WANL-TME-627

DEVELOPMENT OF AN INERT GAS
(TIG) SPOT WELDING PROCESS FOR TIE PLATES

MASTER

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INFORMATION CATEGORY

UNCLASSIFIED

10-12-64
Authorized Classifier Date

MASTER

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INTRODUCTION

This report covers the development of a tie plate to capsule weld. This work was done in the Westinghouse Headquarters Manufacturing Metals Joining Laboratory. The type of weld developed was the TIG arc spot. Full penetration was not desired. Rather, uniform penetration approaching 50% of the joint thickness was established as a goal so that, if the weld failed, the remaining pin would continue to hold the capsule in place. To assure maximum reliability the entire sequence of events, gas shielding, fusion time and shut-off, was to be completely automatic. The only manual operations permitted were the positioning of parts in the weld fixture and initiation of the arc by a foot switch.

PURPOSE

The purpose of the investigation was to determine:

1. weld parameters and procedure
2. equipment
3. the effect of variances in fitup on weld quality consistency (per PS 294519-2 Appendix I)

SCOPE

Three types of tungsten inert gas welding processes were investigated:

1. single phase DC
2. three phase DC
3. AC single phase

MATERIAL

Production components were used as follows:

1. .074 inch thick tie plates of 304 stainless steel (simulated step plate thickness)
2. .042 inch thick tie plates of 304 stainless steel (Drawing 944C734)
3. capsule plugs (Drawings 976D468 Item 3 and 976D469 Item 3)

These components and the dimensions that relate to the welding problem are shown in Figure 1.

EQUIPMENT AND METHOD

The equipment used to produce test pieces for this program was as follows:

1. A Westinghouse Single Phase AC-DC Model RST with electronic arc spot timer control.

2. Miller SR-33 3 Ø DC Welder with saturable reactor and electronic arc spot timer.
3. Weld current and voltage were measured on thermal conversion ammeter-voltmeter equipment with a high speed, null-balance recorder.
4. Weld cycle time was recorded on a Visicorder.
5. A welding fixture (Figure 2) was used to position the parts. This fixture had been used for individual welds in earlier production.

To establish parameters and weld penetration, two welds were made at each setting sectioned, polished and evaluated on a B & L Metallograph.

DISCUSSION

The first group of samples was produced by single phase DC straight polarity welding. However, penetration was in excess of the maximum permitted (50%) see Table I. Current and weld time parameters were adjusted in an attempt to correct the erratic behavior of the process and excessive penetration; however, when the current was reduced to a point where the penetration would not exceed the 50% maximum, arc instability was observed. Single phase DC tests were discontinued at this point. Single phase DC welds are shown in Figure 3.

The second group of samples were then run with 3 phase saturable reactor controlled DC straight polarity. It was felt that the greater arc stability of this equipment at lower currents plus an extended weld time would develop a wider weld nugget with controllable penetration. The results were unsatisfactory – the characteristically narrow arc current path of this mode of equipment would not consistently weld the tie plate. Samples 2, 3 and

4 (Table 1) were produced by this method. Figure 4 illustrates a three phase DC weld.

MODULE TIE PLATE AND CAPSULE PLUG

Single phase AC equipment (Figure 2) was then evaluated. After a set of compatible preliminary weld variables were established, one module was assembled using .042" tie plates. These tie plates were welded to the capsules using the parameters listed in Table 1 series 5 and 6 (one series for each end). Penetration averaged 48% (minimum 34%, maximum 60%). A module was then assembled using .074 inch tie plates. The average penetration observed after sectioning the two ends was 38% and 42.5% respectively (meeting the 50% maximum requirement established for this program. Nugget diameter was controllable and consistent in all welds.

A simulated assembly, series 9 in Table 1, was then welded in the production fixture. The maximum allowed assembly variation (.008 inch) was then deliberately created by forcing the pin to one side of the hole; welds were made within the minimum and maximum amperage limits. Average penetration was 42% under these extreme conditions. This compares favorably with the 48% observed on the initial trials where assembly tolerances were nominal and where laboratory assembly methods were employed.

Subsequently the tie plate (.043 thickness) was evaluated with regard to distortion by measuring the gap between the plug and the tie plate. The maximum permissible gap is .005" (Figure 1). A minimum of .005" and maximum of 0.010" gap were measured between the outside edge of tie plate and the plug. A support for the center section of the tie plates was added to the fixture and an additional assembly welded at the settings listed in Table 1. This assembly was checked for distortion and found to be within the permissible .005" gap.

Distortion was not a problem with the thicker (.075") tie plates. Typical welds are shown in Figure 5.

The surface of welds produced by the single phase AC is not as smooth as welds produced by the DC equipment. Additionally AC welds exhibit slightly more undercut at the circumference of the weld nugget compared to DC welding. Metallographic examination of all samples failed to show any weld cracking. All welds were visually examined on their external surfaces. Additionally each was sectioned and examined metallographically for soundness and penetration. Since the process is automatic, the weld quality can be controlled by a periodic sectioning of a test piece (see Appendix I - PS 294519 Process Sheet Number 2).

CONCLUSIONS AND RECOMMENDATIONS

1. The AC automatic arc spot welding is recommended for this particular application because the resulting welds were more uniform, with regard to penetration, than were DC welds.
2. Normal manufacturing tolerances can be used to produce the holes and pins if the AC welding process is used.
3. By automating the AC process the human variable is eliminated. Welding is automatically timed and is reproducible within narrow limits.
4. Finished parts can be welded to meet drawing requirements (.005" maximum gap between the capsule and tie plate).

TABLE I
TIE PLATE AND SIMULATED CAPSULE
WELD TEST DATA

Equipment	Test	Number Welds	Tie Plate Thickness	Weld Amperes	Arc Volts	Weld Time (Cycles)*	Diameter Tungsten	Percentage Penetration
Single Phase DC	1	6	.042	100	8	80	1/16"	58 (thru pin only) No uniformity in tie plate penetration; Arc unstable.
3 Phase DC	2	4	.042	100	10	90	1/16"	100 (thru pin only)
		2	.042	90	10	109	1/16"	60-100 (thru pin only)
	3	2	.042	80	8	80	1/16"	100 (thru pin only)
	4	2	.042	60	8	120	1/16"	75 (thru pin only) No uniformity in tie plate penetration.
Single Phase AC	5	6	.042	110	20	125	1/16"	Average 48
	6	6	.042	110	20	125	1/16"	Average 48
	7	6	.074	152	20	125	1/8"	Average 38
	8	6	.074	152	20	125	1/8"	Average 42.5
	9	4	.042	110	20	125	1/8"	Average 42 Note: Average weld diameter in plate .224".

Tests 6, 7, 8, and 9 were made in assembly fixture; tie plates were forced to one side to obtain maximum gap (.008") on opposite side - Penetration consistency was not materially affected.

*60 cycles per second time base

TIE PLATE

.042 thick - 944C734

.078 thick - Simulated Step Plate

CAPSULE PLUG

.060" - 976D468 - Item 3

.093" - 976D469 - Item 3

WELD MOCK-UP

Maximum Distortion
Gap .005"

TIG Spot Weld

FIGURE 1 - TIE PLATE AND CAPSULE COMPONENTS

FIGURE 2 - TIE PLATE AND WELDING DEVELOPMENT SETUP

FIGURE 3 - SINGLE PHASE D.C. STRAIGHT POLARITY WELDS

FIGURE 4 - THREE PHASE D.C. STRAIGHT POLARITY WELDS

FIGURE 5 - SINGLE PHASE A.C. WELDS