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(54) **Mandrel for drawing expansion of tubes for finned-pack heat exchanger coils**

(57) A mandrel is described for drawing expansion of tubes (6) for finned-pack coils, comprising a head with petals (2), a through hole (3) and a rod slidably housed in said hole (3). Said through hole (3) includes a portion

(5) with reduced diameter at the head with petals (2), said rod being capable of being forced in a thrusting action into said reduced-diameter portion (5), causing by interference the opening of the petals (2) and consequently the expansion of the tube (6).

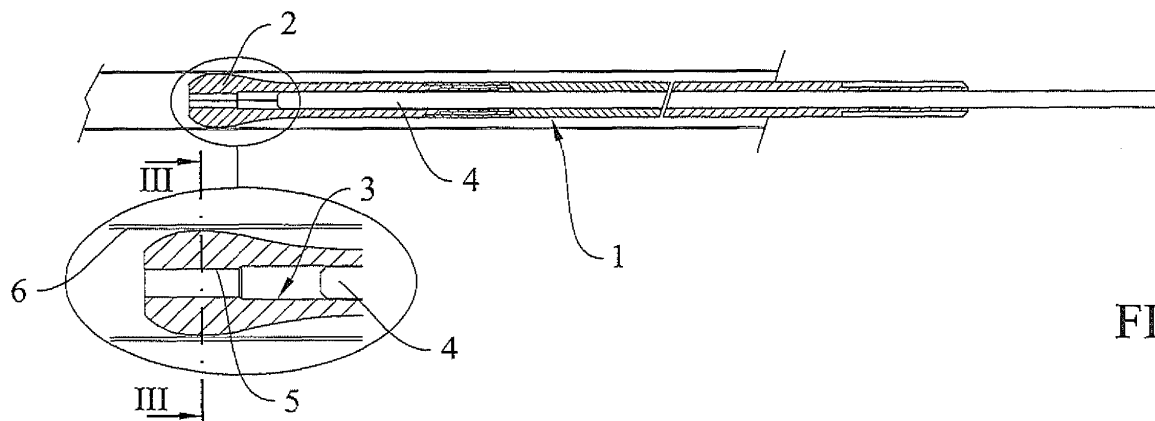


FIG.1

Description

[0001] The present invention concerns a mandrel for drawing expansion of tubes for finned-pack heat exchanger coils.

[0002] The construction technology for finned-pack heat exchanger coils must ensure excellent heat conduction at the interface between the tubes and the fins.

[0003] Except in the case of integral construction (which is possible by rolling to form external fins on circular tubes), the contact/interference fit between the tubes and the fins is achieved by mechanical forcing (wrapping the fins with a collar under pressure, or expansion of the tubes by use of a mandrel or hydraulic pressure), or by welding, brazing or gluing.

[0004] The fins usually consist of aluminium (or stainless steel) strips, stamped out and pierced for subsequent coupling to a series of tubes in copper, aluminium or stainless, curved to form "U-bends", or to straight tubes.

[0005] Use of a mandrel is known for mechanically expanding the tubes, performing a thrusting action by means of a taper nose: the mandrel with the taper nose is thrust through the entire length of the tube as far as the beginning of the curved section, or throughout the entire length in the case of a straight tube. This type of mechanical expansion has the disadvantage of not being able to control the withdrawal of the tube during the expansion stage, with consequent lack of homogeneity in the finished product.

[0006] Mandrels are also known for mechanical drawing expansion by means of a head with petals which are expandable by a drawbar consisting of a rod and a terminal spacer or expander. The mandrel is inserted into the tube with the petals closed and the expander located beyond the petals. With the mandrel positioned fully inserted into the tube, the rod is pulled (with the mandrel stationary), to expand the petals and thus force the expansion of the tube. At the end of the expansion stage, the mandrel is pulled outwards to expand the tube for its full length (expansion by a drawing action).

[0007] This type of cold mandrel action, however, only makes it possible to work with tubes with external diameters of 7.94 mm (5/16 inch) or larger, because a thickness of rod and petals would be necessary that was too small to compensate for the thickness of the rod, which for physical reasons cannot go below certain limits as it has to pull the expander in order to bring about the opening of the petals. Said rod cannot go substantially below 3 mm because of problems due to stretching of the rod and consequent failure of the petals to open. The expander provides a lead-in for the expansion of the tubes which, however, necessitates extremely high drawing forces. In order to expand a tube with a diameter smaller than 7.94 mm, it would be necessary to provide very small petals and rod, physically incompatible with the force necessary for expanding the tube.

[0008] Furthermore, there are limits to the usefulness

of this mandrel system in proximity to the curve of the U-bend, since a space has to be provided in which the expansion cannot be performed because of the protrusion of the expander (approx. 7-8 mm long).

[0009] An object of the present invention is to create a mandrel for expanding tubes by a drawing action, which allows the above problems to be resolved.

[0010] In accordance with the invention, this object is achieved with a mandrel for drawing expansion of tubes for finned-pack coils, comprising a head with petals, a through hole and a rod slidably housed in said hole, **characterized in that** said through hole includes a portion with reduced diameter at the head with petals, said rod being capable of being forced in a thrusting action into said reduced-diameter portion, causing by interference the opening of the petals and consequently the expansion of the tube.

[0011] A further object of the present invention is to create a method for opening the petals of the head of a mandrel for expanding tubes, which allows the above problems to be resolved.

[0012] In accordance with the invention, this further object is achieved with a method for drawing expansion of tubes for finned-pack coils, characterized by providing for the expansion of the petals of a head of a mandrel by means of a rod performing a thrusting action, slidably housed in a through hole of said mandrel with a reduced-diameter portion, wherein the rod by interference causes the opening of the petals and consequently the expansion of the tube.

[0013] These and other characteristics of the present invention will be made more clearly apparent from the following detailed description of an example of embodiment which is illustrated without limiting effect in the attached drawings, in which:

figure 1 shows a view in axial section, partially enlarged, of the head of the mandrel inserted into the tube with the petals closed;

figure 2 shows a view in axial section, partially enlarged, of the head of the mandrel inserted into the tube with the petals open;

figure 3 shows a sectional view along the line III-III in figure 1;

figure 4 shows a sectional view along the line IV-IV in figure 2;

figure 5 shows a partially sectioned side view of a mandrel and its driving machine.

[0014] Figure 1 illustrates a mandrel 1 with a head with petals 2 (i.e. with axial notches) and a through hole 3, within which runs a rod 4.

[0015] The through hole 3 has an end portion 5 with reduced diameter so as to allow interference with the rod 4 which performs a thrusting action, thus forcing the opening of the petals 2 and therefore the expansion of the tube, or U-tube or "fork", 6 (two straight stretches joined by a U-shaped section, or, better, a tube bent into

a U).

[0016] The rod 4 has a tapered leading end to facilitate insertion of the rod itself into the end portion 5. The taper must be such as to favour the start of the opening of the petals 2. Figures 1 and 2 show a slight, almost imperceptible reduction in the diameter of the rod, but sufficient to start the opening of the petals 2.

[0017] The tubes 6 are in cold-deformable material, generally copper or aluminium.

[0018] By looking closely at the enlargements in figures 1 and 2, and at figures 3 and 4, it is possible to perceive the opening of the petals 2.

[0019] The operation of cold mandrel action on a straight tube or U-tube 6 of a finned-pack coil of tubes provides the following stages:

- insertion of mandrel 1 (with petals 2 closed) into U-tube 6 as far as the start of the curved joining section which is beyond the heat-exchange fins;
- opening the petals 2 by forcing rod 4 in a thrusting action, which moves forward (towards the end of the tube) with respect to the stationary mandrel 1: the U-tube 6 deforms (figure 2), thrust by petals 2; in the position of maximum opening of the petals 2, the rod 4 does not protrude beyond the head of the mandrel.
- pulling of mandrel 1 (which performs a drawing action) for the purpose of deforming the U-tube 6 for its entire length, followed by the exit of mandrel 1.

[0020] The mandrel according to the present invention is indispensable for the drawing expansion of tubes with external diameters less than 5/16 inch (7.94 mm) because it is possible to increase the thickness of the tube for the same external diameter: for example, in the case of expanding a tube with an external diameter of 7.94 mm, it is possible to work tubes with thicknesses greater than the current ones. The increase (40-50%) in the thickness of the mandrel entails greater resistance to wear and mechanical stresses.

[0021] The present invention also eliminates the problem of the stretching of rod 4, which used to be severely stressed by having to force the aforementioned expander to open the petals 2. To limit the risks of breakage, the known systems using a mandrel in a drawing action employ rods with a thickness starting at 3 mm instead of the 2.7 - 2.8 mm according to the present invention.

[0022] The reduction in the thickness of rod 4 enables the mandrel to enter tubes 6 which are much smaller while still having a thickness of petals 2 much greater (4 - 6 times) than the known art.

[0023] This is possible because the opening of the petals 2 does not have to be forced by an external expander acting in tension, but by a rod 4 performing a thrusting action; consequently the petals open even though they are much thicker. The rod 4 has a point which facilitates the opening of the petals in a thrusting action where the forces involved are much smaller than those between the expander acting in tension and the petals.

[0024] The difference in the action of the rod 4 on the petals 2 is fundamental, consisting of a thrusting action in the mandrel according to the present invention, and a drawing action in the known systems.

[0025] In conclusion, it should be noted that the mandrel according to the present invention, besides being indispensable for physical reasons for tubes of diameter less than 5/16 inch (7.94 mm), is also advantageous even for tubes of diameter much larger than 5/16": rod 4 is much more durable (because it is not stressed by the expander), as are the petals 2 (which are thicker for the same thickness of tube to be worked).

[0026] A further advantage consists of the facility of centring the mandrel with respect to the tube, due again to the absence of the expander, which unbalances the front end of the drawbar and makes the clearance too large between drawbar and closed petals 2.

[0027] The advantages mentioned for a single tube or U-bend are multiplied for normal production of coils which may contain hundreds of tubes. Above all, the better centring makes it possible to obtain a much more efficient finned-pack coil, as deformations of one tube with respect to the others are much reduced. The repetitiveness of the process improves considerably in consideration of all the advantages listed above.

Claims

1. Mandrel for drawing expansion of tubes (6) for finned-pack coils, comprising a head with petals (2), a through hole (3), and a rod slidably housed in said hole (3), **characterized in that** said through hole (3) includes a portion with reduced diameter (5) at the head with petals (2), said rod (4) being capable of being forced in a thrusting action into said reduced-diameter portion (5), causing by interference the opening of the petals (2) and consequently the expansion of the tube (6).
2. Mandrel according to claim 1, **characterized in that** said rod (4) has a tapered leading end to facilitate insertion of the rod (4) into the end portion (5) to allow the opening of the petals (2).
3. Mandrel according to claims 1 or 2, **characterized in that** the leading end of the rod (4) does not protrude from the mandrel (1) when in the position where the petals (2) are open.
4. Mandrel according to any of the preceding claims, **characterized by** being suitable for expanding tubes with external diameter less than or more than 5/16 inch (7.94 mm).
5. Mandrel according to claim 4, **characterized by** being suitable for expanding tubes with thickness greater than or less than 0.7 mm.

6. Mandrel according to claims 4 or 5, **characterized in that** the rod (4) has a thickness of 2 mm or more.
7. Method for drawing expansion of tubes for finned-pack coils, **characterized by** providing for the expansion of the petals (2) of a head of a mandrel (1) by means of a rod (4) performing a thrusting action, housed in a through hole (3) of said mandrel (1), having a portion (5) with reduced diameter, wherein the rod (4) by interference causes the opening of the petals (2) and consequently the expansion of the tube (6).
8. Method according to claim 7, **characterized in that** the thrusting action of the rod (5) necessary for opening the petals (2) ends before the leading end of the rod (4) protrudes from the head with petals (2) of the mandrel (1).

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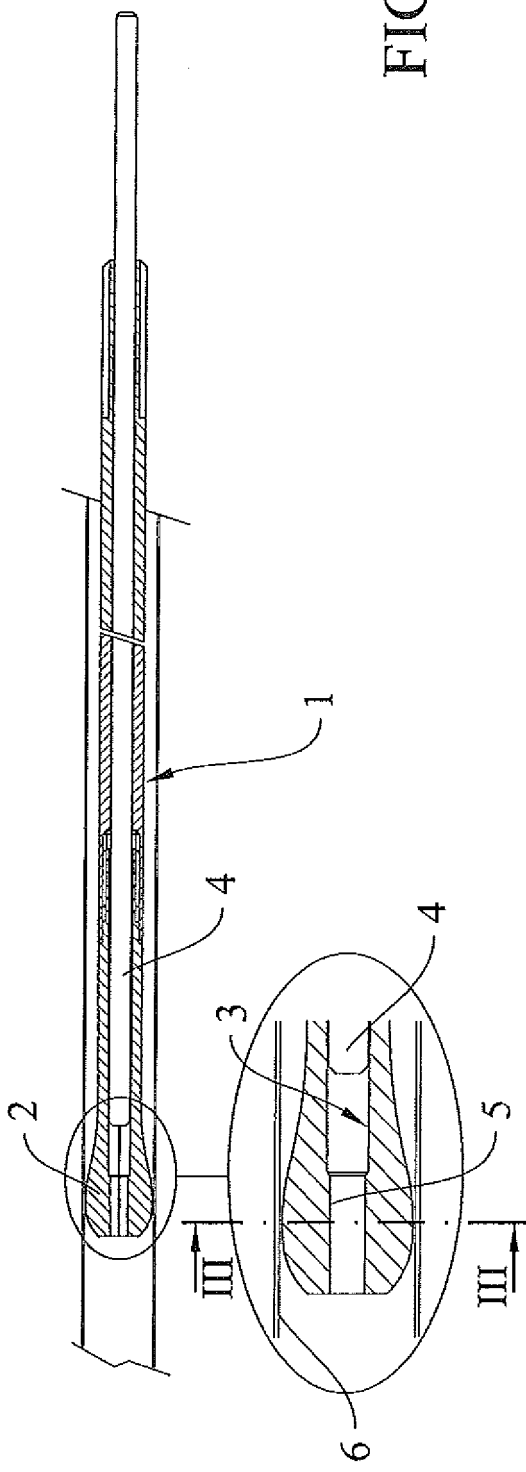


FIG.1

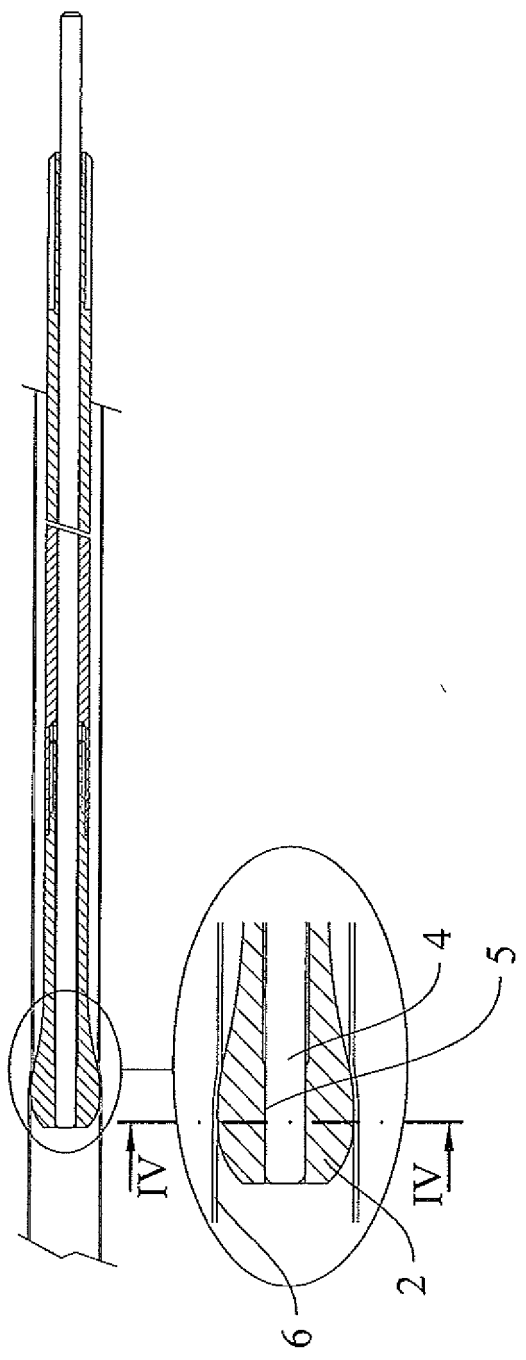


FIG.2

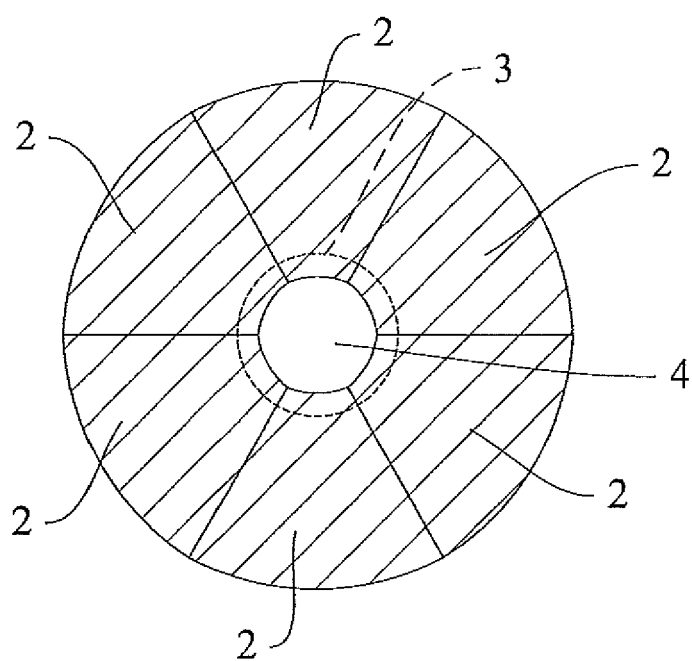


FIG.3

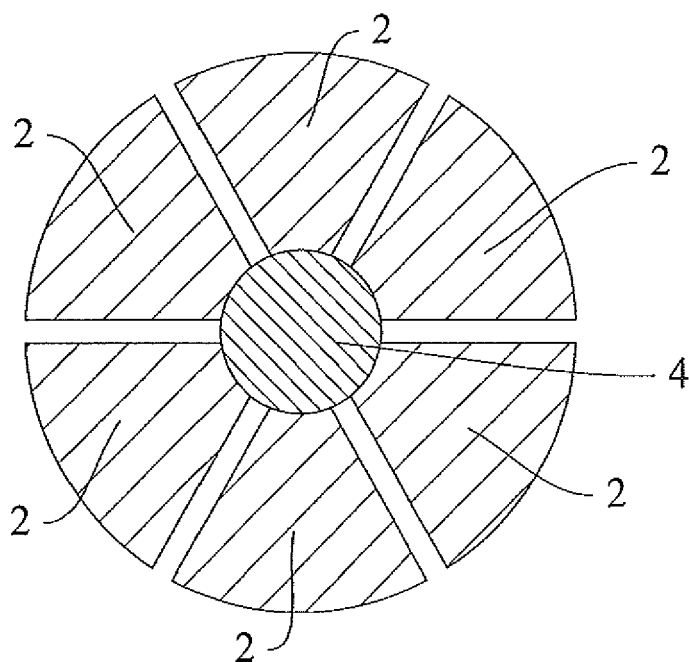


FIG.4

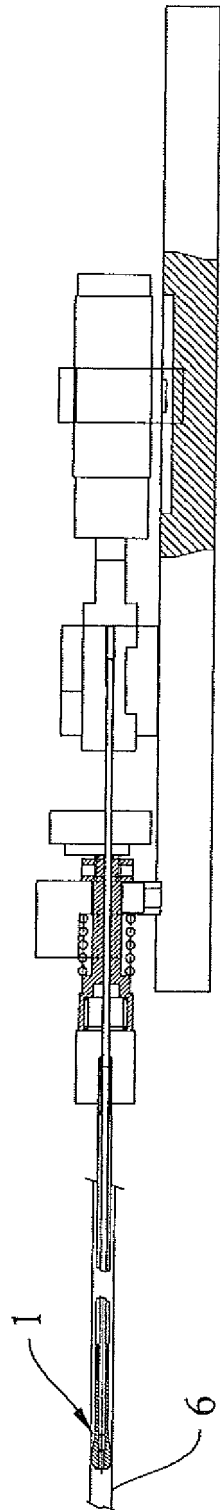


FIG. 5



EUROPEAN SEARCH REPORT

Application Number
EP 09 16 2252

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	JP 59 010427 A (TOKYO SHIBAURA ELECTRIC CO) 19 January 1984 (1984-01-19) * abstract; figures 1-6 * -----	1-8	INV. B21D39/20
			TECHNICAL FIELDS SEARCHED (IPC)
			B21C B21D
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 21 August 2009	Examiner Augé, Marc
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 09 16 2252

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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21-08-2009

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
JP 59010427	A	19-01-1984	NONE

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82