexible titanium core, brazed to the flexible .010" titanium skin, snapped apart at the braze interface when weakly brazed. Basically, this test was a form of a peel test. Specimens which did not fail were exposed to salt spray for 8 hours and again tested by bending over the mandrel. Failure from flexure resulted from separation of the core-skin joint which had been weakened by crevice corrosion. Those specimens which did not fail were exposed to 8 additional hours of salt spray and flexure tested. The flexure test was then repeated after 16 hours of salt spray exposure. An 8 hour - 16 hour cycle of salt spray corrosion-flexure testing was continued to failure or until a total of 500 hours exposure without failure was obtained. Salt spray exposure was conducted in a standard salt spray cabinet made by Universal Pump and Filter Company. Test procedures conformed to the standards established by Federal Test Method Standard 151, Method 811 (20% salt spray).

Metallographic Studies

Specimens for metallographic examination were made by brazing a 1" x 1" x 1/2" C. P. titanium core section to a slightly larger piece of .010" RS 140 titanium. Standard metallographic techniques were exercised in the mounting, polishing, and etching of the specimens.

VI. RESULTS AND DISCUSSION

The master braze alloy was chemically analyzed for aluminum content and found to contain 5.12% Al. The balance of the alloy was assumed to be silver plus trace elements contained in the original alloying elements. An analysis of the experimental braze alloys having manganese additions yielded the following results:

Manganese, % by Weight	
Nominal	Actual
0.1	0.09
0.2	0.16
0.3	0.29
0.5	0.43
1.0	0.92

The actual manganese contents were quite close to the desired levels.

Lap Shear Results

The results of the single lap shear tests, given in Table I, indicate that the manganese addition reduced the average shear strength of the brazed joints. The 0.1% Mn addition was the most detrimental, reducing the average shear strength by 24%. The effect of the 0.2, 0.3, and 0.5% Mn additions were almost identical to one another in so far as strength was concerned. Of the five levels of manganese investigated, 1.0% Mn had the least deleterious effect on shear strength. However, with the exception of the 0.1% Mn addition, the lap shear results were rather indeterminate due to the wide range of values for each braze alloy. It would be difficult to select a composition based on these results alone. Visual examination of the sheared joint faces of all failed specimens did not reveal any joints which were not completely brazed.

Corrosion Results

The salt spray corrosion flexure test results definitely indicate that specimens brazed with the alloy containing .5 to 1.0% manganese show the best resistance to this type of corrosion. The .3% Mn alloy was a borderline case in that one specimen failed after 464 hours while the other specimen did not fail in 500 hours of testing. The condition of the specimens after having been exposed to the salt spray corrosion may be seen in Figure 1. Results are given in Table II.

Metallographic Results

Photomicrographs of honeycomb sandwich specimen brazed with the various alloys are shown in Figures 2 through 5. As shown by the photomicrographs, increasing the manganese content of the brazing alloy from 0 to 1.0% improves the formation of fillets. Wetting of the base metal by the braze alloy was excellent in every case. Specimens brazed with 95 silver-5 aluminum without manganese attacked the C. P. titanium core excessively. The addition of as little as .1% manganese reduces this reaction. As can be seen in Figures 5 and 6, the 0.5 and 1.0% brazing alloys have formed an additional diffusion layer in the C. P. titanium core. This diffusion layer apparently did not affect the salt spray corrosion flexure results but should be further evaluated by testing samples of brazed sandwich, particularly column compression tests.

VII. CONCLUSION

Considering all the brazing alloys investigated, the 95 silver-5 aluminum + 1.0 manganese had the best lap shear strength, salt spray corrosion flexure strength, and fillet forming characteristics.

VIII. RECOMMENDATIONS

On the basis of the tests conducted in this investigation, it is recommended that the optimum manganese content of the 95 silver-5 aluminum braze alloys system be 1.0%. Further tests should be conducted to:

(1) examine effect of manganese contents between .5 to 1.0%

(2) determine the effect of this braze alloy composition on the strength of brazed titanium honeycomb sandwich panels.

TABULATION SHEET

TABLE I — Lap Shear Test Results - Brazed .050" Thick RS140 Titanium.

Braze Alloy	Specimen No.	Braze Area in²	F_{tu} Lbs.	K.S.I.
95% Ag - 5% Al.	A-1	.1497	2745	18.3
	-2	.1496	3665	24.5
	-3	.1679	2870	17.1
	-4	.1629	3130	19.2
	-5	.1657	4420	26.7
	-6	.1408	3675	26.1
	-7	.1425	3880	27.2
	-8	.1493	4300	28.8
Avg.				23.5
95% Ag - 5% Al + .1% Mn.	B-1	.1485	1960	13.2
	-2	.1666	2055	12.3
	-3	.1531	3545	23.2
	-4	.1614	3890	24.1
	-5	.1469	2835	19.3
	-6	.1520	2560	16.8
	-7	.1595	1935	12.1
	-8	.1628	2870	17.6
	-10	.1612	2415	15.0
	-11	.1593	3875	24.3
Avg.				17.8
95% Ag - 5% Al. + .2% Mn.	C-1	.1571	3220	20.5
	-2	.1513	3150	20.8
	-3	.1469	3725	25.4
	-4	.1488	3280	22.0
	-5	.1475	2775	18.8
	-6	.1453	3280	22.6
	-7	.1565	2585	16.5
	-8	.1360	2760	20.3
	-10	.1498	2410	16.1
	-11	.1593	2735	17.2
Avg.				20.0

Braze Alloy	Specimen No.	Braze Area in²	F_{tu} Lbs.	K.S.I.
95% Ag - 5% Al + .3% Mn.	D-1	.1600	3205	20.0
	-2	.1601	3895	24.3
	-3	.1442	3490	24.2
	-4	.1502	2750	18.3
	-5	.1500	3845	25.6
	-6	.1604	2890	18.0
	-7	.1642	3470	21.1
	-8	.1511	2585	17.1
	-10	.1455	2693	18.5
	-11	.1542	3075	19.9
Avg.				20.7
95% Ag. - 5% Al. + .5% Mn.	E-1	.1862	3170	17.0
	-2	.1789	4030	22.5
	-3	.1579	2665	16.9
	-4	.1899	4175	22.0
	-5	.1684	3215	19.1
	-6	.1682	3775	22.4
	-7	.1496	3525	23.6
	-8	.1677	3330	19.9
Avg.				20.4
95% Ag. - 5% Al. + 1% Mn.	F-1	.1512	3565	23.6
	-2	.1414	3290	23.3
	-3	.1709	3860	22.6
	-4	.1566	3320	21.2
	-5	.1462	3180	21.8
	-6	.1582	3565	22.5
	-7	.1496	3175	21.2
	-8	.1535	3490	22.7
	-10	.1871	3755	20.1
	-11	.1581	3525	22.3
Avg.				22.1

TABLE II

RESULTS OF SALT SPRAY CORROSION FLEXURE TESTS

C. P. titanium honeycomb core brazed to .010" RS 140 titanium sheet tested by periodically flexing specimen over 5" dia. mandrel after exposure to 20% salt spray exposure.

Braze Alloy	Spec. No.	Exposure Time
95 Ag-5 Al	A-1	Failed before exposure
	A-2	Failed after 314 hours exposure
+.1% Mn.	B-1	Failed before exposure
	B-2	Failed after 290 hours exposure
+.2% Mn.	C-1	No failure after 500 hours exposure
	C-2	Failed after 290 hours exposure
+.3% Mn.	D-1	No failure after 500 hours exposure
	D-2	Failed after 464 hours exposure
+.5% Mn.	E-1	No failure after 500 hours exposure
	E-2	No failure after 500 hours exposure
+1.0% Mn.	S-1	No failure after 500 hours exposure
	S-2	No failure after 500 hours exposure

FIGURE 1

250X Etch: 10% HNO_3 + 1% HF.

FIGURE 2.

C. P. titanium core brazed to RS 140 titanium sheet with 95 Ag-5 Al braze alloy. Attack of the core by the brazing alloy is obvious.

a. .1% Manganese added

b. .2% Manganese added

FIGURE 3 250X Etch: 10% HNO_3 + 1% HF

C. P. titanium core brazed to RS 140 titanium skin with 95 Ag-5 Al + Mn braze alloy.

a. .3% Manganese added

b. .5% Manganese added

FIGURE 4 250X Etch: 10% HNO_3 + 1% HF

C. P. titanium core brazed to RS 140 titanium skin with 95 Ag-5 Al + Mn braze alloy.

250X   Etch: 10% HNO_3 + 1% HF

<u>FIGURE 5</u>

C. P. titanium core brazed to RS 140 titanium skin with 95 Ag-5 Al + 1.0 Mn braze alloy. It is evident that this braze alloy forms good fillets. An additional diffusion layer has formed in the core.