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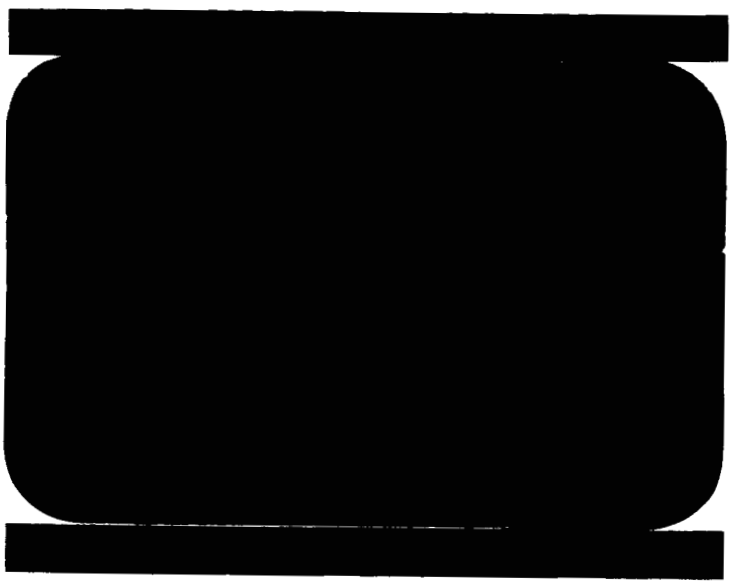

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EVALUATION OF ELECTROFORMED NICKEL TO 301 STAINLESS STEEL RESISTANCE SPOTWELDS at 78°F and -423°F.

GD/C MRG - 288

January 25, 1962

Prepared by: L.D. Girton

MRG-288

25 January 1962

SUBJECT: "Evaluation of Electroformed Nickel to 301 Stainless Steel Resistance Spotwelds at 78°F and -423°F"

ABSTRACT: As evaluated by the notched tensile test .062" electroformed nickel had excellent toughness at -423°F having a notched-unnotched ratio of 1.21. The electroformed nickel resistance spotwelded to .020" type 301 (0-71004) stainless steel met the shear and tension requirements of MIL-W-6858A. The .020"-301 to .062" electroformed nickel spotweld tension strengths increased in value at -423°F as compared to spotweld tension strengths in .020" type 301 welded to Inconel-X and to itself which decreased at cryogenic temperatures.

19455

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25 January 1962

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SUBJECT: Evaluation of Electroformed Nickel to 301 Stainless Steel Resistance Spotwelds at 78°F and -423°F

INTRODUCTION:

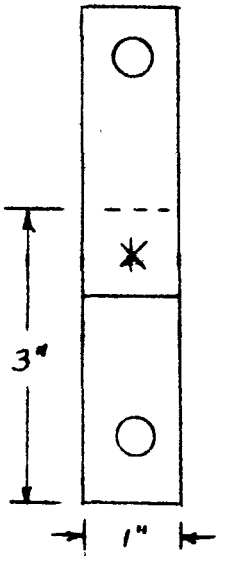
Electroforming, sometimes called, "cold casting" or electro-fabricating is a method of fabricating parts by depositing a metal on a mandrel of the desired shape. The mandrel can either be extracted and reused, or dissolved away, depending upon the shape of the part. Deposition or metal build-up rate is usually in the range of .001" - .003" per hour. Although many metals can be deposited by this process the most commonly used ones are copper, iron, nickel, gold and silver. Some companies have recently been working with aluminum and alloys. Small items such as waveguides have constituted the main type of parts fabricated by electroforming. Thickness tolerances for waveguide walls are generally plus or minus .001" - .002". This can be held to closer tolerances, in the ten thousandths range if necessary. Due to the nature of the process parts can be made having almost identical dimensions, particularly inside dimensions. The metal deposits on the mandrel and duplicates its shape and surface finish almost exactly. If the mandrel has a highly polished surface the interior surface of the part produced on it will also.

Two areas in which electroforming could be used in the Atlas and Centaur structures are the rings and bulkheads. Of the metals that could be deposited by the electroform process nickel appeared to hold the most promise because of its relatively high strength, excellent toughness at cryogenic temperatures and the possibility of being able to spotweld it to thin gauge extra full hard type 301 stainless steel presently used as tank walls.

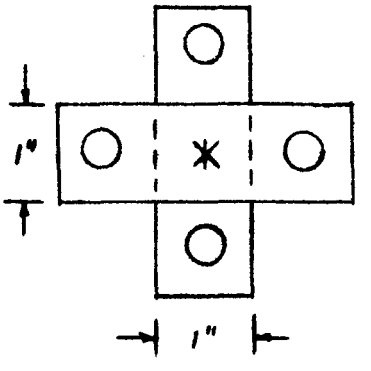
PROCEDURE AND RESULTS:

To determine the actual strength and toughness of electroformed nickel standard smooth and notched tensile specimens were cut and machined from nominal .062" thick material supplied by an outside vendor and tested at 78°F and -423°F by immersion in liquid H_2. The results are tabulated in Table I. The F_{ty} (KSI), F_{tu}(KSI) and e averaged 86, 139, 7.5 at +78°F and 109, 184, 15.9 at -423°F. The toughness of the material, as evaluated by the notched tensile test, was excellent, having a notched-unnotched ratio of 1.21 at room temperature and 1.17 at -423°F.

Weldability experiments were conducted on production resistance welding equipment at Astronautics. It was found that a spotweld nugget could be formed between .062" electroformed nickel and .020" - 301 stainless steel (Spec. 0-71004) meeting the internal quality and penetration requirements of MIL-W-6858A. It was not necessary to use a .020" stainless steel doubler on the 301 side as had been the case when .060" Inconel-X was welded to .020" - 301 (Reference, MRG-134). To ascertain spotweld shear strength and toughness, several shear and cross-tension type specimens were made and tested at room temperature and -423°F. The specimen configurations are shown below:



Single Spot
Shear Specimen



Single Spot
Cross-Tension Specimen

A total of twelve cross-tension and shear spotweld specimens were tested at +78°F and -423°F, see Table II. The room temperature shear strengths of the single spotwelds averaged 1025 lbs., well above the minimum of 530 lbs. for .020" stainless steel required by MIL-W-6858A. Paragraph 4.15 of this specification also requires that, "materials previously not welded in production shall require establishment of non-hardening and weld ductility characteristics. This evaluation shall be conducted without special heating sequence applied purposely to temper the weld. Such welded material shall exhibit a tension strength not less than 25 percent of the minimum shear strength requirements."

As seen from the data in Table II the tension strength of spotwelds in electroformed nickel welded to extra full hard type 301 stainless steel were 102% (at +78°F) and 63% (at -423°F) of the shear strength, well above the required minimum of 25%. Table II also compares the spotweld tension and shear strengths of Inconel-X welded to type 301 and type 301 welded to itself. The averages are compared below:

		Cross Tension Lbs	Shear Lbs	Tension - Shear Ratio
.062" Electroformed Ni to .020" - 301	78°F	1045	1025	1.02
	-423°F	1107	1753	0.63
.060" Inconel-X to .020" - 301	78°F	870	1077	0.81
	-423°F	402	1663	0.24
.020" - 301 to .020" - 301	78°F	486	634	0.77
	-320°F	164	856	0.19

CONCLUSIONS:

On the basis of the limited data it is concluded that electroformed nickel can be resistance welded to type 301 stainless steel with resultant spotwelds that meet the quality, shear and tension requirements of MIL-W-6858A. Of particular significance for integral bulkhead applications at LH_2 temperatures is the toughness and load carrying ability of the spotweld when loaded in tension. Spotweld tension strengths of .020" - 301 stainless steel welded to .062" electroformed nickel actually increased at -423°F as compared to spotweld tension strengths in .020" type 301 welded to Inconel-X and to .020" type 301 which decreased at cryogenic temperatures.

Reference:

(1) MRG-134, Evaluation of Inconel -X to 301 Stainless Steel Resistance Spotwelds at 78°F and -423°F, by J. L. Christian 18 Feb. 1962

TABLE I

MECHANICAL PROPERTIES OF ELECTROFORMED NICKEL
AT ROOM TEMPERATURE AND -423°F

Test Temp.	Thickness Inches	Fty KSI	Ftu KSI	e % in 2"	Notched Tensile KSI (Kt=6.3)	e % Across Notch	Notched/ Unnotched Tensile Ratio
RT	.066	90.8	147	7.5			
	.067	81.0	131	7.5			
	.062	____	___	___	169	1.0	_____
	Avg.	85.9	139	7.5	169	1.0	1.21
-423°F	.072	104	192	7.5			
	.062		165	24.0	169	1.0	
	.062	105	200	15.0			
	.062	119	177	17.0			
	.067				215	1.5	
	.062				221	2.0	
	.062				217	2.0	
	.060	____	___	___	212	1.5	_____
	Avg.	109	184	15.9	216	1.75	1.17

TABLE XI

Comparison of Spotweld Tension and Shear Tests of Electroformed Nickel, Inconel-X and Type 301 Stainless Steel Spotwelded to Type 301 Stainless Steel

0.062" Electroformed Nickel Spotwelded to 0.020" Type 301 Stainless Steel, Spec. 0-71004				0.060" Incomel X Spotwelded to 0.020" Type 301 Stainless Steel Spec. 0-71004, with 0.20" Stainless Steel Tab over the 301 Sheet				.020" Type 301 Stainless Steel, Spec. 0-71004 Welded to .020" Type 301 Stainless Steel			
Test Temp. °F	Cross-Tension Strength of Single Spotweld Lbs	Shear Strength of Single Spotweld Lbs	Tension-Shear Ratio	Test Temp. °F	Cross-Tension Strength of Single Spotweld Lbs	Shear Strength of Single Spotweld Lbs	Tension-Shear Ratio	Test Temp. °F	Cross-Tension Strength of Single Spotweld Lbs	Shear Strength of Single Spotweld Lbs	Tension-Shear Ratio
+78°F	1000	990		+78°F	820	1115		+78°F	445	616	
	1125	1065			790	1090			520	610	
	1010	1020			940	1050			479	598	
Ave.	1045	Ave. 1025	1.02		890	1080			482	600	
				Ave.	870	1077	0.81		506	745	
-423°F	1385	1675		-423°F	400	1600		Ave.	486	634	0.77
	1135	1785			425	1685					
	800	1800			375	1495		-320°F	170	814	
Ave.	1107	Ave. 1753	0,63		375	1670			182	874	
					435	1865			150	800	
				Ave.	402	1663	0.24		152	880	
									164	910	
								Ave.	164	856	0.19

MRG-286

25 January 1962