

UNITED STATES PATENT OFFICE

2,618,846

METHOD OF PLATING TUBE SHEETS

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Application August 15, 1947, Serial No. 768,780

6 Claims. (Cl. 29—157.4)

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This invention relates to the production of plated tube sheets for heat exchangers, or the like.

In the plating of tube sheets, according to one practice, a corrosion-resisting metal alloy is applied in a fused state to one face of a tube sheet blank both of whose faces are flat and parallel and, after the applied metal has hardened, the blank is machined to render its opposite faces flat and parallel, the tube holes are drilled and other finishing operations, such as machining to provide gasket seats, are performed. As the applied plating metal hardens and cools, it sets up severe contracting stresses which warp the tube sheet and render the plated face of the blank concave and the opposite face convex. Such distortion necessitates the application of more plating metal than is needed to protect the blank, in order to fill the concavity when the blank is warped and thus enable the plating to be machined to a plane surface for accurate drilling of the tube holes and for accurate fitting of the tube sheet within a heat exchanger assembly.

An important object of the present invention is to provide an improved method of producing a plated tube sheet or other plate-like article whereby the plated face of the article will be substantially plane after the plating metal has hardened and cooled so that the necessity for applying excess plating material is avoided and so that a uniform thickness of the plating can be obtained.

Other objects and advantages of the invention will appear hereinafter.

In the drawing, Fig. 1 is a diametrical sectional view of a tube sheet blank prepared to receive the plating metal upon one face thereof;

Fig. 2 is a view similar to Fig. 1 and showing the plating metal applied in a fused state to the tube sheet blank;

Fig. 3 is a view similar to Fig. 2 showing the blank warped by the hardening of the plating metal;

Fig. 4 is a view similar to Fig. 3 and showing a backing block or plate secured to the tube sheet blank to limit the warping thereof;

Fig. 5 is a diametrical sectional view of the plated tube sheet and showing same finished with the exception of the drilling of the tube holes; and

Fig. 6 is a sectional view of a portion of a heat exchanger assembly embodying the plated tube sheet.

The invention will be described as employed in the production of a plated tube sheet of cir-

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cular, disk-like form. However, the utility of the method described is not limited to a tube sheet of that particular form nor is it limited to a tube sheet. Features of the method may be employed advantageously in the production of other plated articles.

In the performance of the method for tube sheet production a tube sheet blank 1 of the form shown in Fig. 1 is provided. This blank is formed with a cylindrical periphery 2, a flat face 3 and an opposite face 4 which is machined uniformly convex throughout on all diameters so that the thickness of the blank diminishes progressively from the center outward on all radii. In the present instance, the face 4 is shown as provided with an annular groove 5 in its margin and a diametrical groove 6 connecting opposite sides of the annular groove. These grooves are provided to accommodate a gasket of common form having an annular body portion and a diametrical portion. However, the blank may be formed at either face thereof to accommodate gaskets of any desired form and in any required location. The blank may be formed of any suitable metal such as a mild carbon steel, or an alloy steel, for examples.

Upon the convex face 4 of the blank, the plating metal 7 in a fused state is applied to a desired depth. Such metal may be applied in any suitable manner. For example, it may be applied by moving a weld rod of the metal over the face 4 and fusing the rod by an electric arc, or by oxy-acetylene or hydrogen flame. Preferably, the application of the metal is commenced at the center of the face 4 and advanced in a spiral to the outer boundary of the area to be covered. In the present instance, the plating metal should be corrosion resistant and the metal chosen may be a suitable alloy such as nickel-copper, copper-nickel or a chrome stainless steel alloy, for examples. The invention is of particular utility when the alloy is one comprising approximately $\frac{2}{3}$ nickel and $\frac{1}{3}$ copper because of the high shrinkage of such an alloy.

As the applied plating metal hardens and cools upon the tube sheet blank, it sets up severe contracting stresses which warp the blank into the shape shown in Fig. 3. The plated face 4 is rendered substantially plane and the convexity of the face 4 is displaced to the opposite face 3. The size and proportions of the blank shown in Fig. 1 are chosen for proper correlation with the required depth of applied plating metal and the character of said metal to obtain approximately the degree of warping of the blank re-

quired to render the plated face flat. For example, a blank of mild carbon steel having low carbon and silicon content, ranging in diameter from 36 to 40 inches, 3 inches thick at the edge, and requiring a plating of nickel-copper alloy approximately $\frac{1}{8}$ inch thick when finished should have a convexity or crown of from $\frac{1}{16}$ to $\frac{1}{2}$ inch at its face 4. By the progressive increase in thickness of the blank from the edge to the center thereof along all radii a desired control and distribution of the warping effect is obtained.

As the plating metal hardens upon the blank the warping effect is observed and, if it appears to continue after the plated face has become flat, the warping is arrested by securing to the blank a backing element 8. As shown in Fig. 4, this backing element may be in the form of a flat disk-shaped plate or block of metal. It is placed against the face 3 which has become convex and is welded to the blank, as at 9, at points spaced around its edge. The backing block then resists further material warping of the tube sheet blank and preserves the plated face of the blank substantially flat. Such employment of the backing plate is particularly desirable when the face 4 of the blank becomes warped to a flat form before the required amount of plating metal has been deposited upon the blank. Application of the required additional metal would then cause additional warping of the blank but for the resistance provided by the backing plate.

After the plating metal has fully hardened, the plated blank and the attached backing plate are heated to relieve them of internal stresses. This heating may be done by placing the blank and plate in a furnace. After stress relief the backing plate is detached from the blank by breaking the welds 9.

The blank thus plated is finished by machining the convexity from the face 3 to render the face flat and parallel to the face 4, further machining the face 3 to provide it with a depressed margin 10 for a gasket seat, machining the plating 7 smooth, and grooving the metal thereof overlying the grooves 5 and 6 to form the gasket-receiving grooves 5a and 6a. The finished blank is shown in Fig. 5. Tube holes are drilled in the blank and the finished tube sheet is then ready for employment in a heat exchanger assembly, as shown in Fig. 6.

In Fig. 6 a portion of a heat exchanger shell is shown at 11, and a portion of a channel at 12. The shell and channel have opposed flanged ends bolted together, with the plated tube sheet therebetween and with its plated face at the channel side. The channel has an annular rib bearing upon the gasket 13 seated within the grooves 5a and 6a, and a pass partition 14 within the channel has an edge thereof bearing upon the cross portion of said gasket. Another gasket 15 is interposed between the margin 10 of the tube sheet and the opposed end of the shell 11. Two groups of tubes T joined to the tube sheet communicate respectively with the channel members at opposite side of the pass partition 14. It will be understood, of course, that the tube sheet may be modified to suit different pass partition arrangements and different arrangements of the gaskets. The plated face of the tube sheet may also be upon the shell side of the sheet instead of the channel side, if required.

It is, of course, to be understood that the above description is merely illustrative and in no wise limiting and that the invention comprehends such

modifications as are included within the scope of the following claims.

We claim:

1. The method of producing a plated article, comprising providing a plate-like metal blank of the article convex at one face and substantially plane at the opposite face thereof, and in which the highest point of said convexity is at the center of the blank and the depth of said convexity at its highest point comprises only a minor portion of the maximum thickness of the blank, applying in a fused state and in bead form to said blank over the convex face thereof plating metal having a higher coefficient of expansion than the metal of the blank and capable of a strong bond therewith, maintaining said metal application substantially symmetrical around the center of the blank as the application progresses, and warping the blank, while free from external restraint of warping, by contraction of the applied metal as same solidifies and cools to render the said opposite face of the blank convex and render the plated face approximately plane.

2. The method claimed in claim 1, wherein the metal of said blank is carbon steel and the said plating metal is a nickel copper alloy.

3. The method of producing a plated article, comprising providing a plate-like metal blank of the article convex at one face and substantially plane at the opposite face thereof, and in which the highest point of said convexity is at the center of the blank and the depth of said convexity at its highest point comprises only a minor portion of the maximum thickness of the blank, applying in a fused state to said blank over the convex face thereof plating metal having a higher coefficient of expansion than the metal of the blank and capable of a strong bond therewith, warping the blank, while free from external restraint of warping, by contraction of the applied metal as same solidifies and cools to render the said opposite face of the blank convex and render the plated face approximately plane, imposing external restraint upon the blank to prevent further warping, heating the blank while so restrained to relieve same of internal stresses, and removing the convexity from said opposite face of the blank.

4. The method of producing a plated article, comprising providing a metal plate-like blank of the article convex at one face and with the highest point of said convexity at the center of the blank, and having a groove in said face, applying in a fused state to said blank over the convex face thereof plating metal having a higher coefficient of expansion than the metal of the blank and capable of a strong bond therewith, and in said application of the plating metal overcharging the cross section of said groove with said metal, warping the blank, while free from external restraint of warping, by contraction of the applied metal as same solidifies and cools to render the plated face approximately plane, and forming in the applied plating only a groove directly over and along said first groove and narrower than the latter.

5. The method of producing a plated article, comprising providing a plate-like metal blank of the article circular in outline and substantially spherically convex at one face and having the highest point of said convexity at the center of the blank, applying in a fused state to said blank over the convex face thereof plating metal having a higher coefficient of expansion than the metal of the blank and capable of a strong bond there-

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with, maintaining said metal application substantially symmetrical around the center of the blank by applying the metal progressively entirely around the highest point of the convexity and progressively radially thereof, and warping the blank, while free from external restraint of warping, by contraction of the applied metal as same solidifies and cools, to render the plated face approximately plane.

6. The method of producing a plated article, comprising providing a metal plate-like blank of the article substantially circular in outline and substantially spherically convex at one face, applying in a fused state and in bead form to said blank over the convex face thereof plating metal having a higher coefficient of expansion than the metal of the blank and capable of a strong bond therewith, maintaining said metal application substantially symmetrical around the center of the blank as the application progresses, warping the blank while free from external restraint of warping by contraction of the applied metal as same solidifies and cools to render the plated face approximately plane, placing a metal backing

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plate against the resulting convexity of the opposite face of the blank, welding said backing plate to the edge portion only of the blank to limit said warping, heating the blank and backing plate while so welded together to relieve the blank of internal stresses, and breaking the welded connection between the backing plate and the blank to free the latter.

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