

HEAT EXCHANGER

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is based upon and claims the benefit of
5 priority from the prior Japanese Patent Application No.
2006-077169 (filed on March 20, 2006); the entire contents of
which are incorporated herein by reference.

BACKGROUND OF THE INVENTION

10 FIELD OF THE INVENTION

The present invention relates to a heat exchanger for
exchanging heat between gas and a thermal medium.

DESCRIPTION OF THE RELATED ART

15 Heat exchangers are utilized in various uses. A heat
exchanger is provided with a plurality of tubes for conducting
a thermal medium and a plurality of fins respectively projecting
from the tubes. Any gas subject to heat exchange is pressurized
to flow through spaces among the tubes and the fins so as to
20 exchange heat with the thermal medium. For improvement of
efficiency of the heat exchange, dimensions of the tubes and
the fins are the subject of research.

SUMMARY OF THE INVENTION

25 An object of the present invention is to provide a heat
exchanger which improves efficiency of heat exchange.

According to a first aspect of the present invention, a

heat exchanger for exchanging heat with gas made to flow in a flow direction is provided with: a plurality of plates each having a first side and a second side; a plurality of tubes configured to conduct a thermal medium, the tubes penetrating the plates and being arranged in parallel with each other and on a plurality of planes perpendicular to the flow direction, wherein the tubes on each plane are disposed adjacent to gaps between the tubes on any of adjacent planes so as to form a plurality of serpentine flow lines among the tubes; and a plurality of bridges projecting on the first sides of the plates, the bridges being respectively arranged to be perpendicular to the serpentine flow lines.

According to a second aspect of the present invention, a heat exchanger for exchanging heat with gas made to flow in a flow direction is provided with: a plurality of plates each having a first side and a second side; a plurality of tubes configured to conduct a thermal medium, the tubes penetrating the plates and being arranged at an even pitch in parallel on a plurality of planes perpendicular to the flow direction, wherein the tubes on each plane are respectively deviated in a lateral direction with respect to the tubes on any of adjacent planes by half of the pitch of the tubes and the half of the pitch is not greater than diameters of the tubes; and a plurality of bridges projecting on the first sides of the plates, the bridges being respectively arranged to be perpendicular to the serpentine flow lines.

According to a third aspect of the present invention, a heat exchanger for exchanging heat with gas made to flow in a

flow direction is provided with: a plurality of plates each having a first side and a second side; a plurality of openings formed on the plates and arranged in a plurality of rows perpendicular to the flow direction, wherein the openings in each row are disposed adjacent to gaps between the openings in any of adjacent rows; a plurality of bridge groups respectively projecting on the first sides of the plates and being disposed at the gaps, each of the bridge groups including a plurality of bridges perpendicular to the flow direction and arranged in a row along the flow direction, a first pair of sub-bridges disposed on an upstream end of the row with respect to the flow direction and slanted from a center to both sides of the first pair toward the flow direction, and a second pair of sub-bridges disposed on a downstream end of the row with respect to the flow direction and slanted from both sides to a center of the second pair toward the flow direction; and a plurality of tubes configured to conduct a thermal medium, the tubes respectively penetrating the openings.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a schematic cross sectional view of a heat exchanger in accordance with an embodiment of the present invention;

Fig. 2 is a side view of the heat exchanger;

Fig. 3 is a sectional view of the heat exchanger taken along a line A-A of Fig. 1;

Fig. 4 is a perspective view of a plate applied to the

heat exchanger;

Fig. 5 is a plan view of the plate;

Fig. 6 is a sectional view of the plate taken along a line B-B of Fig. 5; and

5 Fig. 7 is a sectional view of the plate taken along a line C-C of Fig. 5.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

An embodiment of the present invention will be described
10 hereinafter with reference to the appended drawings.

A heat exchanging unit 17 of the present embodiment is used in a housing such as one shown in Fig. 1. The housing is provided with a cylinder 14 and flanges 15, 16 fixed at both ends thereof for air-tightening. The exteriors of the flanges
15 15, 16 are further enclosed by walls, which respectively define fluid rooms 23, 24. The heat exchanging unit 17 is provided with a plurality of tubes 18 running along an axis of the cylinder 14, which liquid-tightly penetrate the flanges 15, 16 and have openings at both ends to communicate with the fluid rooms 23,
20 24.

The heat exchanging unit 17 is further provided with a plurality of plates 21, which the tubes 18 penetrate. The plates 21 stand substantially vertical to the axis of the cylinder 14 and are arranged to have even intervals therebetween.

25 Referring to Fig. 2, the fluid room 23 is liquid-tightly partitioned into two sub-rooms 23a, 23b by a partition 25. An inlet port 26 is linked with the sub-room 23a and an outlet port

27 is linked with the sub-room 23b, thereby a thermal medium such as a cooling water is capable of flowing in and out of the fluid room 23. The thermal medium flowing through the inlet port 26 into the sub-room 23a further flows through some of the tubes 18 and then reaches the opposite fluid room 24. Further, the thermal medium in the fluid room 24 flows through the rest of the tubes 18, reaches the sub-room 23b, and are then exhausted out of the outlet port 27.

The cylinder 14 has a partition 28 therein, which runs along the axis, to partition the interior thereof into a gas migration chamber 29 and the rest as shown in Fig. 3. The rest of the interior is further partitioned into a gas inflow chamber 32 and a gas outflow chamber 33 by a partition 31 provided at an axial middle of the interior of the cylinder 14 as shown in Fig. 1. The cylinder 14 is provided with a gas inflow port 33 and a gas outflow port 35 to respectively communicate with the gas inflow chamber 32 and the gas outflow chamber 33.

Gas subject to heat exchange, such as air to be cooled, is made to flow into the gas inflow port 34 by any gas feeding means such as a rotating fan or a pump. The gas flows through the gas inflow port 34 into the gas inflow chamber 32 as indicated by arrows from the top to the right in Fig. 3. The gas further flows through the heat exchanging unit 17 as indicated by arrows from the right to the left in Fig. 3, and enters the gas migration chamber 29. The gas migrates in the gas migration chamber 29 from the left to the right of Fig. 1 and then flows through the heat exchanging unit 17 to the gas outflow chamber 33. The gas

in the gas outflow chamber 33 flows out of the gas outflow port 35.

In the course of the aforementioned flow of the gas, the thermal medium exchanges heat with the gas. If cooling water is applied to the thermal medium and air is the gas, the air is cooled by the cooling water as a result of the heat exchange. The cooled air is extracted from the gas outflow port 35.

Details of the heat exchanging unit 17 will be described hereinafter with reference to Figs. 4-7.

The plates 21 are configured to increase contact area with respect to the flowing gas and serve as cooling (or heating) fins. As mentioned above, the gas flowing around the plates 21 is as a whole directed in a direction from one end to another end of each of the plates 21. The direction is shown as from the right to the left in Fig. 3 and as from the top to the bottom in Fig. 5. Throughout the specification and claims, "a flow direction" with respect to each of the plates 21 is defined as a direction along which the gas is made to flow and correspondent with a direction from one end to another end of each of the plates 21.

Each of the plates 21 is provided with a plurality of openings 36 which fixedly support the tubes 18. The openings 36 are arranged in a plurality of rows which are perpendicular to the flow direction and arranged at even intervals. Positions of the openings 36 in each row are laterally deviated from positions of the openings 36 in the adjacent row by half of a pitch of the openings 36, thereby the openings 36 in each row

are disposed adjacent to gaps between the openings 36 in the adjacent row. The half of the pitch is not greater than the diameter of the openings 36.

Collars 37 respectively stand around the openings 36. The collar 37 serves as a spacer for keeping gaps toward an adjacent plate 21. The collar 37 further serves to transmit heat between the plate 21 and the tube 18.

Respective spaces among the openings 36 are cut or punched out to project from one side of the plate 21 as shown in Figs. 4 and 7. These projections form a group in each space and each projection is formed to be a shape of a bridge having legs at both ends and a flat top spanning the legs as shown in Fig. 6. Bridges 39, 40, 41 at the middle of each group are directed perpendicular to the flow direction and arranged in a row along the flow direction. Upstream of the bridges 39, 40, 41 with respect to the flow direction, just downstream of one opening 18, a pair 38 of sub-bridges 38a, 38b is formed. The sub-bridges 38a, 38b are arranged to be symmetrical with respect to the center of the pair and are slanted from the center to both sides of the pair 38 toward the flow direction. Similarly, downstream of the bridges 39, 40, 41, just upstream of another opening 18, a pair 42 of sub-bridges 42a, 42b is formed, however, contrary to the aforementioned sub-bridges 38a, 38b, the sub-bridges 42a, 42b are slanted from both sides to the center of the pair 42 toward the flow direction.

Arrangement of the tubes 36 respectively inserted in the openings 36 defines a plurality of serpentine flow lines 44 among

the tubes 36, as indicated by serpentine arrows in Fig. 5. The bridges 39, 40, 41 and the sub-bridges 38a, 38b, 42a, 42b are arranged along and perpendicular to the serpentine flow lines 44. Further, the legs of the bridges 39, 40, 41 and the sub-bridges 38a, 38b, 42a, 42b are substantially in parallel with the serpentine flow lines 44.

The plate 21 is provided with ribs 43 projecting on the same side as the bridges as shown in Fig. 7. The shape of the ribs 43 is not limited to but can be a triangular sectional shape. The ribs 43 run at respective middles of the rows of the openings 18.

When assembling the plates 21 and the tubes 18, one of the plates 21 is handled so that the tubes 18 are inserted to the respective openings 36 thereof. The plates 21 are one by one put under assembly to be combined with the tubes 18. When one of the plates 21 abuts on another of the plates 21 with interposing the collar 37, the gap therebetween is regulated by the collar 37 serving as a spacer. After all of the plates 21 and the tubes 18 are assembled, the tubes 18 are broadened so as to fix the tubes 18 with the plates 21.

Thereby, the tubes 18 and the plates 21 are combined to form the heat exchanging unit 17. The assembled heat exchanging unit 17 is combined in the cylinder 14.

The heat exchanging unit 17 exchanges heat in accordance with the following manner.

The gas subject to the heat exchange, such as air to be cooled, is made to flow from the top to the bottom in Fig. 5.

When the gas goes around any of the tubes 36, the gas tends to turn aside around an upstream face thereof. Since the sub-bridges 42a and 42b in the upstream stand there so as to conduct the flow, the flow of the gas is smoothly branched into right and left streams. Then the right stream is conducted by the sub-bridge 38a of another group of bridges at the right and the downstream, and the left stream is conducted by the sub-bridge 38b of the other group of bridges at the left and downstream. The streams are respectively merged with the other adjacent branched streams. These merged streams are then further branched by the lowermost sub-bridges 42a and 42b of the current bridge group. Therefore, the streams of the gas are respectively faired along the serpentine flow lines 44.

In general, gas flowing among cylindrical bodies such as the tube 18 tends to form stagnation around downstream faces of the cylindrical bodies, however, the faring effect of the bridges prominently reduces the stagnation. Further, since the streams of the gas just downstream of the tube 18 receive force in lateral directions by the ribs 43, the stagnation is further reduced. Reduction in the stagnation improves efficiency of heat exchange of the heat exchanging unit 17.

The streams of the gas further receive force in a direction perpendicular to the plates 21 (perpendicular to a paper face of Fig. 5) from the bridges 38-42 and the ribs 43 to three-dimensionally fluctuate. Therefore contact length of the gas with the plates 21 increases and hence efficiency of the heat exchange further increases.

The ribs 43 may be formed not of continuity as mentioned above but of discontinuity. For example, merely portions just downstream of the tubes 18 may be formed to project but portions just downstream of the bridges 38-42 may not be projected.

5 Moreover, the ribs 43 may be formed in paired parallel rib shapes or half-round sectional shapes, or any other modifications may be applicable.

Further, the bridges may be formed in other shapes, such as arch shapes. Any bridge between the sub-bridges 38, 42 may
10 also be divided in a pair of sub-bridges like as the sub-bridges 38, 42.

Although the invention has been described above by reference to certain embodiments of the invention, the invention is not limited to the embodiments described above.
15 Modifications and variations of the embodiments described above will occur to those skilled in the art, in light of the above teachings.

What is claimed is:

1. A heat exchanger for exchanging heat with gas made to flow
in a flow direction, the heat exchanger comprising:
a plurality of plates each having a first side and a second
5 side;

a plurality of tubes configured to conduct a thermal medium,
the tubes penetrating the plates and being arranged in
parallel with each other and on a plurality of planes
perpendicular to the flow direction, wherein the tubes
10 on each plane are disposed adjacent to gaps between the
tubes on any of adjacent planes so as to form a plurality
of serpentine flow lines among the tubes; and

a plurality of bridges projecting on the first sides of the
plates, the bridges being respectively arranged to be
15 perpendicular to the serpentine flow lines.

2. The heat exchanger of claim 1, wherein each of the bridges
includes a pair of legs at both ends to be arranged along
the serpentine flow lines.

20 3. The heat exchanger of claim 1, further comprising ribs
projecting on the first sides of the plates and running
at respective middles of the planes.

25 4. A heat exchanger for exchanging heat with gas made to flow
in a flow direction, the heat exchanger comprising:
a plurality of plates each having a first side and a second

side;

a plurality of tubes configured to conduct a thermal medium,
the tubes penetrating the plates and being arranged at
an even pitch in parallel on a plurality of planes
5 perpendicular to the flow direction, wherein the tubes
on each plane are respectively deviated in a lateral
direction with respect to the tubes on any of adjacent
planes by half of the pitch of the tubes and the half of
the pitch is not greater than diameters of the tubes; and
10 a plurality of bridges projecting on the first sides of the
plates, the bridges being respectively arranged to be
perpendicular to the serpentine flow lines.

5. The heat exchanger of claim 4, wherein each of the bridges
15 includes a pair of legs at both ends to be arranged along
the serpentine flow lines.

6. The heat exchanger of claim 4, further comprising ribs
projecting on the first sides of the plates and running
20 at respective middles of the planes.

7. A heat exchanger for exchanging heat with gas made to flow
in a flow direction, the heat exchanger comprising:
a plurality of plates each having a first side and a second
25 side;

a plurality of openings formed on the plates and arranged in
a plurality of rows perpendicular to the flow direction,

wherein the openings in each row are disposed adjacent to gaps between the openings in any of adjacent rows; a plurality of bridge groups respectively projecting on the first sides of the plates and being disposed at the gaps, each of the bridge groups including a plurality of bridges perpendicular to the flow direction and arranged in a row along the flow direction, a first pair of sub-bridges disposed on an upstream end of the row with respect to the flow direction and slanted from a center to both sides of the first pair toward the flow direction, and a second pair of sub-bridges disposed on a downstream end of the row with respect to the flow direction and slanted from both sides to a center of the second pair toward the flow direction; and a plurality of tubes configured to conduct a thermal medium, the tubes respectively penetrating the openings.

8. The heat exchanger of claim 7, wherein the openings are arranged at an even pitch in each row and a half of the pitch is not greater than diameters of the tubes.

9. The heat exchanger of claim 7, wherein each of the bridges and sub-bridges includes a pair of legs at both ends to be arranged along flow lines of the gas directed by the tubes.

10. The heat exchanger of claim 7, further comprising ribs projecting on the first sides of the plates and running at respective middles of the rows of the openings.