CANEL-1784

PRATT & WHITNEY AIRCRAFT DIVISION
CONNECTICUT OPERATIONS - CANEL

WELDING & BRAZING DEVELOPMENT GROUP
ADVANCED TOOL ENGINEERING

Interim Report - Project 1047 June 17, 1959

Bonding of Tantalum

Object:

This investigation was undertaken to determine the necessary requirements for obtaining sound bonded joints on tantalum.

Equipment:

P & H 300 amp Arc Welder - TIG
Sciaky 50 KVA Resistance Welder
Vacuum Chamber
Plastic Bag Chambers
Tantalum Sheet - XM-238A - 1/16" Thick

Summary:

Corrosion and Mass Transfer Loops LTTN 237A and 427 called for fabrication of 430 stainless steel clad tantalum tubing. Since there was little or no experience at welding this material at CANEL, specimens were welded using vacuum chambers and plastic chambers as normally used for loop fabrication. XM-238A material was used for this work, which was vacuum arc cast and cold rolled from three inch minimum diameter ingots.

Tantalum, like other refractories, has a strong affinity for oxygen, nitrogen, the halogens, carbon monoxide and water vapor at temperatures between 600°F and 2200°F. Degasing can be accomplished at temperatures above 3300°F in vacuo. Hydrogen causes embrittlement. It is soluble in hydrofluoric acid, strong alkalies and solutions containing free sulfur trioxide.

Carbon arc welding under a liquid cover of carbon tetrachloride is described in literature, however, attempts to reproduce this method at CANEL were unsuccessful. The main reason being that the liquid rapidly clouds up to the extent that the joint cannot be followed. Adequate ventilation must be provided to carry off the noxious fumes produced by this process.

Resistance welding was performed without the use of a special atmosphere producing sound bonds. See Fig. III.

TABLE I

Spec.	Joint	Weld Method		Remarks
4	Lap - 1/16 Sheet	Spot Weld		Diffusion Type Bond
		50 KVA - 65% Phase Shift		
		Cool Cycles	3	Grain Size Base - Cold Worked Structure
		Heat Cycles	10	Nugget - ASTM 5-6
		Squeeze Cycles	3	
		Impulses	3	
		600# Constant High Pressure		
5	Lap - 1/16 Sheet	Same as above		Shear Strength - 51,000 PSI

Butt joints were fusion welded both in vacuum chambers and plastic bags. Specimens were degreased and pickled for six minutes in a solution of 16% hydrofluoric and 20% nitric acids, prior to welding. Specimens were then X-Rayed and metallurgically examined. See Fig. I and II.

TABLE II

Spec.	Joint	Weld Chamber	X-Ray	Remarks
6	1/16 Sheet Butt	Vacuum-Argon	No Defects	Incomplete penetration
7	"	"	"	"
8	"	"	"	"
9	1/16 Sheet Butt .020 Filler	Plastic-Argon	No Defects	
10	1/16 Sheet Butt .032 Filler	Plastic-Argon	No Defects	Weld sound and clean - small amount of second phase in spheroidal form dispersed through matrix of weld.
			Grain Size	Base Cold worked: 2 to >1; Weld: >1
			Hardness-DPH	219; 146; 142
11	1/16 Sheet Butt	Plastic-Argon	No Defects	
12	1/16 Sheet Butt Welded both sides	Vacuum-Argon	No Defects	
13	"	"	Poor Fusion	
14	1/16 Sheet Butt Braided 1/64 Filler both sides	"	Porosity	A few small voids
15	1/16 Sheet Butt Braided 1/64 Filler	"	No Defects	Machined weld was bent through 180° flat against itself
16	1/16 Sheet 1/32 Filler Welded both sides	"	No Defects	Same as Spec. #10
			Grain Size	Base Cold worked: 4 to >1; Weld: >1
			Hardness-DPH	219; 149; 130
17	"	"	No Defects	Tensile Tested 62,000 PSI

Specimens were brazed with Coast Metals #52 and Nicrobraz 130 in helium. Flow with Nicrobraz 130 was poor while Coast Metals 52 produced a sound joint although ductility was poor.

2 3

TABLE III

"T" Joint	Pickle	Braze Filler	Braze Temp.	Time at Temp.	Atmos.	Results
1	16 HF 20 HNO_3 64 H_2O	NB 130	1925	10 min.	He	Poor flow, very brittle.
2	"	"	"	15 min.	He	Poor flow, braze very porous. Brittle.
3	"	CM 52	"	15 min.	He	Fair to good flow. Sound strong joint. Good Fillet. Poor ductility. Max. dilution 1 1/2 Mils

Physical Data:

Melting Point	5425° F
Annealing temperature	above 1920° F in vacuo
Outgasing temperature	above 3300° F in vacuo
Thermal expansion	3.6×10^{-6} in/in/°F
Tensile Strength	
Sheet, annealed	50,000 PSI
Sheet, worked	110,000 "

Chemical Specifications - XM-238A

Carbon	200 PPM	Hydrogen	10 PPM	Iron	50 PPM
Oxygen	100 "	Nitrogen	30 "	Tantalum	Bal.

Conclusions:

No difficulties are anticipated in tantalum to itself in loop applications. Atmosphere purity precautions similar to those currently employed when welding other refractory metals should be adhered to. Chill bars can be used to advantage to reduce grain growth and the extent of heat affected zones. This is demonstrated by comparing Figures I and II where the latter specimen utilized chill bars. There was no appreciable difference between welds made in vacuum chambers and plastic chambers. The main fault in weld joints was the frequent lack of complete penetration, attributable to the operators inexperience with this high melting metal.

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SLR:mg 2 4

TANTALUM
BUTT WELDED IN PLASTIC CHAMBER
0.062 SHEET

MAGNIFIED: 16X

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FIG 1

TANTALUM

BUTT WELDED BOTH SIDES IN VACUUM CHAMBER

0.062 SHEET

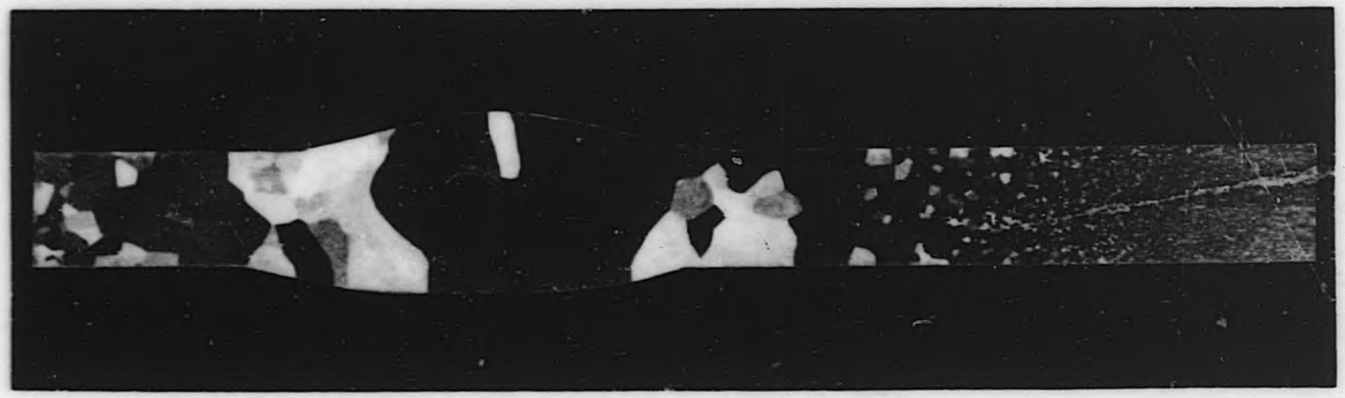

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FIG 2

TANTALUM SPOT WELD - 0.062 SHEET

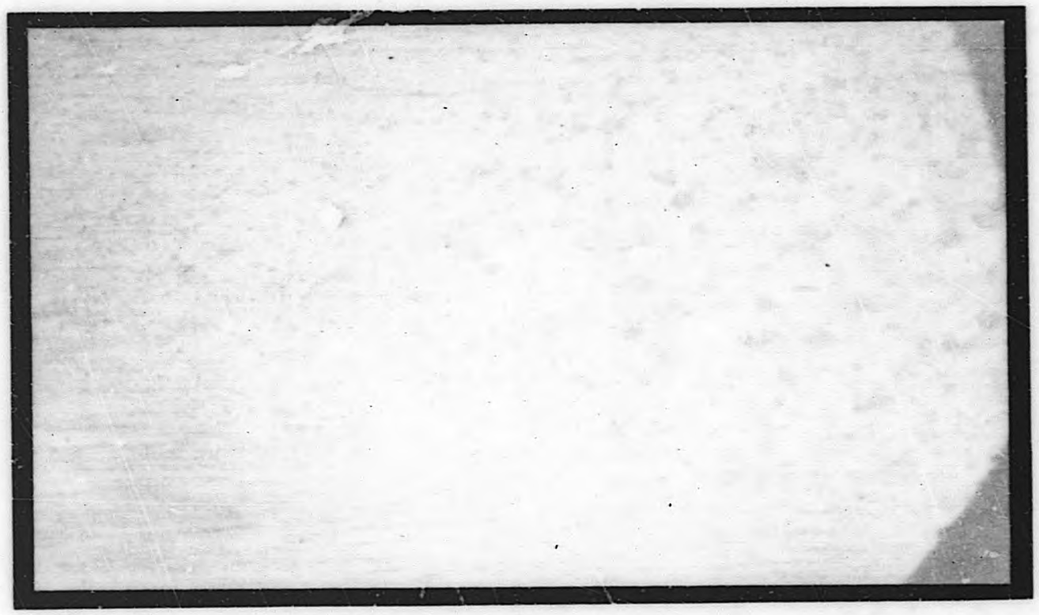

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FIG 3

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END