METHOD OF FORMING JOINTS OF NON-CYLINDRICAL TUBING

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ABSTRACT

Structures built from metal tubing and a method for their construction wherein cast curved sections of tubing are welded to substantially straight sections of metal tubing according to the design requirements of the structures. The cast curved components are stronger and lighter than equivalent components made by bending. In addition, the cast components can be manufactured in a much wider range of configurations, sizes and dimensions (e.g. cast curves can have a greater degree of curve and a much smaller radius of curve than bent components).
METHOD OF FORMING JOINTS OF NON-CYLINDRICAL TUBING

FIELD OF THE INVENTION

This invention relates to structures made of metal tubing and a method for their construction.

BACKGROUND OF THE INVENTION

Square metal tubing is used in a wide variety of applications. It is used, for example, in the construction of rollover and falling object protection systems (ROPS and FOPS, respectively) on heavy machinery, such as forklifts. Metal tubing is also widely used in all manner of railings, fences, brush-guards, building construction, etc.

Such applications often require corners or angled joints to be made between substantially straight sections of tubing. This is commonly accomplished in the prior art, for example, by welding together the ends of two straight metal tubes, or by bending the tubing to achieve the desired angle or curve. However, both of these approaches suffer from several drawbacks.

The first drawback is that welding together two straight sections of tube results in a corner, which may not be aesthetically acceptable if a rounded look is desired. In addition, sharp corners present a hazard in that they are sharp points on which people and objects may get caught.

A drawback of bending is that the minimum radius of the bend is limited. Short radius bends or elbows cannot be achieved by bending metal tubing because the side that forms the outer curve of the tube is stretched by bending and therefore is weakened and may even be broken. In addition, the side that forms the inner curve of the tube is wrinkled or deformed such that its appearance and structural strength are compromised. Accordingly, only relatively large radius curves can be achieved by bending.

Furthermore, for FOPS and ROPS type applications, where the strength of the finished rectangular tube structure is crucial, weak joints are unacceptable. In some cases the weakness of bent joints and elbows can be compensated for by using thicker metal, however, this is in exchange for greater cost, labour and material. In addition, thicker metal results in a heavier structure, which may not be desirable. It appears, from commercially available bent tubing products, that the minimum radius that can be achieved by bending square steel tubing is approximately 2.5 times the width of the tubing (width being measured in a plane parallel to the radius of curvature). This limit will obviously vary with tube size, tube wall thickness, and bending techniques, etc.

Bending also requires that a certain minimum thickness of metal be used to withstand the stretching. Therefore for many applications, such as hand railings, a thinner metal could be used but for the requirement that it withstand the stress of bending.

Finally, bending, although technically possible, is simply not practical for larger sized metal tubing (for example, 12”x12” square steel tubing).

Attempts have been made to address some of these needs in the prior art. For example, U.S. Pat. No. 5,441,241, issued to McKim, discloses a Knuckle for Welding of Safety Hand Railings. However, the knuckle disclosed by McKim being a solid piece of metal is inappropriate for use with large diameter rectangular tubing because it would be extremely heavy. In addition, McKim’s knuckle results in a sharp inside angle or corner in which, in the case of handrails, clothing or even user’s hands can be caught. Finally, the angle of McKim’s knuckle cannot be modified, for example, on a job site during construction (i.e. each knuckle is manufactured for a specific angle and is not readily modified).

Several U.S. patents have issued for inventions relating to joints for structures, railings or fences, (for example, U.S. Pat. Nos. 4,667,935; 5,820,289; 2,930,638; 4,322,176; 5,617,694; 6,164,706; and 4,314,861) however, the systems disclosed by such patents generally suffer from one or more of the following disadvantages: (a) they do not provide the requisite strength necessary for applications such as FOPS and ROPS; (b) the angle of the joint or elbow cannot be readily adjusted or modified; (c) they are not aesthetically pleasing; (d) they are unnecessarily complex and/or expensive to produce; and (e) they are limited in the radius and degree of bend that can be achieved.

Accordingly, there exists a need in the art for elbows and joints for use with metal tubing that address these deficiencies.

SUMMARY OF THE INVENTION

The present invention relates to the construction of structures, such as handrails, fences, brush-guards, rollover protection systems and falling object protection systems, by welding together sections of substantially straight square or rectangular metal tubing and sections of cast curved square or rectangular metal tubing. The curved sections of square tubing may be made by means other than casting, provided that they are not made by bending. The cast sections of tubing are welded to one another or to substantially straight sections of metal tubing according to the design of the structure. The cast curved components are stronger and lighter than equivalent components made by bending. In addition, the cast components can be manufactured in a much wider range of configurations, sizes and dimensions (e.g. pre-fabricated curves can have a greater degree of curve and a much smaller radius of curve than bent components).

In the preferred embodiment adjacent sections of metal tubing are butt welded together, however, they can be joined together by other means appropriate to the design of the structure.

Casting the curved components results in lower manufacturing costs when compared with the costs of producing equivalent components by bending.

BRIEF DESCRIPTION OF THE DRAWINGS

Further features and advantages will be apparent from the following detailed description, given by way of example, of a preferred embodiment taken in conjunction with the accompanying drawings, wherein:

FIG. 1A is a side view of a section of prior art square tubing;

FIG. 1B is a cross-sectional view through the prior art bent tubing of FIG. 1A;
DETAILED DESCRIPTION

[0028] When a metal tube is bent it is deformed. The act of bending a metal tube results in the stretching, wrinkling, narrowing and possibly cracking of portions of the tube. The amount and type of deformation depends on several factors, including the dimensions of the metal tubing, the type of metal used, the method used to bend the tubing, the angle or degree of the bend and the radius of the bend. The smaller the radius and the greater the degree of the bend the more the tube will be deformed. The most common deformation is stretching, thinning and strain hardening of the outside wall of the bent tube (i.e. the wall that forms the outer curve of the bent tube). Due to such deformations, for any given type of metal tubing, there is a definite limit to the minimum radius that can be achieved by bending. When a tube is bent to too small a radius the outside wall of the tube can crack. Such cracking is more likely to occur if the weld seam of the metal tube is located near or along the outer curve of the bent tube.

[0029] In other words, in bending any given size of metal tubing the strength of the tubing is necessarily compromised and one is limited in both the degree of bend and the minimum radius that can be achieved.

[0030] Referring to FIGS. 1A and 1B, a section of bent square tubing 100 is shown having an outer curved wall 110, an inner curved wall 120 and lateral walls 130 (FIG. 1B shows a cross-section of the square tubing of FIG. 1A taken along line A-A). Bending the tubing 100 results in the thinning and narrowing of the outer curved wall 110 relative to the inner curved wall 120. The portions of the lateral walls 130 nearest the outer curved wall 110 also experience some thinning and are deflected toward one another. The maximum deformation is experienced near the center of the outer curved wall 110. Such deformation has the effect of weakening the tubing 100 and, therefore, any structure in which the tubing 100 is incorporated may be compromised.

[0031] Referring to FIG. 2, an end view of the bent section of metal tubing 100 is shown. The bending process often causes the metal tube to twist. This is shown in FIG. 2 by the deviation of the metal tube 100 from the reference line 140, which represents the position that would be occupied by the lateral wall 130 of an un twisted section of metal tubing.

[0032] Referring to FIGS. 3 and 4, an end and side view of a corner joint between two sections of 4"x4"x lips" square metal tubing 150, 152 is shown. In FIG. 3 the joint is shown without welds and in FIG. 4 the joint is shown with welds 158, 160, 162, 164. FIGS. 3 and 4 demonstrate that, when making corner joints between relatively large corner radius tubes, excessive weld is required to fill the space 154 between the tubes so that it is flush with the flat surfaces of the tubing 150, 152. In addition, a backing bar 156 must often be employed to aid in welding the two tubes together.

[0033] Another difficulty encountered in such joints is that, due to the excessive welding, there is a risk that lamellar tears will develop in the wall of the metal tube. Lamellar tearing is the separation of the metal of the tube in a plane generally parallel to the rolling direction of the plate of the metal tube. The tearing develops in susceptible material as a result of high through-thickness strains. The through-thickness strains are the normal results of weld metal shrinkage. By definition lamellar tears always lie within the base metal, (i.e. the metal tube) generally parallel to the weld fusion boundary. The tear may initiate just outside the visible heat affected zone and propagate to the root or toe, in which case the tear may be detected visually. Often, however, the tear is subsurface, in which case it must be detected by other means (e.g. ultrasonic testing).

[0034] The welding between the two tubes 150, 152, and in particular the inside corner weld 158, causes the free end of the upper tube 150 to deflect downwards toward the lower tube 152. The end result is that after taking care to ensure that the joint is properly aligned and welding the two tubes together, one of the tubes may no longer be straight.

[0035] When making a T-joint or corner joint as shown in FIGS. 3 and 4 it is often necessary to weld a plate 166 onto the end of the upper tube. Such a plate 166 helps to reinforce the upper tube 150 against twisting that may occur when the structure is placed under stress. The welding of such a plate represents an additional step in the making of such a T or corner joint, which step is required in many jurisdictions by occupational safety regulations (for example, when such a joint is used in the construction of ROPS or FOPS). As will become clear later, this extra step is unnecessary in structures constructed according to the present invention.

[0036] Referring to FIG. 5, a miter joint is shown between two straight sections of metal tubing 170, 172. The need for bending metal tubing can in some instances be avoided by such miter joints, however, such miter joints involve an extra cutting step, (the ends of the metal tubes must be cut on an angle) and have sharp inside and outside corners 174, 176, which represent potential hazards. In addition, miter joints may be aesthetically undesirable in certain applications.

[0037] Referring to FIG. 6, a cast metal 45-degree elbow 10 is shown having an outer curved side 12 and an inner curved side 14. Referring to FIG. 7, the 45-degree elbow 10 is shown in cross-section taken along line B-B of FIG. 6. The elbow 10 is a 4"x3" metal tube having a wall thickness
of \( \frac{1}{4''} \). The outer curved side 12 has a radius of curvature of 6'' and a length of approximately 5.3'' and the inner curved side 14 has a radius of curvature of 2\%'' and a length of approximately 2.16''. Due to the degree of the bend, the radius of the bend, and the wall thickness of the elbow 10, it generally cannot be made by bending a straight piece of metal tubing using known bending techniques and standard metals because the outer curved side 12 would be stretched to the point of cracking. The outer curved side 12 is almost 2.5 times as long as the inner curved side 14 and the radius of curvature of the inner curved side 14 is less than \( \frac{3}{4} \) of the width of the elbow 10 (i.e. 4'').

[0038] Referring to FIG. 8, a cast metal 90-degree elbow 20 is shown having an outer curved side 22 and an inner curved side 24. Referring to FIG. 9, the 90-degree elbow 20 is shown in cross-section taken along line C-C of FIG. 8. The elbow 20 is a 3''x3'' metal tube having a wall thickness of \( \frac{1}{2}'' \). The outer curved side 22 has a radius of curvature of 5\%'' and a length of approximately 8.2'' and the inner curved side 24 has a radius of curvature of 2\%'' and a length of approximately 3\%''. Due to the degree of the bend, the radius of the bend, and the wall thickness of the elbow 20, it cannot generally be made by bending using known bending techniques and standard metals because the outer curved side 22 would be stretched to the point of cracking. The outer curved side 22 is more than twice as long as the inner curved side 24 and the radius of curvature of the inner curved side 24 is less than \( \frac{3}{4} \) of the width of the elbow 20 (i.e. 3'').

[0039] Referring again to FIG. 8, the ends of the elbow 20 are beveled 26 such that they are ready for butt welding to the ends of adjacent sections of metal tubing.

[0040] Referring to FIG. 10, a 2''x2''x\( \frac{3}{8}'' \) 90-degree cast steel elbow 50 is shown butt-welded to adjacent sections of square tubing 60. One butt-weld 52 is ground flush to the surface of the metal tube 60 and elbow 50 and the other butt-weld 54 is not. FIG. 10 illustrates the basis of the present invention; structures built from metal tubing wherein the curved joints or elbows are cast and welded to sections of metal tubing.

[0041] Referring to FIG. 11, a cab guard 70 for a truck is shown by way of example of a structure built according to the present invention. Cab guards are designed to prevent objects on the bed or trailer of a truck from striking the cab of the truck. The cab guard 70 is constructed from 4'' steel square tubing and a steel mesh screen 72. Straight sections of square tubing 74 are butt welded to 90-degree cast steel elbows 76.

[0042] Referring to FIGS. 3 and 4, right angle junctions between substantially straight sections of metal tube can be made according to the present invention by welding the ends of the substantially straight sections of metal tube to a cast 90-degree curved elbow. When made according to the present invention, such junctions are easier to make, (i.e. easier to weld) less susceptible to lamellar tearing, less likely to cause bending of the substantially straight sections of tubing, generally stronger and lighter and more aesthetically pleasing than prior art junctions (such as shown in FIGS. 3 and 4).

[0043] The present invention also contemplates a method of constructing metal tube structures using cast curved elbows and/or joints. The method involves the welding together of sections of metal tubing to form the desired structure wherein the curved are cast rather than bent. The cast sections or components are welded to the other sections of metal tubing in the metal tube structure according to known welding techniques. In other words, structures that would normally require elbows or joints made by bending metal tubing if they were built according to prior art methods, can be built without using parts made by bending.

[0044] Accordingly, while this invention has been described with reference to illustrative embodiments, this description is not intended to be construed in a limiting sense. Various modifications of the illustrative embodiments, as well as other embodiments of the invention, will be apparent to persons skilled in the art upon reference to this description. It is therefore contemplated that the appended claims will cover any such modifications or embodiments as fall within the true scope of the invention.

1. A structure comprising at least two substantially straight sections of square or rectangular metal tubing and at least one cast curved section of square or rectangular metal tubing, wherein an end of a first one of said substantially straight sections is welded to a first end of said curved section and an end of a second one of said substantially straight sections is welded to a second end of said curved section.

2. The structure of claim 1, wherein said structure is one of a handrail, a fence, a brush-guard, a rollover protection system and a falling object protection system.

3. The structure of claim 1, wherein said ends of said substantially straight sections are butt welded to said first and second ends of said curved section.

4. A structure comprising a plurality of sections of square or rectangular metal tubing welded together, wherein an end of at least one substantially straight section of square or rectangular metal tubing is welded to an end of at least one section of cast curved square or rectangular metal tubing.

5. The structure of claim 4, wherein said structure is one of a handrail, a fence, a brush-guard, a rollover protection system and a falling object protection system.

6. The structure of claim 4, wherein an end of said substantially straight section is butt welded to an end of said cast curved section of metal tubing.

7. A method of constructing a structure from metal tubing, comprising the following steps:

   a) providing a plurality of substantially straight sections of square or rectangular metal tubing;

   b) providing at least one section of cast square or rectangular curved metal tubing; and

   c) welding an end of one of said substantially straight sections of metal tubing to an end of said section of cast curved metal tubing.

8. The method of claim 7, wherein said welding step comprises butt welding.

9. The method of claim 7, wherein said structure is one of a handrail, a fence, a brush-guard, a rollover protection system and a falling object protection system.