PATENT SPECIFICATION

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(21) Application No. 18400/77 (22) Filed 3 May 1977
(31) Convention Application No. 689774
(32) Filed 25 May 1976 in
(33) United States of America (US)
(44) Complete Specification published 29 Oct. 1980
(51) INT CL[3] B23P 15/26 F16B 11/00 F28F 1/12
(52) Index at acceptance B3A 122G 158 26 78A B3V 10 F4S 2B12 2B3 2B5

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(54) HEAT EXCHANGER TUBE AND METHOD OF PRODUCTION

(71) We, CARRIER CORPORATION, a corporation duly organized under the laws of the State of Delaware, United States of America, having its principal place of business at Syracuse, New York, United States of America, do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:

This invention relates to a tube for use in a heat exchanger and a method of producing such a tube.

Although there are many advantages associated with a wrapped fin tube, this type of device has not as yet been widely utilized in the industry primarily because of the many difficulties associated with tube fabrication. This is particularly true where the exchanger tube and fin strip are formed of aluminium or other materials which are difficult to join.

Heretofore, the fin strip has been joined to the exchanger tube by either a metal bonding process, such as welding, soldering, brazing, or the like, or adhesive bonding. The metal bonding techniques generally require special, relatively expensive, equipment to join the components. Furthermore, most-to-metal bonding processes invariably expose the components to high temperatures which can warp or thermally damage the parts. Adhesive bonding, on the other hand, is typically achieved by covering the outer surface of the exchanger tube with an adhesive coating and then wrapping the fin strip over the coated tube. A thermal resistance, i.e., the adhesive layer, is thus introduced into the critical region between the fin strip and the exchanger tube through which energy in transit must pass. Generally, this region represents a bottleneck in the heat transfer system and any impediment to passage of energy through this region will, of course, reduce the efficiency of the heat exchanger tube.

The invention provides a tube for use in a heat exchanger including a metal tube, a U-shaped metal fin strip having a base and two substantially parallel rows of fins extending from the base, the fin strip being wound about the tube with the base of the fin strip tensioned against the surface of the tube to provide intimate metal-to-metal contact therebetween and the fins extending radially from the tube, and a continuous meniscus of adhesive along both sides of the fin strip for securing the fin strip in contact with the tube surface.

The spines or fins are separated from each other throughout their entire length by an air gap that increases progressively from the base of the heat transfer surface to the tip of each spine. The tube's resistance to air is thus minimized making the tube well suited for use in air conditioning equipment or the like. The structure of the fin strip also minimizes the possibility of condensate freezing upon the tube. Moisture forming on the tube is directed downwardly by the fin strip and, because of the surface tension involved, is rapidly released by the tube. It should be further noted that a single section of wrapped fin tube can be conveniently formed into any number of shapes to produce a heat exchanger of almost any desired geometry that is easy to assemble and which eliminates costly components, such as tube return bends or the like, normally found in exchangers of a more conventional construction, and which are soldered or brazed into position.

The meniscus of adhesive may extend upwardly from the base of the fin strip to support each individual fin substantially perpendicular to the base.

The tube may have a thin layer of material which extends over the exposed surfaces of the fin strip and the tube to provide a protective coating thereover, the meniscus forming part of the protective coating. Preferably, the material is a heat curable adhesive.

The invention also provides a method of producing a heat exchanger tube including the steps of slitting a flat elongated sheet of thin gauge metal material laterally inwardly from both edges thereof to form uniformly spaced fins along the edges of said sheet, bending the fins to a position substantially perpendicular to the plane of the sheet so as to form a U-shaped fin strip having two substantially parallel rows of fins extending upwardly from the base thereof, wrapping the base of the U-shaped fin strip about a metal tube to provide continuous metal-to-metal contact between the base and the outer surface of the tube whereby the fins extend radially outwardly from the tube, establishing a meniscus of adhesive material along both sides of the fin strip at the point of contact between the fin strip and the tube surface whereby the integrity of the metal-to-metal contact between the base of the fin strip and the tube surface is preserved, and curing the adhesive to securely bond the fin strip to the tube surface.

Preferably the fin strip is tensioned as it is wrapped upon the tube with sufficient force to ensure continuous metal-tc-metal contact between the base of the fin strip and the surface of the tube along the entire length of the wrap. It is preferred that the viscosity of the adhesive bonding of fin strip to the tube is sufficiently high so that the adhesive cannot penetrate the metal-to-metal contact maintained between the fin strip and the tube surface.

The invention will be more particularly described with reference to the accompanying drawings in which:

Figure 1 is a partial perspective view illustrating the formation and winding of a secondary heat transfer surface upon a primary tubular element;

Figure 2 is also a partial view illustrating the application and curing of an adhesive material upon the tube surface; and

Figure 3 is a partial sectional view showing a typical cross section taken through the heat exchanger tube illustrated in Figures 1 and 2.

In carrying out the present invention, a thin gauged planar strip of material 10 having good heat transfer properties is provided with a series of slits 11 extending inwardly from each side of the sheet as illustrated in Figure 1. The cuts or serrations terminate at the backbcne 13 of the sheet so as to form laterally extended spine-like fin segments 14. The cut strip is then passed through roller die means, as for example, die 15, specifically contoured to turn the fins upwardly on each side of the backbone to generate a continuous fin strip 20 of U-shaped cross-sectional form having a relatively flat base 16 and two parallel dependent legs 17, 18 containing the spine-like fins 14.

Upon the formation of the U-shaped element, the strip is spirally wrapped about a tubular element 24 at a predetermined helix so that the backbone or base 16 of the strip seats in contact against the outer surface of the tube. As the fin strip is wrapped about the tube, it is tensioned to ensure that a positive metal-to-metal contact is maintained between the tubular element and the fin strip. As best seen in Figure 1, the fin strip, which contains the two rows of extended fins, is deformed as it is wound over the tube causing the spine-like fins to spread out radially from the center of the tube. The individual spines or fins are thus separated from each other by an air gap 25 that increases gradually from the base of the fin strip to the outer extremities of the individual spines.

As best seen in Figure 2, the fin strip can be continuously wound about the tubular member to produce a finned tube 26 of almost any desired length. In practice, the lead of the helix at which the fin strip is wound about the tube is preferably equal to the lateral distance between the two parallel legs of the fin strip. The spiral wound rows of fins supported upon the tube are thus evenly spaced along the length of the tube to produce a uniform and highly dense spine population thereupon. The dimensions of the individual fins are selected so as to maximize the surface area presented to the air passing over the tube, while at the same time, minimizing the pressure drop over the tube. Depending upon the operating conditions involved and whether the exchanger is to be used as a condenser or an evaporator, the width of the fins can be between 0.020 and 0.100″.

With the fin strip wrapped about the tube, the tube is placed in a lathe-like fixture and turned below a nozzle 30 that is arranged to spray a curable adhesive over the exposed surfaces of the tube. Alternatively, the adhesive can be simply allowed to flow from a spigot or tap over the spined tube. The nozzle (or nozzles) is arranged directly over the wound tube and in this position will permit the adhesive to coat the fin tube at a controlled rate as it is advanced from the winding operation. A measured quantity of adhesive is thus applied to the tube to coat the exposed tube surfaces with a thin layer 32 of adhesive which is shown exaggerated in Figure 3 for illustrative purposes. As the tube rotates, any excessive adhesive which might have been applied to the tube is caused to flow down the radially extended spines and eventually released leaving behind a relatively uniform coating.

Simultaneously therewith, the adhesive automatically moves up each leg of the strip and outwardly along the tube surface so as to provide a meniscus on both adhesive sides of the fin tube contact area along the length of the strip. This double fillet thus serves to bond the secondary fin strip in metal-to-metal contact against the primary tube and also supports the individual fins in a radially extended position. As can be seen, the adhesive in the meniscus also has the ability to flow beneath the fin strip base to fill any air gaps or voids thus preventing foreign material, particularly corrosion inducing materials, from being collected between the strip and the tube. By tensioning the strip against the tube, the adhesive is prevented from penetrating into the metal-to-metal contact region. Accordingly, when the adhesive is cured, the secondary fin strip is securely held in contact against the tube to provide for an efficient transfer of energy therebetween.

Preferably, the exposed surfaces of both the tube and the fin strip are coated with a thin layer of adhesive about 0.0007" thick. As noted, this coating acts as a thermal resistance in the system. However, sufficient fin area is provided to accommodate for this added resistance so that the overall efficiency of the tube is not impeded.

Positioned behind the nozzle in relation to the wound fin tube's path of travel is a radiant lamp 35, or other heat source, for rapidly curing the adhesive that has been sprayed upon the tube surface. Any suitable adhesive capable of being cured by exposure to radiant energy can thus be employed in the practice of the present invention. The lamp, or other heat source, is arranged directly in line with the path of travel of the wound fin tube to treat the coated surfaces of the tube rotating thereunder. A sufficient distance is maintained between the lamp, or other heat source, and the nozzle to permit any excessive adhesive sprayed upon the tubular surface to be completely drained from the tube prior to its being treated with radiant energy. Also as an example, the linear rate at which the fin tube moves can be coordinated with the cure cycle and a series of lamps employed which will permit a complete adhesive cure as a function of tube length per minute requirements.

Although a spraying process is herein utilized to apply the coating to a finned tube, the present invention is not necessarily limited to this particular coating technique. A coated heat exchanger tube can be similarly fabricated by dipping the finned tube into a bath of adhesive material and, upon removal, permitting the coated tube to drip-dry for a short period of time to release excessive adhesive therefrom prior to treating the tube with radiant energy. Similarly, when the adhesive is formed of a heat sensitive material, the adhesive can be conveniently cured by an oven drying process, or the like. Regardless of the method employed, it has been found that a fin strip comprising a base element capable of being wound upon a tube and at least one finned leg dependent upon the base that is turned outwardly in the manner herein described, will automatically form a meniscus at the juncture of the leg to the base and the outer surface of the tube for securing the fin strip to the tube and supporting the spines in a radially extended position.

While this invention has been described with reference to the structure herein disclosed, it is not confined to the details as set forth, and this application is intended to cover any modifications or changes as may come within the scope of the following claims.

WHAT WE CLAIM IS:

1. A method of producing a heat exchanger tube including the steps of slitting a flat elongated sheet of thin gauge metal material laterally inwardly from both edges thereof to form uniformly spaced fins along the edges of said sheet, bending the fins to a position substantially perpendicular to the plane of the sheet so as to form a U-shaped fin strip having two substantially parallel rows of fins extending upwardly from the base thereof, wrapping the base of the U-shaped fin strip about a metal tube to provide continuous metal-to-metal contact between the base and the outer surface of the tube whereby the fins extend radially outwardly from the tube, establishing a meniscus of adhesive material along both sides of the fin strip at the point of contact between the fin strip and the tube surface whereby the integrity of the metal-to-metal contact between the base of the fin strip and the tube surface is preserved, and curing the adhesive to securely bond the fin strip to the tube surface.

2. The method of claim 1 wherein the fin strip is tensioned as it is wrapped upon the tube with sufficient force to ensure continuous metal-to-metal contact between the base of the fin strip and the surface of the tube along the entire length of the wrap.

3. The method of claim 2 wherein the viscosity of the adhesive bonding the fin strip to the tube surface is sufficiently high so that the adhesive cannot penetrate the metal-to-metal contact maintained between the fin strip and the tube surface.

4. The method of claim 1, 2 or 3, wherein a thin layer of adhesive material is provided over the exposed surfaces of the fin strip and tube to provide a protective coating thereover, said meniscus forming part of the protective coating.

5. A tube for use in a heat exchanger including a metal tube, a U-shaped metal fin strip having a base and two substantially parallel rows of fins extending from the base, the fin strip being wound about the tube with the base of the fin strip tensioned against the surface of the tube to provide intimate

metal-to-metal contact therebetween and the fins extending radially from the tube, and a continuous meniscus of adhesive along both sides of the fin strip for securing the fin strip in contact with the tube surface.

6. The tube of claim 5 wherein the meniscus of adhesive extends upwardly from the base of the fin strip to support each individual fin substantially perpendicular to the base.

7. The tube of claim 6, wherein a thin layer of adhesive material extends over the exposed surfaces of the fin strip and the tube to provide a protective coating thereover, said meniscus forming part of the protective coating.

8. The tube of claim 7 wherein said material is a heat curable adhesive.

9. A heat exchanger tube substantially as described herein and with reference to the accompanying drawings.

10. A method of producing a heat exchanger tube substantially as described herein and with reference to the accompanying drawings.

ERIC POTTER & CLARKSON,
Chartered Patent Agents,
5 Market Way,
Broad Street,
Reading RG1 2BN.

Printed in England by Her Majesty's Stationery Office, 1980. Published by the Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.

1577577 COMPLETE SPECIFICATION

1 SHEET *This drawing is a reproduction of the Original on a reduced scale*

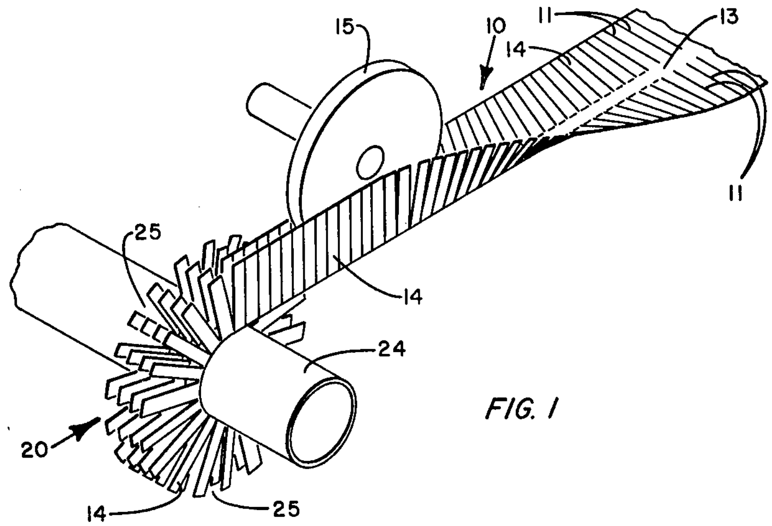

FIG. 1

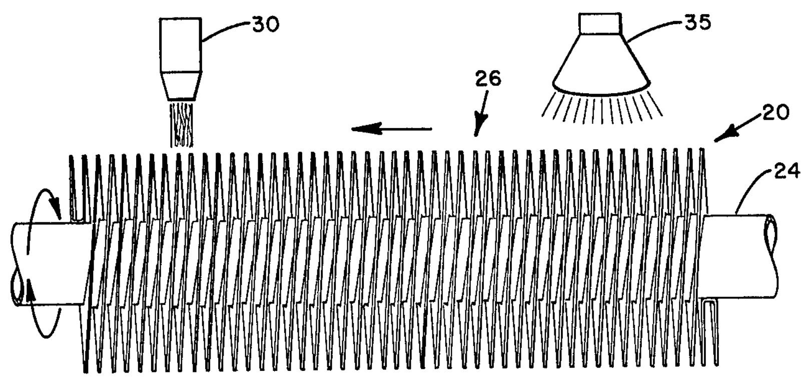

FIG. 2

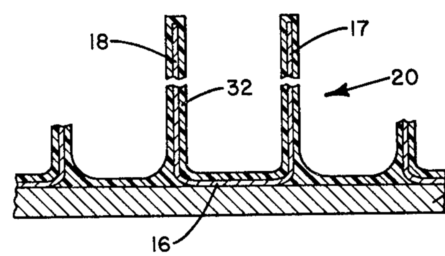

FIG. 3