

Heat exchanger jackets and heat transfer devices incorporating such jackets

The invention relates to heat exchanger jackets and heat transfer devices incorporating such jackets. The invention has particular, though not exclusive application, to heat exchangers with heat pipes or other pipes containing fluid to, or from, which heat is to be transferred.

Heat pipes are described, for example, in Australian patent specification 455 797. As described in this specification, heat pipes are passive sealed units having a working fluid with a free-standing liquid and a substantial space along substantially the entire length of the heat pipe. In use, heat is automatically transferred along the pipe in response to a difference between the respective temperatures of warmer and cooler portions of the pipe. This heat transfer takes place by a process of vaporisation of the working fluid in one portion of the pipe and condensation of the working fluid in another portion of the pipe thus absorbing and giving up its latent heat of vaporisation.

In heat exchangers used with heat pipes, heat transfer is achieved by flowing a transfer fluid past a portion of a heat pipe to remove heat from or to transmit heat to the pipe. In some previously proposed heat exchangers of this kind, the flow path of the transfer fluid past the heat pipe has been fairly random.

While some previous proposals have taken some account of the relationship between the flow dynamics of the transfer fluid and the efficiency of heat transfer which is obtained, little attention appears to have been given to the way in which the flow of transfer fluid affects the overall efficiency of the heat exchanger operation. In particular, prior proposals do not appear to have taken into consideration the desirability of minimizing head loss as transfer fluid flows through a heat exchanger while at the same time obtaining efficient heat transfer.

According to the invention there is provided a heat exchanger jacket to surround a portion of a fluid-containing pipe with at least one end of the jacket in fluid tight connection to the pipe, the jacket including a substantially tubular body portion and two fluid conduits lying on opposite sides of the body portion, each of the conduits being in fluid tight connection with the body portion adjacent a respective opposite end portion thereof in such a manner as to impart a turbulent swirling or helical path to fluid passing in use from one conduit to the other through the body portion and the end of at least said one of the fluid conduits being formed before connection of the conduit to the body portion as a nozzle presenting a decreased cross-sectional flow area normal to the flow of the fluid.

A heat transfer device which incorporates the jacket may, and often will, incorporate more than one jacket and the conduits may then be connected directly or through an appropriate junction pipe to an adjacent jacket.

For convenience, the invention will be described in detail hereafter with reference to use of the heat exchanger jacket in association with a heat pipe. It is to be appreciated, however, that the invention is broadly applicable to other types of fluid-containing pipes to, or from, which heat can be transferred by passing a heat transfer liquid through a jacket surrounding a portion of the pipe.

The invention is diagrammatically illustrated by way of example in the accompanying drawings, in which:—

Figure 1 is a plan view showing the use of one form of heat exchanger jacket in accordance with the invention; and

Figure 2 is a cross-section taken on line X—X of Figure 1, to an increased scale.

Referring to the drawing, a body portion 16 of a heat exchanger jacket is connected adjacent its opposite ends to conduits 17 and 18. If the conduit 17 is an inlet conduit, it will be seen that the conduit is transformed, in the direction of fluid flow, from a substantially cylindrical tube 19 into an inlet nozzle 20 of decreased cross-sectional flow area normal to the fluid flow path. The nozzle 20 is formed at the end of the conduit 19 before the conduit is connected to the body portion 16. A heat pipe 22 extends through the jacket to form an annular chamber 21. The cross-sectional flow area of the nozzle 20 preferably decreases to an area which is not more than the cross-sectional area normal to the fluid flow path through the annular chamber 21 adjacent the nozzle and normal to the flow path in said chamber. As illustrated, the nozzle 20 is preferably of flared wedge formation.

In order to avoid over-constriction of the nozzle 20 and consequent excessive head loss for the fluid passing through the nozzle, the annular chamber in the path of the fluid flowing directly from the nozzle may be formed so that the flow path cross-section area in this part of the chamber is the same as the minimum flow path cross-section area in the nozzle. The annular chamber 21 adjacent the nozzle may thus have a greater radial dimension than the remainder of the annular chamber between the connection of the conduits at the end portions of the jacket body. There is thus provided a transition zone in which the change of speed and direction of the transfer fluid can occur over a greater area than if the nozzle leads directly into a uniform annular chamber. The effect of this nozzle formation is to accelerate the flow rate of the transfer fluid as it passes through the nozzle into the annular chamber 21 between the inner surface of the jacket body portion 16 and the outer surface of the heat pipe 22.

The flared wedge form of inlet nozzle may be formed by first expanding the free end of the tubular conduit 19 and then forming the expanded portion to a uniformly tapered nozzle having an orifice at the free end in the form of an elongate slot. The free end of the nozzle is preferably trimmed off at an angle as indicated at "a" in Figure 2 to assist connection to the body portion 16 of the jacket as hereinafter described.

It will be seen that the fluid conduits are connected to the body portion of the jacket at a respective orifice 23 of complementary shape to the end of the nozzle in the conduit. The orifice 23 may be formed by punching an appropriate slot in the body portion and preferably working the periphery of the orifice to provide protruding support surfaces as at 24 and 25 within which the free end portion of the nozzle can be inserted and to which the end of the nozzle is sealed in fluid tight engagement. The formation of such support surfaces minimizes the interruption to the flow path of the transfer fluid as it passes from the inlet conduit into the annular chamber between the body portion and the heat pipe.

As will be apparent from a consideration of Figure 2, the transfer fluid entering through the conduit 17 has a flow path which is substantially tangential to the circumference of the heat pipe 22. The acceleration of the transfer fluid caused by the form of the nozzle 20 increases the speed and hence the turbulence of the flowing transfer fluid. Heat transfer in turbulent flow conditions is superior to that occurring in laminar flow conditions. Acceleration of the transfer fluid in the nozzle enables the use of lower flow speeds, and hence lower head loss, in pipes connecting one heat exchanger jacket to another. The orifice for the conduit 17 is located adjacent sealing means 26 and the transfer fluid is therefore forced to flow around the annular chamber 21 between the body portion 16 and the heat pipe 22 with a swirling or helical motion before leaving via the outlet conduit 18. The orifice for the outlet conduit 18 is similarly located adjacent sealing means 27 which, with the sealing means 26 at the other end of the jacket, seal the jacket in fluid tight connection to the heat pipe 22.

In the embodiment shown in Figures 1 and 2, the annular chamber 21 is of substantially constant transverse cross-section and the relative diameters of the heat pipe 22 and the jacket body portion 16 are such that only a small amount of water or other heat transfer fluid can be contained in the chamber 21. This feature makes it possible to reduce the thermal mass of the heat exchanger although the relative diameters chosen should also have regard to the ease of movement of the heat transfer fluid through the heat exchanger so that the amount of said fluid can be optimized.

The conduits 17, 18 at opposite end portions of the jacket are substantially coplanar. Accordingly, the conduits of adjacent similar jackets cannot be aligned simply by turning the jacket longitudinally through 180°, that is, end over end. This alignment problem can be overcome without the need to fabricate and use alternatively mirror-image or opposite-handed jackets by extending the respective conduits tangentially at the opposite end portions of each jacket from the same side of the jacket at an angle to align with the conduit of an adjacent, 180° turned jacket.

The illustrated heat exchanger jacket is shown with both ends open so that a heat pipe can be passed into and through the jacket from either

end. However, if desired, the jacket may be formed, at least initially, with one or both ends closed and the or each closed end removed for insertion of the heat pipe. It is preferred to pass the end portion of the heat pipe right through the jacket to which the end portion is to be connected, as this avoids back pressure between the end of the heat pipe and a sealed end of the jacket tending to force the pipe and jacket apart.

The jackets of the present invention may be used in various forms of heat transfer device. The relative positions of the jacket or jackets and heat pipe or heat pipes used in a particular heat transfer device will depend on the nature of the device and the purpose for which it is to be used. However, the jackets of the invention have been developed particularly for use in conjunction with a solar heat collector to be used in water heating apparatus. In this application, each heat pipe is preferably connected to two laterally extending fins located on opposite sides of the heat pipe and running the length of the heat pipe, apart from the end portion or portions of the heat pipe which are to be mounted in a heat exchanger jacket. The fins may be connected by any method providing efficient heat conduction between the fins and the pipe. Thus, the fins may be welded or rivetted to the pipe. The fins may alternatively be extruded integrally with the heat pipe in which case part of the fins will be removed at the portion of the heat pipe to which the heat exchanger jacket is to be connected. Preferably, however, the heat pipe 22 is extruded with a pair of top jaws 38 and a pair of bottom jaws 39, with the two pairs extending laterally from opposite sides of the pipe 22. Each pair of jaws can contain the edge of a respective fin 37 and may be connected to the respective fin, for example, by passage through appropriate rollers to force the jaws together with the edge of the fin 37 between them. The techniques used to connect the heat pipe and the associated fins may be of the kind disclosed for the formation of compression seam joints and stitch seam joints in United States patent specification numbers 3 722 052 and 3 789 563, both granted to Andrew J. Toti.

The use of preformed fins which are connected through jaws extruded integrally with the heat pipe is preferred. Thus, preformed fins of the order of 0.5 to 1.8 mm in thickness allows a reduction in material over that required for a one-piece finned heat pipe extrusion and in the thermal mass of the heat exchanger device. The fins may be formed with a stepped edge complementary to the jaws of the heat pipe to assist in joining these components. The free edge of the fin opposite the heat pipe may be rippled for stiffening purposes.

An integrally formed fin structure may extend continuously in a plane which forms a tangent to the circumference of the heat pipe. This formation provides an attractive finish for an assembly of adjacent heat transfer devices making up a solar heat collector. The fin structure 37 illustrated in Figure 1 shows the fins joined by a stitch seam technique to the jaws 38 and 39 which are

extruded with the heat pipe, on opposite sides thereof.

In the use of the invention for a solar heat collector, it will normally be preferable to assemble a plurality of adjacent heat pipes and associated jackets in order to provide an adequate area for collection of the incident solar radiation. Such an assembly will preferably include a plurality of heat pipes mounted with their longitudinal axes parallel and their end portions in alignment. One end portion of each heat pipe will be fitted with a heat exchanger jacket and adjacent heat exchanger jackets will be appropriately connected to allow through-flow of heat transfer fluid.

Alternatively, the heat transfer device may comprise an assembly of at least one group of two heat pipes mounted with their longitudinal axes in alignment with their ends adjacent and in fluid tight engagement in a single heat exchanger jacket. Thus, in this form of heat transfer device, a single jacket is used to transfer heat to or from separate heat pipes on each side of the jacket.

A further alternative heat transfer device assembly comprises at least one heat pipe mounted with each end thereof in fluid tight connection with a respective heat exchanger jacket. It will be appreciated that with both this assembly and the assembly described in the preceding paragraph, a plurality of heat pipes and associated jackets can be assembled with the jackets appropriately connected for through-flow.

Although the foregoing specific description has, as explained, described the invention in relation to its use with heat pipes, it will be appreciated that alternative forms of heat exchanger device to those described in the immediately preceding paragraphs can be constructed using other kinds of fluid-containing pipes. With other such pipes, the forms of device constructed will normally involve use of a jacket or jackets other than at an end portion of the fluid-carrying pipe.

As indicated above, the various forms of heat transfer device which can be assembled using heat pipes and cooperating heat exchanger jackets will preferably include a plurality of heat pipes and associated jackets with the jackets appropriately connected for through-flow of the heat transfer liquid. Adjacent jackets may be connected so that the heat transfer liquid will flow through the jackets either in series or in parallel. The method of connection used will depend upon the results which are desired for the particular heat transfer device.

Where the heat transfer device is assembled to allow series flow of the heat transfer fluid, the fluid flows successively from one jacket to the next and so on picking up an increment of heat in each jacket. This results in the outlet of the heat transfer device, such as a solar collector, using jackets connected in this way, operating at a significantly higher temperature than the inlet, and can cause higher heat losses. In a wide multiple heat pipe solar collector, the resulting temperature gradient could differentially stress a glass cover of

the collector resulting in glass breakage. In addition, series flow connection involves the full inlet flow volume passing through each heat exchanger jacket so that the total flow volume is limited to the maximum flow rate allowable in the heat transfer device having regard to impingement corrosion of its inner surfaces.

With the parallel flow method of assembly, however, the flow volume can be divided between the heat exchanger jackets by inlet and outlet manifolds, and the flow volume and rate in each is therefore considerably lower than for the series case. If the maximum flow rate limitation imposed by the need to avoid impingement corrosion is achieved in each heat exchanger jacket, obviously a much greater flow rate can be achieved in the inlet and outlet of the respective manifolds. Moreover, this arrangement will result in only one increment of temperature increase occurring in the whole collector, and as the overall temperature is less than in the series case, heat loss to the surrounding environment is less. There is also no, or very little, temperature gradient induced in any glass cover.

Another benefit of the parallel flow connection is that if the flow rate in each heat exchanger jacket is reduced below the maximum flow rate, but the flow rate is still maintained in the necessary range to achieve turbulent flow within the annular chamber, then a smaller heat loss is achieved in the passage through the connected heat exchanger jackets. Nevertheless, this smaller heat loss is achieved while still allowing a greater total flow volume than the series case and more efficient heat transfer at a lower temperature. A reduction in heat loss is a significant achievement for large installations involving hundred of collectors, as smaller pumps can be used than would be required for the series method of assembly.

The materials of construction used to produce the heat exchanger jacket and heat pipes will depend on the application for which the components are designed. If the jacket is to be used in a domestic or other hot water system, it will preferably be formed from copper tube. However, if the jacket is to be used, for example, in a swimming pool heater system, it may be moulded or otherwise formed from an appropriate plastics material.

In a solar heat collector application, the heat pipes themselves and any associated fins thereon are preferably formed from aluminium. In order to minimize corrosion problems experienced in the use of aluminium in flowing water systems, it is preferred to clad the end of the heat pipe to which the jacket will be connected in use with a copper or other protective sleeve of a heat conductive material. The use of a copper sleeve also assists in sealing the jacket to the heat pipe. The preferred copper sleeve may be fitted onto the heat pipe by shrink-fitting, swaging or drawing. A tight fit between the sleeve and the pipe may thereby be provided to enable efficient heat conduction between the heat pipe and the protective sleeve. If

a non-aqueous heat transfer fluid is to be used, which is non-corrosive to aluminium, no copper sleeve is necessary on the heat pipe and the heat exchanger jacket can be constructed also from aluminium. The use of an all aluminium heat transfer device and a non-aqueous heat transfer fluid boiling above 100°C allows temperatures greater than 100°C to be transferred through the device.

10 CLAIMS

1. A heat exchanger jacket to surround a portion of a fluid-containing pipe with at least one end of the jacket in fluid tight connection to the pipe, the jacket including a substantially tubular body portion and two fluid conduits lying on opposite sides of the body portion, each of the conduits being in fluid tight connection with the body portion adjacent a respective opposite end portion thereof in such a manner as to impart a turbulent swirling or helical path to fluid passing in use from one conduit to the other through the body portion and the end of at least said one of the fluid conduits being formed before connection of the conduit to the body portion as a nozzle presenting a decreased cross-sectional flow area normal to the flow of the fluid.

2. A heat exchanger jacket according to claim 1, in which the fluid passes through said body portion in an annular chamber formed between the pipe and the body portion and said decreased cross-sectional flow area is not more than the cross-sectional area of the fluid flow path in the annular chamber adjacent the nozzle and considered normal to the flow path in the chamber.

3. A heat exchanger jacket according to claim 1 or claim 2, in which the nozzle is of flared wedge form.

4. A heat exchanger jacket according to claim 3 when appendant to claim 2, in which the nozzle is sealed in fluid tight manner in an orifice in the body portion, the part of the body portion defining the edges of the orifice having been formed so as to provide protruding support surfaces within and adjacent to which the free end portion of the nozzle can lie so that the fluid flow path between the nozzle and the annular chamber is

substantially unobstructed.

5. A heat exchanger jacket according to claim 2, in which the body portion, between the connection of the conduits at its respective end portions, is of substantially constant transverse cross-section and such diameter relative to the fluid containing pipe that the annular chamber optimizes the amount of the heat transfer fluid in the heat exchanger.

6. A heat transfer device comprising a heat exchanger jacket according to any one of claims 1 to 5, in which the fluid-containing pipe is formed by a heat pipe.

7. A heat transfer device according to claim 6, in which the heat pipe has one of its end engaged in said heat exchanger jacket and the other of its end engaged in a further similar heat exchanger jacket.

8. A heat transfer device according to claim 6, including a further heat pipe and in which the heat pipe and the further heat pipe are mounted with their longitudinal axes in alignment and with their opposite ends adjacent and in fluid tight connection with the same heat exchanger jacket.

9. A heat-transfer device according to claim 6, in which the heat pipe has two laterally extending fins located on opposite sides thereof running the length of the heat pipe apart from the end portion thereof mounted in the heat exchanger jacket, the fins being attached to the heat pipe by means providing efficient heat conduction between the fins and the heat pipe.

10. A heat transfer device according to claim 6, including at least one further heat exchanger jacket with a heat pipe engaged therein and assembled adjacent said heat exchanger jacket with the heat pipes parallel and the jackets interconnected for series flow of heat transfer fluid.

11. A heat transfer device according to claim 7, including at least one further heat exchanger jacket with a heat pipe engaged therein and assembled adjacent said heat exchanger jacket with the heat pipes parallel and the jackets interconnected for parallel flow of heat transfer fluid.

12. A heat exchanger jacket to surround a portion of the fluid containing pipe substantially as hereinbefore described and illustrated with reference to the accompanying drawing.



5 a non-aqueous heat transfer fluid is to be used, which is non-corrosive to aluminium, no copper sleeve is necessary on the heat pipe and the heat exchanger jacket can be constructed also from aluminium. The use of an all aluminium heat transfer device and a non-aqueous heat transfer fluid boiling above 100°C allows temperatures greater than 100°C to be transferred through the device.

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1. A heat exchanger jacket to surround a portion of a fluid-containing pipe with at least one end of the jacket in fluid tight connection to the pipe, the jacket including a substantially tubular body portion and two fluid conduits lying on opposite sides of the body portion, each of the conduits being in fluid tight connection with the body portion adjacent a respective opposite end portion thereof in such a manner as to impart a turbulent swirling or helical path to fluid passing in use from one conduit to the other through the body portion and the end of at least said one of the fluid conduits being formed before connection of the conduit to the body portion as a nozzle presenting a decreased cross-sectional flow area normal to the flow of the fluid.
2. A heat exchanger jacket according to claim 1, in which the fluid passes through said body portion in an annular chamber formed between the pipe and the body portion and said decreased cross-sectional flow area is not more than the cross-sectional area of the fluid flow path in the annular chamber adjacent the nozzle and considered normal to the flow path in the chamber.
3. A heat exchanger jacket according to claim 1 or claim 2, in which the nozzle is of flared wedge form.
4. A heat exchanger jacket according to claim 3 when appendant to claim 2, in which the nozzle is sealed in fluid tight manner in an orifice in the body portion, the part of the body portion defining the edges of the orifice having been formed so as to provide protruding support surfaces within and adjacent to which the free end portion of the nozzle can lie so that the fluid flow path between the nozzle and the annular chamber is

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6. A heat transfer device comprising a heat exchanger jacket according to any one of claims 1 to 5, in which the fluid-containing pipe is formed by a heat pipe.

7. A heat transfer device according to claim 6, in which the heat pipe has one of its end engaged in said heat exchanger jacket and the other of its end engaged in a further similar heat exchanger jacket.

8. A heat transfer device according to claim 6, including a further heat pipe and in which the heat pipe and the further heat pipe are mounted with their longitudinal axes in alignment and with their opposite ends adjacent and in fluid tight connection with the same heat exchanger jacket.

9. A heat-transfer device according to claim 6, in which the heat pipe has two laterally extending fins located on opposite sides thereof running the length of the heat pipe apart from the end portion thereof mounted in the heat exchanger jacket, the fins being attached to the heat pipe by means providing efficient heat conduction between the fins and the heat pipe.

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11. A heat transfer device according to claim 7, including at least one further heat exchanger jacket with a heat pipe engaged therein and assembled adjacent said heat exchanger jacket with the heat pipes parallel and the jackets interconnected for parallel flow of heat transfer fluid.

12. A heat exchanger jacket to surround a portion of the fluid containing pipe substantially as hereinbefore described and illustrated with reference to the accompanying drawing.