JOINING OF TUBULAR MEMBERS

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This invention pertains generally to the joiner of tubular members. Further this invention relates to the connection of thin-walled tubular members. More particularly, this invention pertains to the joiner of a first tubular member having a flanged opening and a second tubular member having a raised portion circumcising said second member adjacent an end thereof.

One area of endeavor in which it is necessary to join tubular members is in the manufacture of heat exchangers. The heat exchanger which may be either the condenser or the radiator of an automobile engine, typically consists of a number of thin-walled metal pieces, each having fins thereon, to extend the heat transfer surface. Refrigerant flows through the coils and air is passed over the heat exchanger to be either heated or cooled thereby. At one side of the heat exchanger each of the coils is connected to a header assembly. Said assembly is comprised of a tubular member or header and a plurality of tubes connected at one end to a plurality of openings in the wall of said header and adapted to be connected at the other end to the coils of the heat exchanger. The tubular member is normally formed of thin-walled copper tubing having an outside diameter of from 3/16 inch to 3/16 inch. The wall thickness of the tubular member is generally on the order of from .045 inch to .055 inch, however, thinner-walled tubular members may be used. Because of the problems encountered in connecting a tube to the hole in the thin-walled tubular header member, it was found desirable to form a flange around the opening.

Generally, it has been the practice in the manufacture of the header assembly for a conventional heat exchanger, to first punch a plurality of holes in the tubular member serving the purpose of an entrance for each of the tubes to be inserted in a holding device. A former of greater diameter than the hole was placed within the tubular member and drawn through the hole to form a flange around said hole.

Another method of forming the flange was to place a spherical object of greater diameter than the hole within the tubular member. Separate tools each having a cam surface were then inserted into opposite ends of the tubular member on opposite sides of the spherical ball. Pressure was applied to each of the tools to force the ball through the hole and form a flange around the hole.

The flange formed on the conventional header by each of these methods was generally elliptical in cross section and further had a non-planar outer edge. Consequently, the circular tube fit loosely in the non-circular opening of the flange.

As a result of the irregular form of the flange, fabrication of a header assembly could not be readily performed without the aid of special jigs. In the absence of proper jigs, the end of the tube might project too far into the header and interfere with the flow of fluid therein. In addition, some of the material employed to bond the tube and header of said tubular members was wasted and thereby lost. This material would also hinder the flow of fluid in the header. Thus, the quality of the connection between the header and tube was not uniformly high.

A principal object of this invention is to provide an improved connection between tubular members.

Another object of this invention is the provision of a novel method of joining a pair of tubular members.

Still another object of this invention is to provide a novel tool for piercing an opening in a tubular member and forming an annular flange around said opening.

A further object of this invention is the provision of a novel method for punching an opening in a tubular member and simultaneously forming an annular flange around said opening for the purpose of subsequently effecting connection of the tubular member with another tubular member.

Another object of this invention is to provide an apparatus for forming a flanged opening having a planar outer edge in a tubular member comprising means for clamping a tubular member, said means having a bore therein, a tubular mandrel insertable into said tubular member, said mandrel having a transverse bore in a wall thereof, a plug movable in said transverse bore, means within the tubular mandrel for moving the plug through the transverse bore into the bore in the clamping means whereby an opening is punched in the wall of the tubular member and the portion of the tubular member surrounding the opening is extruded to form a flange having a planar outer edge.

A further object of this invention is to provide a novel method of making a flanged opening in a tubular member comprising the steps of forming an opening in said tubular member and forming an annular flange having a planar outer edge around said opening.

Still another object of this invention is to provide a novel method of joining a tubular member to a tube comprising, forming an opening in a wall of the tubular member, forming an annular flange having a planar outer edge around said opening, the internal diameter of the flange being of substantially the same diameter as the opening, forming a bead on the exterior of the tube adjacent one end thereof, inserting the tube into the annular flange until the bead abuts the planar outer edge of the flange, and connecting the tube and tubular member.

A still further object of this invention is to provide a novel structural joint comprising a first tubular member having an opening in a wall thereof, an annular flange integral with said first member formed by upsetting a portion of the wall around said opening, said outer edge lying in a plane, a second tubular member including an end having an outer diameter substantially the same as the diameter of the opening in said first tubular member and a bead circumcising said end adjacent the extremity thereof, said end extending within the flange said end having a second tubular member having a configuration complementary to the configuration of the annular flange and abutting the outer edge of said flange, and means connecting said bead to said flange.

Another object of this invention is to provide a die structure for forming a flanged opening having a planar outer edge in a tubular member comprising a pair of symmetrical dies having confronting surfaces, with a first semi-cylindrical recess in each confronting surface forming a bore adapted to clamp said tubular member, and with a second and a third semi-cylindrical recess of different radii in each of said confronting surfaces forming coaxial bores oriented transversely to the axis of said first bore, said second bore being of greater diameter than said third bore and being in communication with said first bore, said second and third recesses defining a shoulder therebetween, so that material from the wall of the said tubular member is extruded into said second bore by a plug to form a flanged opening and the material adjacent the outer edge of the flanged opening is adapted to be sheared by the interaction of said plug and said shoulder to form a planar outer edge.

The specific details of the invention and the mode of functioning will be made manifest and particularly pointed out in conjunction with the accompanying drawings wherein:
FIGURE 1 is an exploded view in section of a conventional tube and tubular member; FIGURE 2 is a cross sectional view of the connection between the structure shown in FIGURE 1; FIGURE 3 is an exploded perspective view illustrating my novel tube and tubular member; FIGURE 4 is a cross sectional view of the novel connection between a tube and tubular member contemplated by this invention; FIGURE 5 is a perspective view of one of my novel clamping dies employed in the combined pierce and extrude tool to form a flanged opening in a tubular header member; FIGURE 6 is a cross sectional elevational view of my combined pierce and extrude tool illustrating the position of the parts after formation of the flange on the tubular member; FIGURE 7 is a transverse section of my combined pierce and extrude tool taken along the center line of the clamping dies and plug showing the plug in initial position and showing the preferred form of knife means; FIGURE 8 is a transverse section of my combined pierce and extrude tool taken along the center line of the clamping dies and plug showing the plug in final position after formation of the flange and showing the preferred form of knife means; and FIGURE 9 is a perspective view of the preferred embodiment of plug employed in my combined pierce and extrude tool to form a flanged opening in a tubular member.

Referring now more particularly to the drawings, like numerals in the various figures will be taken to designate like parts.

FIGURE 1 illustrates the conventional tube or conduit 2 and tubular member or header 3 just prior to assembly. An opening 4 is formed in the wall of the header and flange 6 is formed around said opening. Flange 6 is normally non-circular in cross section and therefore tube 2 which is normally circular in cross section must be held in place in the opening by means of special handling tools or jigs. Generally the axis of the tube is disposed perpendicular to the axis of the header. The handling tool or jig must provide for proper orientation and also must limit the extent of tube end that is permitted to be within the opening. Flow of fluid in the header would be hindered creating an undesirable pressure drop, if the tube were permitted to extend too far into the opening in the header as shown in dotted lines in FIGURE 2. The tube is then secured to the header, as for example, by welding, brazing or soldering, as clearly seen in FIGURE 2.

My novel tube and header are illustrated in FIGURE 3. I form an annular flange 6 about the opening 7 in header 5. The outer edge 6' of the annular flange lies in a plane parallel to the axis of the header, though it is contemplated that it may lie in a plane at an angle to the axis of the header. A bead or protrusion 8 is circumscribed on tube 9 adjacent the end thereof. The outer diameter of tube 9 and the inner diameter of flange 6 are substantially the same. Mating configurations other than circular may obviously be used. In assembly, tube 9 is inserted into the opening 7 in header 5 until bead 8 abuts planar outer edge 6' of flange 6. The outer surface of the tube adjacent the end of the tube may have been pre-coated with a bonding material or a ring of bonding material may have been placed around the periphery of the header. Bonding may be accomplished by the application of heat sufficient to melt the bonding material the tube would be properly secured to the header. As is apparent to those versed in the art, the tube can be secured to the header by other means as for example, by welding or brazing bead 8 to flange 6. My novel method of connecting a tube to a header eliminates the special handling tools commonly employed in the art.

The end of the tube projects into the opening in the header only a predetermined distance (FIGURE 4) and will not interfere with the flow of fluid in the header. The novel method of connecting the tube is suitable for high speed production techniques and results in material cost savings.

Another aspect of my invention is the novel apparatus for forming a plunger, flanged opening in a tubular member. The opening 7 and flange 6 are formed in the tubular member 5 by combined pierce and extrude tool 10. Said tool is mounted on frame 11. The tool comprises a clamping means 12 having cooperating clamping dies 13 and 14 supported on replaceable guide ways 15 for relative movement toward and away from each other. Each die is mounted on a support member 16 by suitable securing means, preferably dowels 16 and screws 17. Receives 18 and 19 are formed in the confronting surfaces of oppositely disposed portions of the clamping dies and cooperate with one another to clamp a length of tubular member 5.

Mandrel 20 internally supports the end of tubular member 5. The external surface of the mandrel has substantially the same configuration as the internal surface of the tubular member 5. Bore 21 extends transversely through the mandrel, preferably radially as shown in FIGURE 6. Plug 22 is slidably supported in bore 21. At one end of the plug, slot 23 is formed. The slot defines cam surface 24. Groove 25 is formed in a side of the plug as best seen in FIGURE 9. Retaining means 26, preferably in the form of a spring loaded plunger, rides in groove 25 to position the plug in bore 21 and prevent it from falling therefrom. Projection 27 is formed on the opposite end of the plug from slot 23.

The clamping dies 13 and 14 are each formed with a semi-cylindrical recess 28 and 29. The recesses define a bore 30 in alignment with bore 21 in the mandrel when the dies are together. The diameter of the bore so formed is substantially equal to that of the opening 7 in the tubular member. Each semi-cylindrical recess 28 and 29 is countersunk at the upper end thereof to form semi-cylindrical recesses 31 and 32. Recesses 31 and 32 define bore 33 having a diameter substantially equal to that of the exterior diameter of the desired flange 6 when the dies are together. The shoulder defined by the juncture of bores 30 and 33 defines knife means 34 which operate with the plug to shear the material from the outer edge of the flange.

Each clamping die 13 and 14 may be hardened in entirety as shown in FIGURES 5 and 6 but it is preferable to form the knife means separately from the clamping die as shown in FIGURES 7 and 8, so that when the knife means gets dull only it need be replaced and not the entire clamping die. Knives 35 and 35' are removably secured to clamping dies 13 and 14.

Means are provided to move the plug outwardly from the mandrel. Rod 36 reciprocates within the longitudinal bore in mandrel 20 and cam 37 on the end thereof is constructed to engage the cam surface 24 on plug 22 and move the plug downwardly to the position shown in FIGURES 6 and 8. Suitable means are provided for reciprocating the rod, for example, a pneumatic cylinder.

Means are provided to return the plug to the position shown in FIGURE 7. Stem 38 is operatively connected to suitable means to reciprocate said stem up and down to return the plug 22 to its initial position.

As seen in FIGURE 6, means are provided to aid in uniformly spacing the clamping dies 13 and 14 in the mandrel. Stop 41 is suitably adjustable secured in an opening in support block 42 by a set screw (not shown).

The plug 22, bore 21, and projection 27 are preferably cylindrical in cross section. As will be apparent to those persons skilled in the art, the configuration of the cross section of the annular flange may be modified by employing a plug, projection, bore in the mandrel, and bore
means in the clamping means having generally the same cross section as that of the desired annular flange.

The height of the flange on the header may be varied as follows: By increasing the width of projection 27 on plug 22 and decreasing the length of bore 33, an annular flange of substantially uniform wall thickness and of lesser height will be formed on header 5; decreasing the width of the projections will result in the formation of a flange of substantially uniform wall thickness and of greater height. It has been ascertained that the most desirable effective flange height for heat exchange headers is one and one half times the wall thickness of the tubular member, though for other applications the flange height may be increased or decreased, as desired.

**Operation**

The end of tubular member 5 is inserted over the mandrel 20 until the end abuts stop 41. Clamping dies 32 and 34 are actuated to clamp the length of tubular member therebetween. Rod 36 is moved to the right as shown in FIGURE 6. Cam 37 on rod 36 engages cam surface 24 of plug 22 to force the plug 22 downwardly. The projection 27 on the plug 22 forms a minor opening in the wall of the tubular member 5. At the same time, the shoulder of the plug 22 moves the material about the opening into bore 33 to form flange 6. The shoulder of the plug 22 cooperates with knife edge 34 (FIGURE 6) to shear the material and form a planar outer surface on the flange when the shoulder of plug 22 moves past knife edge 34 of the clamping dies. A generally circular slug 29 is punched out. The slug falls out of bore 33 onto deflecting plate 49 and away from stem 38.

After rod 36 is actuated to the left as viewed in FIGURE 6, stem 38 is raised to return plug 22 to its initial position. Plug 22 is frictionally held in initial position by retaining means 26. The spring loaded plunger slides in groove 25 of plug 22 and retains the plug in bore 21. Other constructions will be readily apparent to those having ordinary skill in the art. If they were desired to form a flange at an angle to the axis of the header, the bore 21 would extend through the mandrel at such angle and the bores 30 and 33 in the clamping dies would be coaxial to the bore through the mandrel.

The construction of tool 10 permits the formation of flanged openings in the wall of a tubular member having a diameter approaching the diameter of the tubular member. The tool may be scaled to have a planar outer edge in tubular members of any size, limited only in that the opening in the tubular member must be of sufficient size to receive a mandrel having a movable plug therein. The flanged openings are formed in the tubular member by a single movement of plug 22 relative to the clamping dies.

By means of the planar flanged opening in the tubular member, joining of a conduit or tube to said tubular member is facilitated and readily adapted to automatic assembly techniques.

My novel combined piece and extrude tool is capable of forming flanged openings having planar outer edges in tubular members made from both soft and hard materials, as for example, copper, aluminum or steel. The above disclosure is given by way of illustration and elucidation and it is desired to protect all embodiments of the herein disclosed inventive concept within the scope of the appended claims.

1. Apparatus for forming a flanged opening in a tubular member comprising a frame, clamping means mounted on said frame adapted to grasp said tubular member comprising a pair of dies movable toward and away from each other, said dies including means defining a differential bore, a mandrel member having the external surface thereof engageable with the inner surface of the tubular member, said mandrel sup-ported on said frame, said mandrel having a longitudinal bore therein and a transverse bore, a plug having a cylindrical tip portion of reduced diameter movable in said transverse bore, means in said longitudinal bore engageable with said plug and adapted to move the plug outwardly in the transverse bore, whereby when the plug is moved outwardly in the transverse bore through the mandrel, an opening is punched in the tubular member by said tip and the material around the opening is extruded and cut by the interaction of the plug and means defining a differential bore to form a flanged opening having a planar outer edge.

2. Apparatus for forming a flanged opening in a tubular member comprising means for clamping a tubular member, said means having a bore therein, said bore being of a larger diameter adjacent the tubular member and being of a smaller diameter at a distance therefrom, the edge between said larger diameter bore and said smaller diameter bore defining knife means, a tubular mandrel insertable into said tubular member, said mandrel having a bore in a wall thereof, said mandrel bore being in alignment with said bore in the clamping means, said mandrel bore being substantially the same diameter as said smaller diameter bore, a plug movable in said mandrel bore, means within the tubular mandrel for moving the plug through said bore bore in the wall of the mandrel into the bore in the clamping means and beyond the knife means whereby a flanged opening having a planar outer edge is formed in the wall of the tubular member.

3. Apparatus as in claim 2 wherein said mandrel includes means operatively engaging said plug and retaining said plug in the bore in said mandrel.

4. Apparatus as in claim 2 wherein the means for clamping a tubular member comprises a pair of dies positioned on opposite sides of said tubular member and movable toward one another to clamp the tubular member.

5. Apparatus as in claim 4 wherein the dies include recessed portions which define a bore when the dies are clamping the tubular member.

6. Apparatus as in claim 5 wherein each die includes a semi-cylindrical recessed portion and said bore is cylindrical.

7. A combined pierce and extrude tool comprising a mandrel insertable in a tubular member, said mandrel having an external surface substantially conforming to the internal surface of said tubular member, said mandrel having a longitudinal bore and a transverse bore extending therethrough, means for clamping the external surface of said member, said means having a first and a second bore therein in alignment with said transverse bore, the edge between said first and second bores defining knife means, a plug slidably mounted in said transverse bore, said plug having a projection on an end thereof, the opposite end of said plug having a cam surface formed thereon, a rod reciprocably mounted in the longitudinal bore, said rod having a cam surface at one end thereof to engage the cam surface on the plug and force the plug through the wall of said member into said first and second bores to form a flanged opening having a planar outer edge.

8. A combined pierce and extrude tool comprising a mandrel insertable into a tubular member, said mandrel having an external surface substantially conforming to the internal surface of said tubular member, said mandrel having a longitudinal bore and a radial bore therein, a plug reciprocably mounted in said radial bore, said plug having a projection on one end thereof adapted to pierce the tube, a rod reciprocably mounted in said longitudinal bore, intersecting cam means on said rod and plug for forcing the plug outwardly in the radial bore in response to actuation of said rod, a pair of dies movable toward and away from one another to clamp the tubular member, said dies each having a first recessed portion and a second recessed portion, respectively, being opposed to define
first and second bores through said dies when the dies clamp the tubular member, said second bore being of smaller diameter than said first bore, knife means defined by the edge between the first and second bores, the axis through said first and second bores coinciding with the axis of the radial bore, so that when the plug is forced through the tubular member by said rod a flanged opening having a planar outer edge is formed in the tube.

9. A die structure for forming a flanged opening having a planar outer edge in a tubular member comprising a pair of symmetrical dies having confronting surfaces, with a first semicylindrical recess in each confronting surface forming a first bore adapted to clamp said tubular member, and with a second and a third semicylindrical recess of different radii in each of said confronting surfaces forming coaxial bores oriented transversely to the axis of said first bore, said second bore being of greater diameter than said third bore and being in communication with said first bore, said second and third recesses defining a shoulder therebetween, said shoulder adapted to confine extruded material from about an opening in the wall of said tubular member and adapted to cooperate with a plug member to cut the extruded material about the outer edge of the flange to form a flanged opening having a planar outer edge.

10. In a die structure adapted to cooperate with a plug member for forming a flanged opening having a planar outer edge in a tubular member, the combination of a pair of symmetrical dies having confronting surfaces, said surfaces each having a first semi-cylindrical recess therein, said first recesses forming a first bore adapted to accommodate a length of said tubular member having said first semi-cylindrical recess therein, said second recesses forming a second bore in transverse communication with said first bore, said second bore adapted to receive material therein extruded from about an opening in the tubular member to form a flange, said surfaces each having a third semi-cylindrical recess therein, said third recess forming a third bore of lesser diameter than said second bore and being coaxial therewith, and a shoulder formed in each die between the second and third recesses adapted to confine said extruded material from about an opening in the tubular member and adapted to interact with said plug to shear the extruded material adjacent the outer edge of the flange to form a planar outer edge on said flange.

11. A combined piece and extrude tool comprising a mandrel insertable into a tubular member, said mandrel having a bore extending therethrough, clamping means for grasping said tubular member, means defining a bore in said clamping means, said clamping means bore being in alignment with said bore in the mandrel, knife means extending into and surrounding a portion of said clamping means bore, a plug slidably mounted in said mandrel bore, said plug having a first end adapted to be forced through the wall of the tubular member and a second end having a cam surface thereon, and means for engaging the cam surface on the second end of said plug and forcing the first end of said plug through the wall of said tubular member into said clamping means bore and past the knife means therein to form a flanged opening having a planar outer edge.

12. A combined piece and extrude tool as in claim 11 wherein said clamping means bore includes a first bore and a second bore, said first bore being of greater diameter than said second bore, the shoulder between said first bore and said second bore defining the knife means.

13. Apparatus for forming a flanged opening in a tubular member comprising means for clamping a tubular member, said clamping means including a pair of dies positioned on opposite sides of said tubular member and movable toward one another to clamp the tubular member, first and second recessed portions defining knife means, a tubular mandrel insertable into said tubular member, said mandrel having a bore therethrough, said mandrel bore being in alignment with said larger bore and said smaller bore defined in the dies, a plug movable in said mandrel bore, and means for forcing the plug through the wall of the tubular member past the knife means and into the smaller bore defining a planar outer edge of a flanged opening having a planar outer edge is formed in the wall of the tubular member.

14. Structure for forming a flanged opening having a planar outer edge in a tubular member comprising die means having a surface for abutting at least a portion of the exterior surface of the tubular member and means in a die means defining a plug accommodating differential bore, said differential bore extending from said surface and including a first portion proximate said surface and a second portion remote therefrom, said first portion being of greater diameter than said second portion, the said dies between said first proximate portion and the second remote portion defining cutting means, said cutting means adapted to cooperate with a plug to form a flanged opening having a planar outer edge.

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