HW-7-380

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COATING OF TUBEALLOY SLUGS

This memo summarizes suggestions regarding present practice in coating slugs at H.E.W. as observed by the writer from July 21--August 4. These suggestions are based on experience in developing this coating process at Experimental Laboratory, Cleveland. There is either direct or indirect evidence supporting all these suggestions. These recommendations are made on basis of quality of coatings, and it is realized that in practice operating aspects must also be considered.

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These suggestions are grouped under five Coating Characteristics which it is believed are of greatest importance, and they are further directed as to recommendations on control of present process, on changes in process, and on additional specifications for process. It will be noted that certain proposed controls or changes are indicated for improvement of several properties in final coating. Generally it would seem that greatest improvement could be expected by closer control of the more important variables in the process.

DOCUMENT AND INVENTORY UNIT
JUL 11

I **Thin Compound Layer**

This refers to strata of compounds of Tubealloy-aluminum-silicon next to base metal. On basis of available information from the Technical Section's Metallographic examination of coatings, these seem to be too thick, averaging at least three mils with consequent cracking. Experience

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at Cleveland indicated that average thickness should not exceed about 1.5 mils, with irregular instead of uniform boundaries, in order to avoid continuous and dangerous cracks. Chief danger in a thick, cracked compound layer is lack of corrosion resistance. If water penetrates to compound layer, as through closure of through hole in sidewalls, it can spread through cracks until hole to base metal is found and swelling developes. Improvement in compound layer should result in fewer failures in autoclave test, and in any case would provide insurance against penetration of can or closure.

A. Control

1. Time from Al-Si bath to quench.

This time determines thickness of compound layer. At present it is variable, and too long.

B. Changes

1. Use of hot top plunger on press for carrying cap.

This would shorten time from Al-Si bath to quench by 3 to 5 seconds required for placing cap on slug at present.

2. Placing Al-Si baths closer to presses.

For reduction of transfer time from bath to press.

C. Proposed Specifications

1. An average thickness and character of compound layer as determined by metallographic examination of sample slugs.

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II Sound Brazed Closure

This would seem to be one of weakest points in present coating. Failure to weld an appreciable proportion of slugs produced is claimed to be due to poor braze between can and top cap.

Majority of failures in autoclave test are ascribed to imperfect closures, and there seems to be no evidence that all imperfect closures are found by this test.

A. Control

1. Temperature of cap.

   Variation in this temperature will give variations in bonding between Al-Si and cap surface.

2. Time for preheating cap.

   Preheating for too long time will develop thick oxide layer on cap, which inhibits bonding with Al-Si.

3. Amount of excess Al-Si added to can.

   Addition of too small an amount, i.e. less than 50 grams, results in voids in braze line. There is no positive control at present.

4. Temperature of excess Al-Si added.

   This is important in securing bonding to Al surface. It can vary at present due to variations in temperature of ladle used, and to time from bath to press.

5. Removal of flux from slug in Sn bath.

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Flux carried through Sn bath on slug is not always removed in Al-Si dip, and this may be included in Al-Si braze line. Same is true of oxides from dipping baths.

6. H_2 content of Al-Si baths.

At present no observations are made on H_2 content of Al-Si baths. Presence of appreciable H_2 in Al-Si will produce porosity in braze line.

7. Al can temperature.

There seems to be appreciable variation at present, both with time and location in die. Low temperature at top of can will obviously contribute to poor brazed closure.

8. Cycle of press top plunger.

These are not all uniform at present, particularly so as regards speed of final seating of slug in can. Variation in this speed affects development of voids in braze line.

9. Time and method of swishing in Al-Si bath.

If this is insufficient, there may be appreciable tin content in braze line. Experience at Chicago indicates this interferes with welding.

B. Changes

1. Use of hot top plunger on press for carrying cap.

This permits close control of cap temperature at time it is pressed into can.

2. Use of tapered top cap.

Best results on brazed closures at Cleveland were obtained with tapered top cap, 1.350" at bottom and 1.365" at top.

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3. Preheating caps on large mass of metal having good heat conductance and corrosion resistant surface.
   Nickel or nickel plated copper might be used. This would permit more rapid cap preheating, with less time to form oxide on cap.
4. Preheating caps in inert atmosphere, as nitrogen or argon.
   The purpose of this would be to prevent oxide formation.
5. Treatment of Al-Si baths with Cl_2 or N_2--Cl_2 mixtures.
   Tests at Cleveland showed N_2--Cl_2 treatment of bath preceding sodium modification gave best H_2 removal as indicated by soundness of castings from bath.
6. Use of a high-low-high pressure cycle on top plunger on press.
   This permits rapid contact of plunger with slug, slow seating of slug in can with slow expulsion of excess Al-Si ending with high pressure held for an appreciable time to insure complete seating. Experience showed slow seating minimized voids in braze line.
7. Use of larger Al-Si and Sn dipping baths.
   These facilitate removal of flux and oxides, preventing adhesion to slug and inclusion in braze line.
8. Use of smaller clearances between sleeve and can and sleeve and die. This would facilitate control of Al can temperature.
9. Use of "Cast-in" Calrod press furnace.
   This would permit closer control of Al can temperature.

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C. Proposed Specifications

1. On gas content of Al-Si baths, as observed by casting samples from baths at regular intervals.

2. On cycle for top plunger on press.

3. On purity of excess Al-Si bath.

It has been shown that bonding of Al-Si to Al surfaces is affected by presence or absence of very small amounts of impurities, but identity of these has not yet been established.

III <u>Al-Si Penetration of Al Can</u>

At present penetration occurs on a too high proportion of specimens. It would seem that reduction of this depends largely on more rigid control.

A. Control

1. Temperature of CuSn, Sn and Al-Si baths.

2. Amount of excess Al-Si.

Use of large amount, as 150 grams, gives penetration in almost all cases.

3. Temperature of excess Al-Si added to can.

This can vary at present due to temperature of ladles used.

4. Time in <u>Al-Si</u>, CuSn and Sn dipping baths.

5. Temperature of Al can in die.

B. Changes

1. Temperature of Al-Si dipping bath at 600°C--with CuSn at 720° And Sn at 635°C.

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It has been found that this gives slug temperature of 615--620°C at time of canning which results in minimum penetration. Presumably many other combinations of temperatures would give same end temperature in slug. However, if previous conclusions on desirability of canning in phase are correct, it would be
5 best to hold slug as hot as possible as long as possible to get specified end temperature. This is approximated by above combination.

2. Separate addition of sleeve and Al can to die.

   This would permit heating sleeve for longer time and Al can for shorter time to get more uniform can temperature.

3. Use of hot top plunger on press.

   This would avoid present necessity for holding slug part way in can for 3--5 seconds while placing cap.

4. Smaller clearance between die and sleeve.

5. "Cast-in" Calrod press furnace.

   To facilitate temperature control of Al can.

IV <u>Low Sn Content in Coating</u>

If present process is followed, low tin contents are obtained. Failure to observe proper control may result in high tin content.

A. Control

   1. Time in Al-Si bath.

      Less than 6 seconds in Al-Si dipping bath gives definitely higher tin content. Observed dipping times varied over considerable range.

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2. Degree of swishing in Al-Si bath.

B. Changes--none

C. Proposed Specifications

1. On tin content in final coating--by chemical analysis of samples coatings. (An alternative would be tin content of Al-Si at top of can from press).

V <u>Sound Al-Si Bond to Al Can</u>

Present bonding of Al-Si to can appears excellent. There is room for improvement in regard to voids in Al-Si layer. The items listed below have all been observed above in connection with other properties, but should likewise improve quality of Al-Si bond. Maintainance of sound bonding is important, in order to avoid swelling resulting from penetration of water through outer coating toan unbonded area.

A. Control

1. Can temperature in die.
2. Excess Al-Si temperature.
3. Al-Si, Sn and CuSn dipping bath temperature.
4. Amount of excess Al-Si.
5. Removal of flux from slug in Sn bath.
6. H_2 content of Al-Si baths.
7. Cycle of top plunger on press.
8. Al-Si excess bath purity (to be determined)

B. Changes

1. Cl_2 or Cl_2--N_2 treatment of Al-Si baths.
2. High-low-high pressure cycle for press top plunger.

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3. Larger Al-Si and Sn dipping baths.

4. Smaller clearances between sleeve and die.

5. "Cast-in" Calrod press furnace.

C. Specifications

1. On H_2 content of Al-Si baths.

2. On top plunger cycle on press.

3. On purity of excess Al-Si bath (to be determined)

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