

HEAT EXCHANGERS AND TUBES THEREFOR

FIELD OF THE INVENTION

This invention relates to heat exchangers and tubes therefor, and particularly to heat exchangers using externally finned heat exchanger tubes.

BACKGROUND TO THE INVENTION

In a conventional heat exchanger system, one fluid (hot or cold) is contained within one or more tubes, and another fluid (respectively relatively cold or hot) is arranged to impact upon the tube(s), flowing along or across the tube(s). Most systems utilise an outwards heat flow.

To increase the rate of heat transfer, heat exchanger tubes have long been fitted with secondary or extended surfaces designed to increase the available transfer surface area. In particular, it is standard practice to promote the required heat transfer if one of the fluids has a low thermal conductivity, or is of a high viscosity, either of which characteristics can reduce the heat transfer capability.

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BRIEF DESCRIPTION OF THE PRIOR ART

There are three known arrangements for secondary "enlargement" surfaces, namely (a) inserts within the tube; (b) deformation of the tube; and (c) attachments to the outer surface of the tube.
5 These arrangements can be used singly or jointly.

Typically, the secondary surfaces provided internally of tubes are designed as turbulator inserts to break up possible laminar flow, to ensure for example that hot fast-flowing inner fluid is not insulated by surrounding cooler, slower-flowing fluid from
10 contacting the tube wall.

Disadvantages of this arrangement are that it is difficult to feed the turbulator inserts evenly along the tube, which may be of 15m or more, and that the slower internal turbulent flow can heat load the fins unevenly, with increased mechanical stressing
15 of the tube.

Arrangements requiring deformation of the tube result in "integral fins", upstanding from the tube outer surface. In one arrangement, "large-radius" fins are made by rolling and extruding a thick-wall tube to the desired configuration; the
20 tube is typically of a material such as aluminium or copper which is easily cold formed. In a second arrangement "small-radius"

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fins or corrugations are made by "form rolling" from a plain thick wall tube of copper or copper alloy to produce low radius, high strength upsets ("rolled low fin").

Disadvantages of this arrangement are the cost and complication of the deforming equipment, the stressing of the tube during deformation, and that the tubes cannot usually be reused.

For arrangements with a surface-enlargement attachment to the outer surface of a tube, there is known both chemical and mechanical bonding.

10 In one chemical bonding arrangement, tape or strip has its inner edge crimped during helical winding onto the base tube, in order to give enhanced support to the fin at the root, which is then soft-soldered to the base tube. The usual fin material is copper, and the normal maximum working temperature is 150 degrees
15 Celsius; for higher working or differential temperatures, special solders are usually required. This tube has an improved higher heat transfer rate for a given surface area because of the turbulence created by the crimp at the fin root. The maximum fin density is 500 fins/metre or thereabouts.

20 In an alternative chemical bonding arrangement, a wire fin consisting of a series of elongated wire loops, spirally wound onto the tube outer wall, is held in position by a binding wire

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at the base of the loops; the loops and binding wire are soft soldered to the tube wall to give a metallic bond between the wire fins and the tube; such a wire loop secondary surface also promotes turbulence.

- 5 Disadvantages of chemical bonding are the cost and complication of the manufacturing equipment, and the stressing of the tube. Welding and soldering are expensive pre-production steps, and can cause tube distortion.

In one mechanical bonding arrangement, a helical groove is cut
10 in the outer tube surface with an uplift of metal upon each side; one edge of a strip or tape, typically of aluminium, copper, or carbon steel, is wound into the groove, and the uplift of metal on each side of the groove is peened back onto the fin to produce a mechanical bond. A disadvantage of this arrangement is that
15 the tube is weakened. Another disadvantage is that a machine roller is needed to press the continuous fin into tight mechanical engagement.

To avoid the need to cut such helical groove, is also known to produce externally finned tubes by winding a strip of aluminium
20 or copper around a uniform diameter tube, the tube-contacting edge of the strip being deformed to an "L" shape in cross section so as to increase the surface contact area between this edge and the tube external surface (Fig.1 of the accompanying drawings).

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To further improve the contact, the fin is helically wound under tension, with the two turns adjacent each end interconnected, as by a staple, to prevent subsequent unwinding.

In a modification of the above (Fig.2 of the accompanying 5 drawings), the fin is formed with a double bend, so that adjacent fins fit more snugly together, to provide enhanced protection for the base tube e.g. against corrosive coolant fluid flowing across or through the fins.

Disadvantages of tension wound strips are the need to provide 10 means securely to lock the tape upon the tube to prevent subsequent unwinding, and that unfinned intermediate tube lengths e.g. to permit the fitting of tube supports, are difficult to provide, particularly if the location of the supports is determined by the customer after receipt of the tubes.

15 STATEMENT OF THE INVENTION

We seek to provide an extended outer surface for a heat exchanger tube, without the necessity for forming recesses or grooves in the tube wall, without need for helical winding of a fin strip, without need for the soldering of coils or the like to 20 the outer surface, and without need for substantial spacing between adjacent fins. We also seek to avoid the need for special equipment, for instance to peen back edges of a helical groove formed in the tube (to provide mechanical bonds with the

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contacting fin edge).

Furthermore, we seek to provide a finned tube capable of being made of substantial length, wherein a required tube support length can more easily be provided along the length of the
5 tube, between adjacent finned sections.

Thus according to one feature of the invention we provide a heat exchanger unit comprising a tube, first and second annular discs mounted upon the outer surface of the tube, the second disc having a projection extending from the respective
10 annulus, said projection of the second disc being shaped for engagement by a projection of the first disc.

According to another feature of the invention we provide a heat exchanger unit in which the projections of the first and second discs upstand in the same direction relative to the tube.

15 According to yet another feature of the invention we provide a heat exchanger unit with an extended outer surface in which the surface comprises an annular disc, an upstanding projection from the annulus, the upstanding projection comprising a toe portion remote from the disc and a heel portion adjacent the
20 disc, the heel portion being of a larger internal dimension than the outer dimension of the toe portion whereby to accept the toe portion of an adjacent disc. Preferably, the

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projection is circular in cross-section, so that the respective dimensions are diameters.

We also disclose a header unit having a plurality of finned tubes according to the invention connected between fluid, 5 preferably liquid, containers (and which when in use will usually contain hot liquid).

We further disclose a heat exchanger utilising at least one disc according to the invention. We also seek to provide a heat exchanger wherein tube supporting means can engage a tube 10 between finned tube portions.

We also provide a method of making a heat exchanger tubular unit with an extended outer surface which includes sliding at least two annular discs along a tube, each disc having a projection extending axially of the tube from the annulus, and 15 gripping one projection between the other projection and the tube whereby to locate the discs on the tube.

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BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be further described by way of example with reference to the accompanying schematic drawings, in which :-

- Fig.1 is a side sectional view of one known externally finned
5 heat exchanger tube;
- Fig.2 is a side sectional view of another known externally
finned heat exchanger tube;
- Fig.3 is a perspective view of one embodiment of fin suitable
for fitting upon a tube for a heat exchanger;
- 10 Fig.4 is a perspective view of an alternative embodiment of fin
to that of Fig.3;
- Fig.5 is a side cross sectional view of an externally finned
heat exchanger tube fitted with a plurality of fins
according to Fig.3; and
- 15 Fig.6 is a side cross sectional view of an externally finned
heat exchanger tube fitted with a plurality of fins
according to Fig.4.

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DESCRIPTION OF EXEMPLARY EMBODIMENTS

Fig.1 is of a known arrangement wherein a continuous strip 10 of Aluminium is helically wound around a carbon steel tube 12; the strip is of "L" shape in cross section, and when wound is annular in end view; and in side cross-sectional view has a continuous upstanding (rightwards) "foot" portion 14 in engagement with the outer surface 16 of tube 12. To obtain good contact for heat transfer, the winding is tightly formed, and to prevent subsequent unwinding end coils 18 are held by staples 20. In alternative embodiments the tube is one of stainless steel, copper, copper alloy or titanium, of maximum outer tube diameter 50.8mm; the strip 10 is of copper. The fin height is up to 20mm, fin density is up to 500 fins/metre, tube length is up to 15 metres. Copper fins are typically not used with titanium tube.

In the known arrangement of Fig.2, continuous aluminium strip 110 has a foot portion 114, which in side cross-sectional view is of double "L" shape, with the each "L" radially-spaced and interconnected.

In the fin 200 of Fig.3, according to the invention, annular disc 202 has an annular upstanding portion 204. The upstanding portion 204 terminates in toe 204a, and is joined to the disc at heel 204b, which in this embodiment is curved. Thus as seen in Fig.5, the toe of one fin can fit under the heel of an adjacent

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fin.

* The fins are located against axial movement and are held tightly together against rotational movement by a locking disc or end stop 6, suitably of spring copper, work hardened.

- 5 The annular upstanding portion or projection 204 can be of uniform internal and external diameter, slightly greater than the external diameter of the tube for which it is intended; though in an alternative embodiment the projection 204 can reduce in internal diameter towards the toe 204a, preferably with a draft
10 angle of up to 5 degrees.

The fin 200 has the advantages:- (a) each fin can simply be slid into position along the tube 12, without complicated forming equipment; (b) the toe of one fin is pressed tightly against the outer tube surface by the heel of the adjacent fin, with tight
15 mechanical engagement and good heat transfer potential; (c) the fin density can be increased, for instance as compared to the toe-heel abutting arrangement of the known coiled strip of Fig.1; (d) the end fins can be axially located at selected positions along the tube, with the use of stops such as end stop 6 and/or a
20 crimped upstanding portion, to hold the intervening fins tightly mechanically coupled against both rotation and axial movement, limiting wear under vibration conditions and promoting good heat transfer; (e) spacings between groups of fins can readily be provided as required, for instance to match customer supports, as

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by using the end stops; and (f) the fins can be manufactured in quantity, and held in stock, for use as required in accordance with the number and dispositions called for by the customer, and in accordance with each of the customer selected tube materials.

5 If the tube 12 is of a material e.g. titanium, which is more deformable than extension 204, then fitting the fins 200 can simultaneously be used where appropriate to press back the tube to a round configuration in end view cross-section, desirable in itself and usually necessary if turbolator inserts are also to be
10 used.

Alternatively stated, the fin 200 can be selected to be of a material less deformable than that of tube 12, for the above purpose.

In the alternative embodiment of Fig. 4, fin 300 has a
15 sharp-edged (90 degree) join 304b to the extension 304, and as seen in Fig.6 is undercut to form heel 304c. This embodiment involves additional working of the fin prior to fitting, but may permit additional coverage to the outer tube surface e.g. if the fins 200 of Fig. 3 when pressed together as in Fig.5 do not
20 deform the extension 204 wholly or sufficiently into contact with tube outer surface 16.

In the arrangement of Fig.6 (as also if desired for the embodiment of Fig.5), a length 306 at each end of tube 12 can be

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left unfinned, suitable for welding or otherwise securing to a header tank or the like, preparatory to fitting the pipework in a heat exchanger assembly.

The embodiments of Fig.5 and Fig.6 are of a heat exchanger unit 5 with a first annular disc 201,301 and a second annular disc 202,302, the discs being mounted upon the outer surface of the tube 12. The second disc 202,302 has a projection 204,304 extending from the respective annulus, the projection of the second disc being shaped for engagement by a projection of the 10 first disc with the projection of the first disc being sandwiched between the projection of the second disc and the tube; and similarly for the succeeding discs.

Back to back with the first disc 201,301 is an annular locking disc 6 having a projection also extending from the annulus but 15 oppositely directed to the projection of the first disc 201,301.

Thus we now propose a fin with an annular (upstanding) inner projection, wherein the projection is connected to the fin at a radius greater than the outer diameter of the tube upon which 20 the fin is to be mounted, and wherein the toe of a rearward annular extension thereto can fit between the outer tube diameter and the projection.

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The fins are of hardened material e.g. work hardened, and can fit around a tube of any material e.g. stainless steel of substantially circular outer cross-section. However, a particular advantage is with tube manufactured from strip, and welded, and which may be slightly oval or otherwise non-circular, wherein as above mentioned the fin can deform the tube, especially if the latter is of a significantly softer material e.g. titanium. Thus a subsidiary advantage of our arrangement is that the tube can be forced into a circular cross-section throughout its length, with potentially more efficient through-flow. The fin material can be of 0.18-0.36mm (7-14 thou) thickness, but is preferably 0.25mm (10 thou) when present materials are used, so as properly to withstand pressure cleaning e.g. 15kg/cm². This will allow 550 fins/meter with a fin spacing of e.g. 1.8mm.

If as is usual the tube needs to be supported, mid-way along its length, this is simply effected by interposing an annular sleeve, and then continuing to feed on further fins i.e. it is not necessary to cut the helically wound fins to either side of the support.

We have found it possible to increase the fin density by 13%, using the arrangement of the invention, with increased heat exchanger effectiveness, and/or shorter heat exchanger externally finned tubes.

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In a typical marine application, the tube 12 will be used in a heat exchanger to convey heated sea water, to be cooled by blown air. For deep sea applications, the tube would perhaps be of "admiralty brass"; however, for ships primarily working 5 in coastal waters (where silt may inadvertently be pumped), the tube would perhaps be of the 70/30 cupro-nickel (70% copper, 30% nickel).

Thus we have found it possible to fit 550 fins/meter, simply by hand or by machine, with adjacent fins mechanically 10 interlocking as above described, and upon a tube of any size or material (though for long term reliability the separate question of electrolytic corrosion and compatability would naturally be considered). Thus a new method for mechanically fitting fins to a tube has been disclosed.

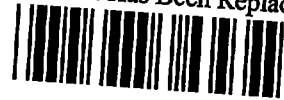
15 A particular advantage of the proposed arrangement (derived from avoiding the use of a single wound fin) is that the "wound coil tension" is not present, possibly to release with temperature changes; in particular, we foresee that this arrangement will continue to be of service at high temperatures 20 e.g. up to 450°C or higher. The performance can equal or exceed that of the disclosed prior art arrangements, and yet is achieved without the above-stated disadvantages of these arrangements.

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Although the projection 204 is centrally disposed and perpendicular to the disc 202 which is circular, in alternative embodiments one or more of these design features can be changed. Thus with "eccentric" discs, the discs can be mounted
5 all to project more to one side of a tube than another (perhaps to allow better access between adjacent tubes) or can be alternately to opposite tube sides (perhaps to encourage turbulent flow around the tube).

In an alternative method of manufacture, the tube 12 may be
10 "bulletted" in known fashion following fitment of the fins; a "bullet" with an outer diameter slightly larger than the inner diameter of the tube 12, is forced through or pulled through the tube 12, thereby stretching the tube wall so as to increase the diameter of the tube, and enhance the engagement between
15 the outer wall 16 of the tube and the extension 204,304 of the fin, if this is needed for thermal flow.

Without such bulletting or equivalent the engagement between the fin 200,300 and the tube 12 (and thus the heat flow characteristics) may be influenced both by the relative
20 diameters of the extension piece 204,304 and the outer tube wall 16, and the force with which adjacent fins are pressed together. However, with bulletting the extension pieces 204,304 may initially be a relatively loose fit on tube 12, and adjacent fins may be easily slid onto the tube, thus increasing
25 the ease of assembly; the subsequent bulletting operation

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thereafter enlarges the tube to provide the required (thermal) contact between the fins and the tube, and so establishes more certainly the required heat exchange or transfer.

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CLAIMS

1. A heat exchanger unit comprising a tube, first and second discs mounted on a tube, the first disc and second disc each having an opening within an opening surround, a single collar extending from each respective opening surround, each collar terminating in a toe portion, the toe portion being a continuous surface, the collar of the second disc terminating within the collar of the first disc, a surface of the collar of the second disc engaging a surface of the collar of the first disc, at least one of said collar surfaces being inclined so as to urge the toe portion of the second disc inwardly against the tube.
2. A heat exchanger unit comprising a tube, first and second discs axially spaced upon the outer surface of the tube, the first disc and second disc each having an opening, a single annular collar of reducing diameter extending from around each respective opening, each opening being merged into a respective annular collar heel portion, the heel portion being spaced from the tube, each collar terminating in a toe portion, the toe portion being a continuous surface, the collar of the second disc terminating within the heel of the first disc and having an outer surface which engages an inner surface of the heel, at least one of said collar surfaces being inclined relative to the tube axis so



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that the toe of the collar of the second disc is pressed inwardly against the tube and so that an axial length of the tube is not engaged by either collar.

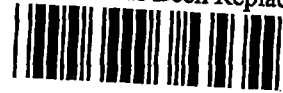
3. A heat exchanger unit comprising an axially extending tube, the tube having an outer surface upon which at least first and second fins are mounted, each fin comprising a disc and a single integral part upstanding therefrom, the said single upstanding part forming a continuous annular collar which extends around an axial length of the tube outer surface and which is aligned with an opening in the disc, the collar having at one axial end a collar heel and at the other axial end a collar toe, the collar heel being of larger inner diameter than the outer diameter of the respective toe, each collar heel being joined to its collar toe by inner and outer annular surfaces inclined towards the axis of the said tube length, the said annular surfaces engaging so as to hold the toe of the collar of the first fin between said surface and the tube outer surface whereby to hold both collars and thus both fins in position relative to the tube, and so that an axial length of the of the tube outer surface is not engaged by either collar.



4. A heat exchanger unit as claimed in any of claims 1-3 in which the opening in a disc is of a reducing cross section through the disc width to form a curved heel.

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5. A heat exchanger unit according to any of claims 1-4 in which the collar is circular in cross-section throughout its length.
 6. A heat exchanger unit according to any of claims 1-5 in which the collar of the second disc terminates within the opening of the first disc.
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7. A heat exchanger unit according to any of claims 1-6 in which the opening is located centrally of the disc.
 8. A heat exchanger unit according to any of claims 1-5 which includes a locking disc having a projection extending from the annulus but oppositely directed to the collar of the said first disc.
 9. A header which includes a plurality of units according to any of claims 1-8, the header being connected between fluid, preferably liquid, containers such that the fluid whilst flowing between the containers can pass around the units for heat exchange.
 10. A method of making a heat exchanger tubular unit according to claim 1 which includes sliding first and second discs along a tube having a longitudinal axis, each disc having an opening to receive the tube and an annular collar extending axially of the tube from the

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opening, each collar having a toe portion and a heel portion, the heel portion having a diameter greater than that of the tube, and gripping the toe portion of the second disc by an internal surface of the collar of the first disc, the said internal surface being inclined towards the tube longitudinal axis so as to sandwich the toe portion of the second disc between the heel portion of the first disc and the outer surface of the tube whereby to locate the second disc relative to the first disc on the tube.

11. A heat exchanger which includes at least one unit constructed and arranged according to any of claims 1-8.
12. A heat exchanger which includes a tubular unit made by the method of claim 10.
13. A disc for fitting around a heat exchanger tube constructed and arranged in accordance with Fig.3 of the accompanying drawings.
14. A heat exchanger unit constructed and arranged in accordance with Fig.5 of the accompanying drawings.

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