Specification

HEAT EXCHANGER

TECHNICAL FIELD

[0001] The present invention relates to a heat exchanger. More particularly, the invention relates to a heat exchanger suitable for use in air conditioners.

BACKGROUND ART

[0002] Conventionally, there has been a heat exchanger disclosed in JP 2000-35296 A.

[0003] This heat exchanger is composed of a plurality of fins stacked at prescribed intervals and a plurality of heat transfer tubes.

[0004] A plurality of the heat transfer tubes are inserted in a plurality of the fins at specified intervals.

[0005] A groove which extends in the direction along an outer edge of the longitudinal direction of the fin is formed in both ends of the width direction of the fin. The groove is to guide condensed water drops produced on the surface of the fin from the upper side to the lower side.

[0006] The conventional heat exchanger uses the groove to guide condensed water drops produced on the surface of

the fin from the upper side to the lower side so as to prevent the condensed water generated on the surface of the fin from being spattered to the outside together with the air.

[0007] However, in the conventional heat exchanger, when the formation position of the groove is too close to the outer edge of the fin or too close to the insertion hole formed in the fin for heat transfer tube insertion, problems arise such as deformation of the edge of the fin with the groove formed therein or deformation of the groove itself. The deformation of the groove leads to generation of a condensed water pool in the groove, making it difficult for condensed water to flow downward in the perpendicular direction. Moreover, the edge of the fin having the groove formed therein is deformed into a waved shape, causing a problem of injuring people with the waved outer edge of the fin.

SUMMARY OF THE INVENTION

[0008] An object of the present invention is to provide a heat exchanger which is capable of smoothly guiding condensed water, generated on the surface of the fin, downward so as not to allow the condensed water to be spattered to the outside and whose fin is not curved nor waved so as not to injure people.

[0009] In order to attain the object, the present invention provides a heat exchanger, comprising:

a plurality of heat transfer tubes; and

at least one plate-shaped fin having a rib generally parallel to an outer edge of the fin and having insertion holes for receiving the heat transfer tubes,

wherein the rib is placed closer to the outer edge than all the insertion holes are, and

wherein when an inside diameter of the insertion holes is set as D [mm], a distance between a center of the insertion hole nearest to the rib and the outer edge is set as L [mm], and a distance between a center of the rib and the outer edge is set as La [mm], then

$0.4 < La < (L-D/2-0.5)$.

[0010] It is to be noted that the center of the rib refers to the center in the width direction of the rib.

[0011] According to the invention, since the rib is formed on the fin according to the present invention, the rib defines a watercourse or water channel by surface tension. Therefore, condensed water does not spatter, or splash easily from the fin.

[0012] According to the present invention, because $0.4<La$ holds, it is possible to prevent the rib from becoming too close to the outer edge of the fin and therefore deformation of the edge portion and/or the rib of

the fin can be avoided. Also, because La<(L-D/2-0.5) holds, it is possible to prevent the rib becoming close to the insertion holes enough to cause deformation of the rib.

[0013] Therefore, since the rib formed on the fin is prevented from deformation, it becomes possible to prevent the rib to have an area where condensed water generated could not easily flow down. This allows the condensed water generated on the surface of the fin to flow downward promptly along the rib in the vertical direction. Therefore, it becomes possible to prevent increase of resistance to air flow associated with narrowing of an airflow path for heat exchange of the fin due to stagnation of condensed water. As a result, heat transfer performance is enhanced. Also, since there is little deformation of the fin, increase in airflow resistance and generation of noise due to fin tilting or falling can be prevented.

[0014] In one embodiment, when a width of the rib is set as LL [mm], a thickness of the fin is set as t [mm], and a height of the rib is set as h [mm], then $0.15 < LL < 0.5$, $0.05 < t < 0.15$, and $0.5t < h < 2.5t$.

[0015] In this embodiment, because 0.15<LL holds, deformation of the rib is prevented with certainty. Also, because LL<0.5 holds, it becomes possible to make the condensed water flow downward without any problem. Since 0.05<t, the strength of the fin can be brought to a

satisfactory level, and since $t<0.15$, it becomes possible to increase the stacking density of the fins and thereby achieve excellent heat exchanging efficiency. Since $0.5t<h$, condensed water can be made to flow downward without any problem, and since $h<2.5t$, it becomes possible to prevent the air flow from colliding with the rib, thereby preventing generation of turbulence and the like so as to achieve smooth air flow.

[0016] In one embodiment, the outer edge of the fin inclines relative to the vertical direction in a condition that the heat exchanger is placed in a refrigeration device in use.

[0017] The "refrigeration device" here refers to an air conditioner, a refrigerator, an ice machine, and the like.

[0018] In this embodiment, the outer edge of the fin inclines relative to the vertical direction in the condition that the heat exchanger is placed in a refrigeration device in use, so that the condensed water present near the outer edge, which tends to fly out of the fin, can surely be made to flow downward through the rib. This can ensure that the condensed water is prevented from jumping out of the fin.

[0019] In one embodiment, the heat exchanger is incorporated in an indoor unit of an air conditioner.

[0020] In this embodiment, it is possible to surely prevent dew from being spattered or scattered into a room.

[0021] In one embodiment, the inside diameter D of the insertion hole is 7.5 mm or less.

[0022] When the inside diameter D of the insertion hole 22 is 7.5 mm or less, resistance to air flow becomes small, so that the heat exchanger is put in an operation condition where large air quantity tends to cause water splashing. However, since the fin is provided with the rib having the above-stated shape and arrangement, water splashing from the fin can surely be prevented even when the heat exchanger is put in the operation condition involving large air quantity.

[0023] In one embodiment, the fin has a raised portion.

[0024] In this embodiment, forming the raised portion in the fin brings an advantage of high heat exchanging efficiency, though it also generates variation in resistance to air flow among the places with and without the raised portion, which may result in uneven airflow speed distribution and cause water splashing in an area where the airflow speed is high. However, the water splashing can surely be prevented with the presence of the rib having the above-stated shape and arrangement.

[0025] In one embodiment, the rib is formed on the fin at least on the leeward of the heat transfer tubes.

[0026] Since the rib is formed at the leeward area of the fin according to the embodiment, it becomes possible to certainly prevent the condensed water generated on the fin from being blown by a heat transfer medium and scattering from the fin.

[0027] In one embodiment, the rib is formed on the fin at least on the windward of the heat transfer tubes.

[0028] Since the rib is formed in a windward area of the fin according to the embodiment, it becomes possible to prevent the condensed water, which is generated in a windward area of the fin and which takes a granular shape with surface tension, from spattering from the windward edge of the fin.

[0029] In one embodiment, the rib is formed on the fin both on the windward of and the leeward of the heat transfer tubes.

[0030] Since the rib is formed in a leeward area of the fin and in a windward area of the fin according to the embodiment, it becomes possible to surely prevent the condensed water from spattering from the fin.

(Effect of the Invention)

[0031] According to the invention, since the rib is formed on the fin according to the present invention, the rib defines a watercourse or water channel by surface

tension. Therefore, condensed water does not scatter easily from the fin.

[0032] According to the present invention, because $0.4<La$ holds, it is possible to prevent the rib from becoming too close to the outer edge of the fin and therefore deformation of the edge portion and/or the rib of the fin can be avoided. Also, because $La<(L-D/2-0.5)$ holds, it is possible to prevent the rib becoming close to the insertion holes enough to cause deformation of the rib.

[0033] According to an embodiment, because $0.15<LL<0.5$ holds, it becomes possible to make the condensed water flow downward without any problem and prevent deformation of the rib with certainty. Also, because $0.05<t<0.15$, the strength of the fin can be brought to a satisfactory level. Also, it becomes possible to increase the stacking density of the fins and thereby achieve excellent heat exchanging efficiency. Furthermore, since $0.5t<h<2.5t$, condensed water can be made to flow downward without any problem, and smooth air flow is achieved.

[0034] According to an embodiment, the outer edge of the fin inclines relative to the vertical direction in the condition that the heat exchanger is placed in a refrigeration device in use, so that the condensed water present near the outer edge, which tends to fly out of the fin, can surely be made to flow downward through the rib.

This can ensure that the condensed water is prevented from jumping out of the fin.

BRIEF DESCRIPTION OF THE DRAWINGS

[0035] The present invention will become more fully understood from the detailed description given hereinbelow and the accompanying drawings which are given by way of illustration only, and thus are not intended to limit the present invention, and wherein:

Fig. 1 is a schematic cross sectional view showing an air conditioner having a heat exchanger in a first embodiment of the present invention;

Fig. 2A is a detailed view showing a part of a fin included in the heat exchanger of the first embodiment;

Fig. 2B is a detailed view showing a part of a fin included in the heat exchanger of the first embodiment;

Fig. 3A is a view showing an example of the rib formed on the fin;

Fig. 3B is a view showing an example of the rib formed on the fin;

Fig. 3C is a view showing an example of the rib formed on the fin; and

Fig. 3D is a view showing an example of the rib formed on the fin.

DETAILED DESCRIPTION OF THE INVENTION

[0036] The present invention will be described in detail below based on the embodiments shown in the figures.

[0037] Fig. 1 is a schematic cross sectional view showing an air conditioner using a heat exchanger in an embodiment of the present invention. In Fig. 1, reference numeral 1 denotes a blower fan, and 2 denote a heat exchanger. In Fig. 1, arrow a shows a vertically upward direction in the state where the heat exchanger is placed in the air conditioner in use, and arrow b shows a flow direction of air as a heat transfer medium. In Fig. 1, a casing in which the blower fan 1 and the heat exchanger 2 are housed is omitted for simplicity's sake.

[0038] This air conditioner is designed such that the blower fan 1 is rotated to blow out air, which was sucked in via the heat exchanger 2, through an unshown blowoff opening.

[0039] The heat exchanger 2 includes fins 6 and heat transfer tubes (unshown). The fins 6 are provided so as to be disposed at specified intervals in a direction perpendicular to the drawing sheet of Fig. 1. Each fin 6 is in a flat plate shape. The fin 6 has a configuration which is bent like an upset V-letter so that its upper part in the vertical direction shown in Fig. 1 by arrow a forms a protruding section.

[0040] The fin 6 has an outer edge inclined with respect to the vertical direction, and also has a first section 8 and a second section 9 which form the bent part, and a third section 10 which links to a lower part in the vertical direction of the second section 9. As shown in Fig. 1, the first section 8 is located downstream of the flow of air from the second section 9. The third section 10 extends in a generally vertical direction. The first section 8, the second section 9, and the third section 10 have an elongate, rectangular-shaped cross section.

[0041] A first rib 15 extending generally in parallel with the longitudinal direction of the second section 9 is formed on a longitudinal edge portion on the leeward of the second section 9. Thus, in the first embodiment, the fin 6 has a rectangular-shaped section, with the first rib 15 extending generally in parallel with an outer edge of the longitudinal direction of the rectangular-shaped section. The rib 15 guides condensed water generated on the surface of the fin 6 downward in the vertical direction in order to prevent the condensed water from flying or being splashed out of the fin 6.

[0042] There are arranged a plurality of heat transfer tubes. Each heat transfer tube extends in a direction in which the fins 6 are arranged or arrayed, i.e., in the direction normal to the surface of the plate-shaped fin 5

(a direction perpendicular to the drawing sheet of Fig. 1). The heat transfer tubes are inserted through the fins 6 which are arrayed at specified intervals. As shown in Fig. 1, in each of the first section 8, the second section 9, and the third section 10, insertion holes for receiving the heat transfer tubes are provided in two rows in staggered arrangement.

[0043] More specifically, in the first section 8, the insertion holes are arranged in two rows in the width direction and in 16 rows in the longitudinal direction, while in the second section 9, the insertion holes are arranged in two rows in the width direction and twelve rows in the longitudinal direction. In the third section 10, the insertion holes are arranged in two rows in the width direction and in eight rows in the longitudinal direction.

[0044] Each of the two rows arranged in the width direction of the insertion holes in the first section 8 is generally parallel to the longitudinal outer edge of the first section 8, while each of the two rows arranged in the width direction of the insertion holes in the second section 9 is generally parallel to the longitudinal outer edge of the second section 9. Each of the two rows arranged in the width direction of the insertion holes in the third section 10 is generally parallel to the longitudinal outer edge of the third section 10.

[0045] Fluid runs through the heat transfer tubes. This heat exchanger performs heat exchange between the fluid flowing through the heat transfer tubes and the air running over the heat transfer tube.

[0046] Figs. 2A and 2B are views showing the second section 9 of the fin 6 in detail. More specifically, Fig. 2A is a partial enlarged view showing the second section 9 of the fin 6. Fig. 2B is a part of the cross sectional view of Fig. 2A taken along an α-α line.

[0047] In Fig. 2A and Fig. 2B, reference numeral 15 denotes a rib and reference numeral 22 denotes an insertion hole formed through the fin 6 for insertion of the heat transfer tube. In Fig. 2A, arrow b shows a flow of air. In Fig. 2A, only the inside diameter of the insertion hole 22 is shown and the detailed aperture shape of the insertion hole is omitted for simplicity's sake.

[0048] The rib 15 extends generally in parallel with an outer edge 25 of the plate-shaped fin 6. The plate-shaped fin 6 has insertion holes 22 for insertion of a plurality of heat transfer tubes. Moreover, the first rib 15 is placed closer to the outer edge 25 than all the insertion holes 22 are.

[0049] In this embodiment, as shown in Fig. 2A and Fig. 2B, when the inside diameter of the insertion hole 22 is set as D [mm], a distance between the center of the

insertion hole 22 nearest to the rib 15 and the outer edge 25 is set as L [mm], and a distance between the center of the rib 15 and the outer edge 25 is set as La [mm], then La is designed to satisfy the following equation (1):

$$0.4 < La < (L-D/2-0.5) \quad \ldots (1)$$

[0050] As shown in Fig. 2B, when the width of the rib 15 is set as LL [mm], the thickness of the fin 6 is set as t [mm] and the height of the rib 15 is set as h [mm], then the fin 6 and the rib 15 are set so as to satisfy the following equations (2), (3), and (4).

$$0.15 < LL < 0.5 \quad \ldots (2)$$

$$0.05 < t < 0.15 \quad \ldots (3)$$

$$0.5t < h < 2.5t \quad \ldots (4)$$

[0051] According to the heat exchanger of the embodiment, the rib 15 formed at the leeward edge portion of the second section 9, which constitutes a part of the fins 6, forms a watercourse by surface tension. Therefore, it becomes possible to guide the condensed water generated on the surface of the fin 6 downward in the vertical direction with the rib 15 and thereby prevent the condensed water from flying out of the fin 6.

[0052] According to the heat exchanger in the embodiment, $0.4<La$ holds, which prevents the center of the rib 15 from becoming too close to the outer edge of the fin 6 and thus avoids deformation of the edge portion and/or

the rib 15 of the fin 6. Also, because La<(L-D/2-0.5) holds, the center of the rib 2 is prevented from becoming too close to positions at which the heat transfer tubes are inserted through the fin (i.e., positions of the insertion holes 22 for receiving the heat transfer tubes) and thus deformation of the rib 15 is avoided.

[0053] This can prevent the edge portion of the fin 6 from deforming and thereby prevent the outer edge of the fin 6 from injuring people. Moreover, since the rib 15 formed on the fin 6 is prevented from deformation, it becomes possible to prevent the rib 2 to have an area where condensed water generated could not easily flow down. This allows the condensed water generated on the surface of the fin 6 to flow downward promptly along the rib 2 in the vertical direction. Therefore, it becomes possible to prevent increase of resistance to air flow associated with narrowing of an airflow path for heat exchange of the fin 6 due to stagnation of condensed water, as a result of which heat transfer performance is enhanced.

[0054] According to the heat exchanger of the embodiment, 0.15<LL holds so that deformation of the rib 15 can be prevented with certainty, and also LL<0.5 holds so that it becomes possible to make the condensed water flow downward without any problem. Since 0.05<t, the strength of the fin 6 is brought to a satisfactory level, and since

$t<0.15$, it becomes possible to increase the stacking density of the fins 6 and thereby achieve excellent heat exchanging efficiency. Since $0.5t<h$, condensed water is made to flow downward without any problem, and since $h<2.5t$, it becomes possible to prevent the air flow from colliding with the rib 15, thereby preventing generation of turbulence and the like so as to achieve smooth air flow.

[0055] According to the heat exchanger of the embodiment, the outer edge 25 of the fin 6 inclines relative to the vertical direction in a condition that the fin 6 is placed in a refrigeration device in use, so that the condensed water present near the outer edge 25, which tends to fly out of the fin 6, can surely be made to flow downward through the rib 15. This can ensure that the condensed water is prevented from jumping out of the fin.

[0056] According to the heat exchanger of the embodiment, the rib 15 is formed at the edge portion on the leeward side of the fin 6, so that it becomes possible to surely prevent the condensed water generated on the fin 6 from being blown by the air and issuing forth from the fin.

[0057] When the heat exchanger 2 of the embodiment is incorporated in the indoor unit of the air conditioner, it becomes possible to surely prevent dew from being spattered into a room.

[0058] When inside diameter D of the insertion hole 22 is 7.5 mm or less, resistance to air flow becomes small, so that the heat exchanger 2 is put in an operation condition where large air quantity tends to cause water splashing. However, since the rib 15 having the above-stated shape and arrangement is provided on the fin 6, water splashing from the fin 15 can surely be prevented even when the heat exchanger is put in the operation condition involving large air quantity.

[0059] In the heat exchanger in the first embodiment, as shown in Fig. 2B, the rib 15 is formed in such a manner that it projects from one surface 27 of the plate-shaped fin 6 so as to satisfy the equations (1) to (4). However, in this invention, a plurality of ribs that satisfy the equation (1) (preferably, equations (1) to (4)) may be formed so that they project from one surface of the plate-shaped fin. A plurality of ribs that satisfy the equation (1) (preferably, equations (1) to (4)) may also be formed so as to project from both the surfaces (e.g., surface 27 and surface 28 in Fig. 2B) of the plate-shaped fin.

[0060] In the heat exchanger of the embodiment, one rib 15 generally parallel to the outer edge 25 is formed only on the leeward side in the width direction of the second section 9. However, in this invention, one or more ribs may be formed so as to satisfy the equation (1)

(preferably, equations (1) to (4)). For example, it is acceptable not only to provide one or more ribs generally parallel to the outer edge on the leeward side in the width direction of the second section, but also to provide one or more ribs generally parallel to the outer edge of the first section on the windward side in the width direction of the first section, while providing one or more ribs generally parallel to the outer edge of the first section on the leeward side in the width direction of the first section and providing one or more ribs generally parallel to the outer edge of the third section on the leeward side in the width direction of the third section. In this case, the condensed water on the fin 6 is positively prevented from being spattered from the fin 6.

[0061] Although in the heat exchanger of the embodiment, the heat transfer tubes are placed in two rows in staggered arrangement in the width direction of the second section 9 and one rib is formed on the leeward side of the second section 9, the heat exchanger in this invention may be structured so that heat transfer tubes are arranged in one row, i.e., one per the width of the fin, or in three or more rows in staggered arrangement in the width direction of the fin at least in a part of the fin and that one or more ribs which satisfy the equation (1) (preferably,

equations (1) to (4)) are formed at least in a part of the longitudinal edge portion of the fin.

[0062] For example, as shown in Fig. 3A, holes for insertion of heat transfer tubes may be placed in one row in a fin 30, while at an longitudinal edge portion of the fin 30 on the downstream side of the flow of air shown by arrow c, one rib 32 generally parallel to an outer edge of the edge portion may be formed. Also, as shown in Fig. 3B, holes for insertion of heat transfer tubes may be placed in one row, i.e., one hole per the width, in a fin 40, while at a longitudinal edge portion of the fin 40 on the upstream side of the flow of air shown by arrow d, one rib 42 generally parallel to an outer edge of the edge portion may be formed. Also, as shown in Fig. 3C, holes for insertion of heat transfer tubes may be placed in one row in a fin 50, while at longitudinal edge portions of the fin 50 on the upstream side and the downstream side of the flow of air shown by arrow e, ribs 52 and 53 generally parallel to outer edges of those edge portions may be formed, respectively. Also, as shown in Fig. 3D, holes for insertion of heat transfer tubes may be placed in two rows in staggered arrangement in the width direction of a fin 60, while at longitudinal edge portions of the fin 60 on both the upstream side and the downstream side of the flow of air shown by an arrow f, ribs 62, 63 generally parallel

to outer edges of those edge portions may be formed, respectively.

[0063] In the heat exchanger of the embodiment, the rib 15 is formed in almost the entire edge portion on the leeward of the second section 9. According to this invention, however, the rib may be provided only in a part of the edge portion such that the rib extends generally parallel to the part of the outer edge of the fin. For example, the rib may be provided only in a part of the edge portion on the leeward of the second section so as to extend generally parallel to the outer edge of that part of the edge portion.

[0064] In the heat exchanger of the embodiment, the fin 6 is composed of the first section 8 and second section 9 which form a bend section, and the third section 10. However, according to this invention, the fin on which the rib is formed may take any shape, without being limited to the shape described in this embodiment, for example, the fin may be composed of one plate having a flat or circular-arc shaped cross section.

[0065] In the heat exchanger of the embodiment, as shown in Fig. 2B, a groove 29 having a trapezoidal cross section is formed on the back side of the area where the rib 15 is formed. In this invention, however, grooves other than the groove having a trapezoidal cross section, such as grooves

having a V-shaped section or a U-shaped section, may be formed on the back side of the area where the rib is formed. It is not imperative to form the groove on the back side of the area where the rib is formed.

[0066] The plurality of insertion holes 22 of the fin 6 are provided in staggered arrangement in the heat exchanger of the embodiment. In this invention, however, a plurality of insertion holes may be placed on the fin in other arrangement pattern, such as lattice arrangement.

[0067] Although a raised portion is not formed in the fin 6 in the heat exchanger of the embodiment, at least one raised piece may be provided by making, for example, a U-shaped cut in a part of the fin in the heat exchanger of this invention. Forming the raised portion in the fin brings an advantage of high heat exchanging efficiency, though it also generates variation in resistance to air flow among the places with and without the raised portion, which may result in uneven airflow speed distribution and cause water splashing in an area where the airflow speed is high. However, in the heat exchanger of this invention, the water splashing can surely be prevented with the presence of the rib having the above-stated shape and arrangement. Therefore, heat exchanging efficiency can be enhanced and the water splashing from the fin can also be prevented with certainty.

[0068] Moreover in the heat exchanger of this invention, the rib may be formed in all of the plurality of fins. Of the plurality of fins, only one or more fins may be formed with the rib and there may be fins without the rib.

[0069] Although the heat exchanger of this invention is applied to air conditioners in the above embodiment, it should be understood that the heat exchanger of this invention can be applied to devices other than the air conditioners, such as the refrigerators.

[0070] Embodiments of the invention being thus described, it will be obvious that the same may be varied in many ways. Such variations are not to be regarded as a departure from the spirit and scope of the invention, and all such modifications as would be obvious to one skilled in the art are intended to be included within the scope of the following claims.

CLAIMS:

1. A heat exchanger, comprising:

a plurality of heat transfer tubes; and

at least one plate-shaped fin (6) having a rib (15) generally parallel to an outer edge (25) of the fin and having insertion holes (22) for receiving the heat transfer tubes,

wherein the rib (15) is placed closer to the outer edge (25) than all the insertion holes (22) are, and

wherein when an inside diameter of the insertion holes (22) is set as D [mm], a distance between a center of the insertion hole (22) nearest to the rib (15) and the outer edge (25) is set as L [mm], and a distance between a center of the rib (15) and the outer edge (25) is set as La [mm], then

$$0.4 < La < (L-D/2-0.5).$$

2. The heat exchanger according to claim 1, wherein

when a width of the rib (15) is set as LL [mm], a thickness of the fin (6) is set as t [mm], and a height of the rib (15) is set as h [mm], then

$$0.15 < LL < 0.5,$$

$$0.05 < t < 0.15, \text{ and}$$

$$0.5t < h < 2.5t.$$

3. The heat exchanger according to claim 1, wherein the outer edge (25) of the fin (6) inclines relative to the vertical direction in a condition that the heat exchanger is placed in a refrigeration device in use.

4. The heat exchanger according to claim 3, which is incorporated in an indoor unit of an air conditioner.

5. The heat exchanger according to claim 3, wherein the inside diameter D of the insertion hole (22) is 7.5 mm or less.

6. The heat exchanger according to claim 3, wherein the fin has a raised portion.