EUROPEAN PATENT SPECIFICATION

(54) PANEL HEAT EXCHANGER FORMED FROM PRE-FORMED PANELS
TAFELWÄRMETAUSCHER, DER AUS VORGEFERTIGTEN TAFELN GEBILDET IST
ECHANGEUR DE CHALEUR A PLAQUES CONSTITUE DE PLAQUES PREFORMEES

(84) Designated Contracting States: BE DE FR GB IT NL SE


(43) Date of publication of application: 27.09.1995 Bulletin 1995/39

(73) Proprietor: Cesaroni, Anthony Joseph
Unionville, Ontario L3R 8J1 (CA)

(72) Inventor: Cesaroni, Anthony Joseph
Unionville, Ontario L3R 8J1 (CA)

(74) Representative: Abitz, Walter, Dr.-Ing. et al
Patentanwälte Abitz & Partner,
Poschingerstrasse 6
81679 München (DE)

(56) References cited:
FR-A- 2 178 253
FR-A- 2 382 666
US-A- 3 561 524
US-A- 4 923 004

Note: Within nine months from the publication of the mention of the grant of the European patent, any person may give notice to the European Patent Office of opposition to the European patent granted. Notice of opposition shall be filed in a written reasoned statement. It shall not be deemed to have been filed until the opposition fee has been paid. (Art. 99(1) European Patent Convention).
Description

The present invention relates to a panel for a panel heat exchanger, in which the panels are formed from tubes with manifolds joined thereto. A plurality of such preformed panels is used to form the panel heat exchanger. Preferably, all of the panel is formed from a thermoplastic polymer. The invention relates also to a panel heat exchanger comprising such panels.

Panel heat exchangers formed from thermoplastic polymers and methods for the manufacture of such heat exchangers are known. For instance, a number of heat exchangers formed from thermoplastic polymers and methods for the manufacture thereof are disclosed in PCT patent application WO91/02209 of A.J. Cesaroni, published 1991 February 21, and in the published patent applications referred to therein. Tubular heat exchangers are also described by E.L. Fletcher and T.H. Kho in U.S. Patent 4 923 004, issued 1990 May 08. A preferred material of construction is aliphatic polyamide.

While panel heat exchangers formed from thermoplastic polymers have been fabricated by the techniques described in the above published documents, improvements in the construction and methods of fabrication would be beneficial to add further flexibility and economy to the fabrication and use of the panel heat exchangers.

FR-A-2 382 666 discloses elementary heat exchangers including manifolds in the shape of a plate having a continuous peripheral wall and at least one face of that plate is planar. That elementary heat exchanger comprises a multitubular plate with a gasket seating in a groove bearing against the multitubular plate in order to form a fluid-tight seal around the multitubular plate. The manifold portion of each panel or elementary heat exchanger is formed of two shells which have been assembled by first moving them together along a first direction until the shells are in close contact and until each of them is in close contact with the corresponding face of the multitubular plate and then by moving the shells with respect to each other along a second direction until stops of each of these shells are in close contact with the multitubular plate.

The present invention as claimed in claims 1 and 7 solves the problem of how to achieve a fluid-tight heat exchanger in as simple a manner as possible.

Preferred embodiments of the panel for a panel heat exchanger are set forth in claims 2 to 6.

The panel heat exchangers are formed from a plurality of such panels by bonding the panels together in a laminar manner. The invention will be described with particular reference to the drawings in which:

Fig. 1 is a schematic representation of a plan view of a panel;
Fig. 2 and 3 are schematic representations of manifolds of a panel;
Fig. 4 and 5 are schematic representations of alternative embodiments of manifolds of a panel; and
Fig. 6 is a schematic representation of a plurality of panels in a laminar arrangement, forming a panel heat exchanger.

Reference is made herein to both first and second manifolds and to inlet and outlet manifolds. In many instances, such expressions are synonymous, an exception being with respect to embodiments of the type illustrated in Fig. 2.

Referring to Fig. 1, a panel (generally indicated by 11) is shown as being formed from inlet manifold 12, outlet manifold 13 and a plurality of tubes 14. Tubes 14 are located between inlet manifold 12 and outlet manifold 13, and are in a parallel spaced apart and side-by-side relationship with each other. The plurality of tubes 14 are also in the same plane, as more easily seen in Figs. 2-6. Each of inlet manifold 12 and outlet manifold 13 is shown as being formed by walls 15 that form the periphery of each manifold, each manifold otherwise being open. Although the embodiment shown has the inlet manifold on one end and the outlet manifold on the other end, the inlet and outlet manifolds may be on the same end, as shown in Fig. 2, with a manifold or chamber for reversal of fluid flow on the other end of the panel i.e. some of the tubes are used for flow in one direction and the remainder are used for flow in the other direction; in this embodiment the panel would have a manifold of Fig. 2 on one end and a manifold of Fig. 3 on the other end.

Fig. 2 shows a panel end 21 having a first manifold 22 and a second manifold 23. First manifold 22 is separated from second manifold 23 by barrier 24. Tubes 25 are in fluid flow communication with first manifold 22 through channels 26. Similarly, tubes 27 are in fluid flow communication with second manifold 23 through channels 28.

Fig. 3 is similar to Fig. 2, except that there is only one manifold i.e. the barrier 24 in Fig. 2 has been omitted. Fig. 3 shows a panel end 31 having a manifold 32. Tubes 33 are in fluid flow communication with manifold 32 through channels 34.

Fig. 4 shows end section 41 that is of similar design to panel end 21 shown in Fig. 2. However, two of end sections 41 in face to face relationship would be required to form panel end 21. Fig. 4 shows an end section 41 having a first manifold 42 and a second manifold 43. First manifold 42 is separated from second manifold 43 by barrier 44. End section 41 has grooves 45 and 46 in a location corresponding to the location of tubes 25 and 27 in Fig. 2. Grooves 45 and 46 are of circular cross-section and of a size to accept tubes 25 and 27.

Fig. 5 shows a cross-section of end section 41 along A-A of Fig. 4. End section member 51 is shown as having grooves 52 of substantially semi-circular cross-section, but being adapted so as to accept tubes.

Fig. 6 shows a panel heat exchanger 61 that has an inlet 62 and an outlet 63. Inlet 62 and outlet 63 are joined together by a plurality of panels 64. Each of panels 64
are of the construction described above, with a plurality of tubes 65 extending from inlet 62 to outlet 63. Outlet 63 is shown as being partially cutaway, to reveal channels 66 of tubes 65. Inlet 62 and outlet 63 are formed by the bonding together in a face-to-face manner of manifolds of the type described above, especially in Fig. 2 and Fig. 3.

While the tubes are shown in the drawings as being both linear and parallel to each other, it is to be understood that this is a preferred embodiment and that other arrangements of tubes in a side-by-side relationship may be used. For example, the tubes may be non-linear i.e. curved or looped or in other convenient configurations.

A number of fabrication techniques may be used to fabricate the panels described herein. The tubing is bonded to manifolds at each end of the tubing. The manifold may be characterized by having channels in the wall thereof into which the tubing may be inserted and bonded. Alternatively, end sections of the type shown in Fig. 4 may be used in which event the ends of the tubing are laid in the grooves; a second similar and section is then placed over the tubing to complete the manifold, and heated in a press to effect bonding and formation of the manifold.

The design of the manifolds is selected depending on the construction of the heat exchanger and the desired flow pattern through the heat exchanger. For instance, if the flow pattern was to be directly from one end to the other, two manifolds of the type shown in Fig. 3 would be used, one as inlet manifold and one as outlet manifold. Alternatively, a manifold of the type shown in Fig. 2 could be used on one end and a manifold of the type shown in Fig. 3 could be used on the other end, in operation, fluid would flow from inlet manifold 22, through tubes 25 to manifold 32 and return through tubes 27 to outlet manifold 28. In this latter mode of operation, the inlet and outlet manifolds are on the same end of the panel, with the manifold on the opposite end of the panel being merely to reverse the direction of flow through the panel. While the manifolds need to be open on at least one face, it is to be understood that shims could be used to cover the other face of a manifold, thereby altering flow patterns, so as to maintain a desired residence time of the fluid in the panel heat exchanger by restrictions to the path of the fluid.

The panel heat exchanger is formed by taking a desired number of panels of the required configurations, optionally including shims, and placing the panels in a face to face relationship so that the manifolds cooperatively will form fluid tight inlets and outlets of the heat exchanger. The manifold sections are then bonded together, used heat and/or adhesives, depending in particular on the polymer used in the fabrication of the panels, especially the manifolds. The inlet and outlet require suitable connectors to permit fluid to enter and pass from the heat exchanger.

In operation, fluid would enter the inlet e.g. inlet 62, pass through tubes (65) to outlet 63. The panel heat exchanger would normally have the manifolds of a construction such that fluid passed several times from one side of the panel heat exchanger to the other e.g. in a zig-zag manner, to increase the efficiency and effectiveness of the operation of the panel heat exchanger.

In embodiments, the centres of tubes in adjacent stacked panels are not in alignment but are off-set by, for instance, one half of a diameter. Such an off-set nature of the tubes is believed to be beneficial for efficient heat exchange.

The sheets may be formed from a variety of polymer compositions. The composition selected will depend primarily on the end use intended for the heat exchanger, especially the temperature of use and the environment of use, including the fluid that will be passed through the heat exchanger and the fluid e.g. air, external to the heat exchanger. In the case of use on a vehicle, the fluid may be air that at times contains salt or other corrosive or abrasive matter, or the fluid may be liquid e.g. radiator fluid. While it is preferred to use the same or similar polymer compositions for both tubing and manifolds, the tubes and manifolds may be fabricated from different polymers, the requirement being that acceptable bonding may be achieved.

A preferred polymer of construction is polyamide. Examples of polyamides are the polyamides formed by the condensation polymerization of an aliphatic dicarboxylic acid having 6-12 carbon atoms with an aliphatic primary diamine having 6-12 carbon atoms. Alternatively, the polyamide may be formed by condensation polymerization of an aliphatic lactam or alpha,omega aminocarboxylic acid having 6-12 carbon atoms. In addition, the polyamide may be formed by copolymerization of mixtures of such dicarboxylic acids, diamines, lactams and aminocarboxylic acids. Examples of dicarboxylic acids are 1,6-hexanedicarboxylic acid (adipic acid), 1,7-heptanedicarboxylic acid (pimelic acid), 1,8-octanedicarboxylic acid (suberic acid), 1,9-nonanedicarboxylic acid (azelaic acid), 1,10-decanedicarboxylic acid (sebacic acid) and 1,12-dodecanedicarboxylic acid. Examples of diamines are 1,6-hexamethylene diamine, 2-methyl pentamethylene diamine, 1,8-octamethylene diamine, 1,10-decamethylene diamine and 1,12-dodecamethylene diamine. An example of a lactam is caprolactam. Examples of alpha, omega aminocarboxylic acids are amino octanoic acid, amino decanoic acid and amino dodecanoic acid. Preferred examples of the polyamides are polyhexamethylen adipamide and polycaprolactam, which are also known as nylon 66 and nylon 6, respectively.

The panels and sheet of the present invention have been described with particular reference to the use of polyamides as the polymer used in the fabrication thereof. It is to be understood, however, that other polymers may be used, the principal consideration being the environment of use of the panel heat exchanger e.g. the properties of the fluid passing through and over the panel heat exchanger, the temperature and pressure of use.
and the like. Examples of other thermoplastic polymers that may be used are polyethylene, polypropylene, fluorocarbon polymers, polyesters, thermoplastic and thermoset elastomers e.g. polyetherester elastomers, neoprene, chlorosulphonated polyethylene, and ethylene/propylene/diene (EPDM) elastomers, polyvinyl chloride and polyurethane. It is to be understood that the tubing could be metallic tubing, although plastic tubing is preferred.

In preferred embodiments of the present invention, the thickness of tubing used in the fabrication of the panels is less than 0.7 mm, and especially in the range of 0.07-0.50 mm, particularly 0.12-0.30 mm.

The polymer compositions used in the fabrication of the panel heat exchangers may contain stabilizers, pigments, fillers, including glass fibres, and the like, as will be appreciated by those skilled in the art.

The polymer composition of the tubing and of the manifolds may be the same or different, depending on the intended use of the panel heat exchangers. All seals in the panel heat exchanger need to be fluid tight seals to prevent leakage of fluid from the heat exchanger.

The panel heat exchangers and the process of manufacture provide a versatile and relatively simple method of fabricating heat exchangers. Simple moulds and fabrication techniques may be used. Panel heat exchangers may be custom made, using panels that have been preformed and are effectively "off the shelf". Combinations of panels of differing configurations may be used, by suitable selection of the panels, with a myriad of flow patterns being possible.

The heat exchangers may be used in a variety of end-uses, depending on the polymer(s) from which the heat exchanger has been fabricated and the intended environment of use of the heat exchanger. In embodiments, the panel heat exchangers may be used in automobile end-uses e.g. as part of the water and oil cooling systems. In other embodiments, the panel heat exchangers may be used in marine end-uses, including for craft that will operate on the sea. The panel heat exchangers may also be used in less demanding end uses e.g. in refrigeration and in comfort heat exchangers, including heating of rooms, floors and the like, and domestic uses.

The present invention is illustrated by the following examples.

Example 1

As an illustration of the invention, a panel heat exchanger of the type described above with reference to Fig. 6 was fabricated from polyhexamethylene adipamide compositions. The manifolds were of the shape shown in Fig. 2. Each panel consisted of 10 tubes and the inlet and outlet manifolds. The panel heat exchanger had six panels. The tubing had a wall thickness of 0.36 mm and an outer diameter of 4.3 mm, and had been formed by extrusion of a polyhexamethylene adipamide composition.

The panels were formed by bonding tubing into channels in the manifolds using an adhesive of the type described in European patent application No. 287 271 of A.J. Cesaroni, published 1988 October 19. Heat was applied to effect bonding. The panel heat exchanger was formed from panels using the same technique.

The resultant panel heat exchanger was tested and found to be fluid tight.

Claims

1. A panel for a panel heat exchanger comprising:

   a plurality of tubes (14, 25, 27, 33) in a single layer, said tubes being arranged in a side-by-side relationship;
   a first and a second manifold (12, 13), each of said manifolds being in the shape of a plate having a continuous peripheral wall (15) enclosing a chamber and with at least one face of said plate being planar, at least one of said planar faces on each of said first and second manifolds being open;
   said tubes being attached at opposing ends thereof to said first manifold and said second manifold so as to provide fluid flow communication between the open faces of said first and second manifolds through the tubes and the chambers in the manifolds;
   said manifolds being capable of being attached to like manifolds in a face to face manner, said peripheral walls of the manifolds on the face to be attached being coplanar with the plane of the tubes and said manifolds being open on at least said face being attached; and
   the tubes and manifolds being fabricated from a thermoplastic polymer;

   characterized in

   that said tubes (14, 25, 27, 33) are spaced apart;
   that a plurality of channels (26, 28, 34) is provided through a section of said wall and each tube is bonded to a separate channel;
   that said tubes are attached to said first manifold and said second manifold by bonding; and
   that said manifolds are capable of being attached to like manifolds by bonding.

2. The panel of Claim 1 in which the channels are parallel.

3. The panel of Claim 1 or Claim 2 in which the tubes are parallel.
4. The panel of any one of Claims 1-3 in which the diameters of the tubes are in a plane.

5. The panel of any one of Claims 1-4 in which the tubes are linear.

6. The panel of any one of Claims 1-5 in which the polymer is a polyamide.

7. A panel heat exchanger comprising at least two panels of any one of claims 1 to 6, said panels being bonded together in a laminar stacked relationship wherein the manifolds of one panel being bonded to the manifolds of a second panel in face-to-face and fluid-tight manner.

Patentansprüche

1. Tafel für einen aus Tafeln aufgebauten Wärmetauscher, umfassend:
   eine Mehrzahl von Rohren (14, 25, 27, 33) in einer einzigen Lage, wobei die Rohre neben einander angeordnet sind; einen ersten und einen zweiten Verteiler (12, 13), wobei jeder der Verteiler die Form einer Platte mit einer durchgehenden peripheren Wend (15) aufweist, die eine Kammer umschließt, und wobei mindestens eine Seite der Platte planar ist und mindestens eine der planaren Seiten an jedem der ersten und zweiten Verteiler offen ist; wobei die Rohre an ihren einander entgegengesetzten Enden an dem ersten Verteiler und dem zweiten Verteiler so befestigt sind, daß eine Fluidstromverbindung zwischen den offenen Seiten der ersten und zweiten Verteiler durch die Rohre und die Kamern in den Verteilern hindurch hergestellt wird; wobei die Verteiler an gleichartigen Verteilern Seite an Seite befestigt werden können, und wobei die peripheren Wände der Verteiler auf der zu befestigenden Seite koplanar mit der Ebene der Rohre sind und die Verteiler auf mindestens der zu befestigenden Seite offen sind; und wobei die Rohre und die Verteiler aus einem thermoplastischen Polymer hergestellt sind; dadurch gekennzeichnet,
   daß die Rohre (14, 25, 27, 33) voneinander beabstandet sind; daß eine Mehrzahl von Kanälen (26, 28, 34) durch einen Abschnitt der Wand hindurch vorhanden ist und jedes Rohr an einen separaten Kanal gebunden ist;

2. Tafel nach Anspruch 1, in der die Kanäle parallel sind.

3. Tafel nach Anspruch 1 oder Anspruch 2, in der die Rohre parallel sind.

4. Tafel nach einem der Ansprüche 1 bis 3, in der die Durchmesser der Rohre in einer Ebene liegen.

5. Tafel nach einem der Ansprüche 1 bis 4, in der die Rohre linear sind.

6. Tafel nach einem der Ansprüche 1 bis 5, in der das Polymer ein Polyamid ist.

7. Aus Tafeln aufgebauter Wärmetauscher, umfassend mindestens zwei Tafeln nach einem der Ansprüche 1 bis 6, wobei die Tafeln in laminar geschichteter Anordnung aneinander gebunden sind und die Verteiler einer Tafel Seite an Seite und fluidisch an die Verteiler einer zweiten Tafel gebunden sind.

Revendications

1. Plaque pour un échangeur de chaleur à plaques, comprenant:
   plusieurs tubes (14, 25, 27, 33) dans une seule couche, lesdits tubes étant agencés dans une relation côté à côté; un premier et un deuxième collecteur (12, 13), chacun desdits collecteurs ayant la forme d'une plaque comportant une paroi périphérique continue (15), renfermant une chambre, au moins une face de ladite plaque étant plane, et au moins une desdites faces planes sur chacun desdits premier et deuxième collecteurs étant ouverte; lesdits tubes étant fixés au niveau de leurs extrémités correspondantes audit premier collecteur et audit deuxième collecteur, de sorte à établir une communication de fluide entre les faces ouvertes desdits premier et deuxième collecteurs à travers les tubes et les chambres dans les collecteurs; lesdits collecteurs pouvant être fixés à des collecteurs similaires d'une manière face à face, lesdites parois périphériques des collecteurs sur la face devant être fixée étant coplanaires.
au plan des tubes et lesdits collecteurs étant ouverts sur au moins ladite face devant être fixée; et les tubes et les collecteurs étant fabriqués à partir d'un polymère thermoplastique; caractérisé en ce que lesdits tubes (14, 25, 27, 33) sont espacés; plusieurs canaux (26, 28, 34) sont agencés à travers une section de ladite paroi et chaque tube étant lié à un canal séparé; lesdits tubes sont fixés audit premier collecteur et audit deuxième collecteur par liaison; et lesdits collecteurs peuvent être fixés à des collecteurs similaires par liaison.

2. Plaque selon la revendication 1, dans laquelle les canaux sont parallèles.

3. Plaque selon les revendications 1 ou 2, dans laquelle les tubes sont parallèles.

4. Plaque selon l'une quelconque des revendications 1 à 3, dans laquelle les diamètres des tubes se situent dans un plan.

5. Plaque selon l'une quelconque des revendications 1 à 4, dans laquelle les tubes sont linéaires.

6. Plaque selon l'une quelconque des revendications 1 à 5, dans laquelle le polymère est un polyamide.

7. Échangeur de chaleur à plaques comprenant au moins deux plaques selon l'une quelconque des revendications 1 à 6, lesdites plaques étant liées dans une relation lamellaire empilée, les collecteurs d'une plaque étant liés aux collecteurs d'une deuxième plaque d'une manière face à face et étanche aux fluides.