(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 870 657 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
26.12.2007 Bulletin 2007/52

(51) Int Cl.:
F28D 9/00 *(2006.01)* ***F28F 21/06*** *(2006.01)*
F28F 13/00 *(2006.01)*

(21) Application number: **06013075.4**

(22) Date of filing: **24.06.2006**

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HU IE IS IT LI LT LU LV MC NL PL PT RO SE SI SK TR
Designated Extension States:
AL BA HR MK YU

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(54) Heat exchanger

(57) A heat exchanger is suggested for fluids comprising each an inlet and an outlet for a fluid to be heated up and for a fluid to be cooled down, at least one heat-up chamber and at least one cooling chamber, wherein the chambers are separated by a means to carry out heat transfer there between and wherein at least one of the chambers comprises a spacer, characterized in that the spacer comprises a three-dimensional mat from thermoplastic filaments, which mat has an open structure, and which filaments are bonded at least partly at their crossing points and which mat creates micro turbulence in the flow of fluid to increase efficiency of heat exchange between the two flows of fluid.

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Description

[0001] The present invention relates to a heat exchanger, which is used in a heat recovery system wherein supplying fresh fluid to be heated up and exhausting fluid to be cooled down are simultaneously carried out to perform heat exchange between the supply fluid and the exhaust fluid. Such heat exchangers are commonly used e.g. for ventilation of buildings, wherein the fluid is a gaseous fluid, such as air.

[0002] In order to meet both the requirements of maximizing heat transfer while at the same time tackling a high volume stream of - in particular gaseous - fluids with a minimum pressure loss, it is necessary to install heat exchangers exhibiting high efficiency, which is commonly accompanied by relatively large units to be installed. The heat recovery units presently used in single-family houses have dimensions of say height x width x depth of 0.85 x 0.60 x 0.55 m^3. They contain an internal heat exchanger of about 0.50 x 0.50 x 0.30 m^3, four 150 mm air pipes and two small ventilators.

[0003] In particular in big cities costs for buildings have been increasing drastically over the years, followed by free space in these buildings being continuously diminished. Demands thus have increased for heat exchangers having not only high an efficiency, but also do not require much room for installation.

[0004] Such a compact heat exchanger is known for example from DE-A-100 08 681.

[0005] DE-A-100 08 681 discloses a heat exchanger that has a gas inlet and outlet to include heat-up and cooling chambers completed with corrugated spacers, which are - preferably - made of corrugated paper. The chambers are preferably stacked in rows with fleece material, which is placed round the chamber and fixed to the respective spacers. The chambers are fixed by stacked arrangement of spacers and joined by fleece materials as secured to any one spacer in each case. Inlets and outlets should be arranged at right angles to one another. According to DE-A-100 08 681 the heat exchanger disclosed should have high efficiency and at the same time a more compact size than the prior art units.

[0006] Although meeting some of the requirements as set up by the building industry, the heat exchanger of DE-A-100 08 681 still leaves room for improvement. First of all, the prior art heat exchanger is limited to gaseous fluids. Secondly, also when dealing only with gaseous fluids, such as air, there are some drawbacks when applying the heat exchanger of DE-A-100 08 681, in particular when the air is loaded with high amounts of water vapour. For example, the demand for a ventilation system with a heat exchanger in cold areas or indoor warm swimming pools has increased with the spread of such kind of heat exchanges. Such environments have a problem in that a great temperature difference between supplied air and exhaust air is apt to form vapour condensation and that the above mentioned corrugated paper - although preferably being resistant to humidity - cannot withstand long use because of deformation due to vapour condensation.

[0007] Further, it is still desired to increase efficiency within the heat exchangers by avoiding as much as possible "dead corners", i.e. regions that exhibit no or only reduced turbulence in the fluids.

[0008] The present invention has for its object to reduce the mentioned drawbacks of the prior art. Further objects will become evident by studying the embodiments in the description.

[0009] In order to achieve the object of the invention a heat exchanger for fluids is proposed which heat exchanger comprise each an inlet and an outlet for a fluid to be heated up and for a fluid to be cooled down, at least one heat-up chamber and at least one cooling chamber, wherein the chambers are separated by a means to carry out heat transfer there between and wherein at least one of the chambers comprises a spacer, the invention being that the spacer comprises a three-dimensional mat from thermoplastic filaments, which mat has an open structure, and which filaments are bonded at least partly at their crossing points.

[0010] Although bonding of the filaments that form the mat can be accomplished by various methods, including but are not limited to applications of glues, it is preferred that the filaments are bonded by thermal fusion, either by melting partially the filaments themselves or by the application of binders that have a melting point lower than the melting point of the filaments. These binders can also be part of the filaments, as for example may form the sheath of a core-sheath filament forming the mat of the invention. Those measures are known to the skilled person.

[0011] Preferably, at least one of the fluids to be heated up or to be cooled down by the heat exchanger of the invention is a gaseous fluid, even more preferably both fluids to be heated up and to be cooled down consist mainly or entirely of air.

This is due to the fact that the main use of the heat exchanger is in ventilation systems of buildings, where both fluids to be treated consist of air. As a matter of fact the invention, however, is not limited to that and the heat exchangers according to the invention may also be used to treat cooling air or exhaust air in industrial processes.

[0012] The application of an open three-dimensional structure, which filaments are bonded, preferably are thermally fused, at least partly at their crossing points, as spacer in the heat exchanger according to the invention leads to various advantages in view of the prior art.

[0013] First of all, the entire spacer allows - due to its open structure - high amounts of fluids to pass through the respective chamber. On the other hand, however, due to its random structure, the mat causes the fluid, such as a gaseous stream, to become not only turbulent, but micro-turbulent without causing substantial pressure losses during operation. Due to the micro-turbulence on either side of the means to carry out heat transfer, the overall efficiency increases substantially compared to the known heat exchangers, which in turn allows making them compacter. This additional reduction in size - as mentioned above - is a major advantage; this applies as well to small units for private housing as for large units for large buildings and industrial use.

[0014] Further, the fact that the spacer is made from thermoplastic filaments renders it entirely insensitive to humidity, increasing the lifetime of the heat exchanger, in particular in environments with high vapour condensation.

An additional advantage lies in the fact that such mats as spacer render a better resilience to the entire structure, which also leads to an increase of the durability of the structure and is of help during the production of the heat exchanger, when the matting is to be handled, and during cleaning operations.

[0015] The more so, if - in a preferred embodiment - the heat exchanger comprises a series of heat-up chambers and a series of cooling chambers that are piled up. In order to allow good performance, it is worthwhile, if the chambers are piled up in an alternating manner, i.e. a cooling chamber followed by a heat-up chamber followed by a cooling chamber and so on.

[0016] It is also preferred that any of the chambers comprises a three-dimensional mat from thermoplastic filaments as spacer.

[0017] For the means to carry out heat transfer between the chambers, it is preferred that this consists of a thin plate or a foil which is made of a material that is gas impermeable, i.e. tight and insensitive to humidity. Furthermore, good heat conductivity will contribute to the efficiency of the heat exchanger. Any plate that is sufficiently thin of a suitable metal, such as aluminium, or a foil could for example achieve this.

[0018] As already mentioned above, although the application of the heat exchanger according to the invention is not restricted to particular gaseous fluids - as long as they are not hazardous to the structure - it is of course preferred that both the gaseous fluids to be cooled down or heated up consist of air.

[0019] Therefore, in a further preferred embodiment the means to carry out heat transfer between the chambers is a foil made of a material that is air impermeable and water vapour permeable.

This leads to good exchange and transport of water vapour throughout the entire structure, rendering the heat exchanger less susceptible to condensates. The skilled man knows foils that are air impermeable and water vapour permeable. An example is foils made of a copolyetherester and sold under the trade name Sympatex® by Sympatex Technologies GmbH, Wuppertal (Germany).

[0020] The thermoplastic filaments applied for the three-dimensional mats are not restricted to any particular material. It is however preferred if the three-dimensional mats comprise a polymer selected from a group consisting of polyolefin, polyester, polyamide or blends thereof.

These polymers can be easily and economically produced and extruded to form filaments exhibiting the desired structural integrity and resistance when formed into mats.

In order to achieve the desired structure, the filaments, preferably monofilaments, are spun randomly and are being thermally fused at least partly at their crossing points. The spinning and fusing steps can be done continuously by spinning the molten polymer into suitable forming devices. These measurements are known to the skilled person.

[0021] It is particularly preferred if the thermoplastic filaments of the three-dimensional mat comprise polyamide 6 as main component. This material can be spun laid into various homogeneous three-dimensional structures in a convenient and reproducible way. Furthermore, polyamide 6 is a very durable polymer, which is insensitive to low temperatures.

[0022] The three-dimensional mat comprises an open random structure, i.e. forming flow paths for the fluid without a preferred flow direction, thus enhancing the formation of micro-turbulences and avoiding too high pressure loss during operation.

[0023] Formulas are established for flow paths with circular section. It is the form best adapted, because it gives the greatest section for a given perimeter.

The theoretical relation for flow paths of an unspecified form reads:

$$D = A * S/P$$

with:

- D = hydraulic diameter
- S = Section of the flow path or duct
- P = Perimeter of the flow path or duct
- A = Area

[0024] When applying the three-dimensional mat of the invention, vortices within the streaming fluid are being created. In a preferred embodiment these vortices exhibit diameters that are less than one half (0.5), more preferably less than one tenth (0.1), of the hydraulic diameter (D) of the flow path within the three-dimensional mat.

By this micro turbulence is generated that increase the efficiency of the heat exchanger.

[0025] A particularly preferred three-dimensional mat exhibiting such a structure is commercially available under the trade name Enka®-Spacer from Colbond Geosynthetics GmbH, Obernburg (Germany).

[0026] Three-dimensional mats from the Enka®-Spacer type have the advantage that they can be used in a convenient and reproducible manner due to the fact that their weight-area-ratio is very constant. This facilitates dosage of the material and as a consequence the reproducibility of the efficiency of the heat exchanger.

[0027] In another preferred embodiment of the heat exchanger according to the present invention the means to carry out heat transfer - also known as separation layer between the heat-up and the cooling chamber - is fixed to the top side and/or to the bottom side of the three-dimensional mat.
This can preferably be accomplished by thermal fixing of this means to the three-dimensional mat, which renders the assembly of the structure very easy and durable.
In particular, if the heat exchanger is formed by simply piling up the means to carry out heat transfer that are (pre-) fixed to the top side or to the bottom side of the three-dimensional mat.

[0028] In operation it must be ensured that the inlet(s) and outlet(s) are arranged such that the fluids to be heated up and the fluids to be cooled down have a maximum contact without being intermixed. This can be achieved for example in that the inlet(s) and the outlet(s) for the fluid to be heated up and for the fluid to be cooled are arranged transverse, in particular, perpendicular to each other.

[0029] It must then be ensured that the fluid to be heated up can only stream into and through the heat-up chamber(s) of the heat exchanger and the fluid to be cooled down only into and through the cooling chamber(s). This can be performed e.g. by sealing those sides of the chambers that should not be reached by a respective fluid.
Those measures are known to the skilled person. Examples for such constructions for gaseous fluids can be found in DE 100 08 681 (Fig. 1 and Fig. 3), which are hereby incorporated by reference.

Claims

1. Heat exchanger for fluids comprising each an inlet and an outlet for a fluid to be heated up and for a fluid to be cooled down, at least one heat-up chamber and at least one cooling chamber, wherein the chambers are separated by a means to carry out heat transfer there between and wherein at least one of the chambers comprises a spacer, **characterized in that** the spacer comprises a three-dimensional mat from thermoplastic filaments, which mat has an open structure, and which filaments are bonded at least partly at their crossing points.

2. The heat exchanger according to claim 1, **characterized in that** the filaments are bonded by thermal fusion.

3. The heat exchanger, **characterized in that** at least one of the fluids to be heated up or to be cooled down is a gaseous fluid.

4. The heat exchanger of claim 3, **characterized in that** both fluids to be heated up and to be cooled down consist mainly or entirely of air.

5. The heat exchanger of any of the preceding claims, **characterized in that** a series of heat-up chambers and a series of cooling chambers are piled up.

6. The heat exchanger of any of the preceding claims, **characterized in that** the means to carry out heat transfer between the chambers is a thin plate or foil made of a material that is gas tight.

7. The heat exchanger of claim 6, **characterized in that** the means to carry out heat transfer between the chambers is a foil made of a material that is air impermeable and water vapour permeable.

8. The heat exchanger of any of the preceding claims, **characterized in that** the thermoplastic filaments of the three-dimensional mat comprise a polymer selected from a group consisting of polyolefin, polyester, polyamide or blends thereof.

9. The heat exchanger of any of the preceding claims, **characterized in that** the thermoplastic filaments of the three-dimensional mat comprise polyamide 6 as main component.

10. The heat exchanger of any of the preceding claims, exhibiting turbulences during operation, **characterized in that** the vortices of said turbulences exhibit diameters that are less than one half (0.5), preferably less than one tenth (0.1), of the diameter hydraulic (D) of the flow paths within the three-dimensional mat.

11. The heat exchanger of any of the preceding claims, **characterized in that** the means to carry out heat transfer is fixed to the top side and/or to the bottom side of the three-dimensional mat.

12. The heat exchanger of claim 11, **characterized in that** the means to carry out heat transfer is thermally fixed to the three-dimensional mat.

13. The heat exchanger of claim 4, **characterized in that** the heat exchanger is formed by piled-up means to carry out heat transfer that are fixed to the top side or to the bottom side of the three-dimensional mat.

14. The heat exchanger according to any of the preceding claim, **characterized in that** the inlet(s) and the outlet(s) for the fluid to be heated up and for the fluid to be cooled are arranged transverse, in particular, perpendicular to each other.

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EUROPEAN SEARCH REPORT

Application Number
EP 06 01 3075

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	WO 01/27552 A (CARRIER CORP [US]) 19 April 2001 (2001-04-19) * page 16, paragraph 2 - page 17, paragraph 2; figures 7,8 * -----	1,3-6, 11-14	INV. F28D9/00 F28F21/06 F28F13/00
A	US 5 527 590 A (PRILUCK JONATHAN [US]) 18 June 1996 (1996-06-18) * column 4, paragraph 3 - column 4, paragraph 4; figures 1-3 * -----	1	
X	EP 1 533 586 A (WIELAND WERKE AG [DE]; COMMISSARIAT ENERGIE ATOMIQUE [FR]) 25 May 2005 (2005-05-25) * paragraph [0035] - paragraph [0038]; figures 1,2 * -----	1,3,5	
A	US 2006/070728 A1 (SHIN SOO-YEON [KR] ET AL) 6 April 2006 (2006-04-06) * paragraph [0042] - paragraph [0046]; figures 5,6 * * paragraph [0056] * -----	1	TECHNICAL FIELDS SEARCHED (IPC) F28F F28D

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	29 November 2006	Martínez Rico, Celia

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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A : technological background
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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO.

EP 06 01 3075

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29-11-2006

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
WO 0127552	A	19-04-2001	US 2002185266 A1	12-12-2002
US 5527590	A	18-06-1996	NONE	
EP 1533586	A	25-05-2005	WO 2005054768 A1	16-06-2005
US 2006070728	A1	06-04-2006	NONE	

EPO FORM P0459

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

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- DE 10008681 A **[0004] [0005] [0005] [0006] [0006]**
- DE 10008681 **[0029]**