

DESCRIPTION

Title of Invention

EVAPORATOR

[Technical Field]

[0001]

The present disclosure relates to an evaporator.

[Background Art]

[0002]

A liquid film-type evaporator in which a liquid-phase refrigerant is supplied from above to a heat transfer pipe group through which a medium to be cooled circulates is known as an evaporator used in a chiller. Such a liquid film-type evaporator is provided with pipe for refrigerant supply to a heat transfer pipe group (for example, Patent Document 1).

[0003]

Patent Document 1 describes a liquid film-type evaporator in which the entire area of both end surfaces of longitudinally extending refrigerant supply pipe is closed. This pipe supplies a refrigerant to a heat transfer pipe group by blowing out the refrigerant from a plurality of slits formed in a pipe bottom portion.

[Citation List]

[Patent Document]

[0004]

[Patent Document 1] Chinese Patent No. 105408703

[Summary of Invention]

[Technical Subject]

[0005]

However, in refrigerant supply pipe in which the entire area of both end surfaces is closed as in Patent Document 1, the flow speed of the refrigerant circulating in the pipe significantly decreases toward the longitudinal end portion. The refrigerant circulating in the refrigerant supply pipe is in a gas-liquid mixed state, and thus the effect of gravity leads to gas-liquid separation when the flow speed decreases. As a result, a liquid-phase refrigerant accumulates in the bottom portion of the pipe and the liquid-phase refrigerant is easy to flow out of the slit. Accordingly, the amount of the liquid-phase refrigerant that reaches the longitudinal end portion may decrease.

A decrease in the amount of the liquid-phase refrigerant that reaches the longitudinal end portion results in a distribution in the amount of the refrigerant that is supplied to the heat transfer pipe group. As a result, the heat exchange efficiency in the heat transfer

pipe group may decline and the performance of the evaporator may decline.

[0006]

The present disclosure has been made in view of such circumstances, and an object of the present invention is to provide an evaporator capable of improving heat exchange efficiency and improving the performance of the evaporator.

[Subject to be solved]

[0007]

In order to solve the above subjects, the evaporator of the present disclosure employs the following means.

An evaporator according to one aspect of the present disclosure includes: a housing forming an outer shell; a first heat transfer pipe group accommodated in the housing, immersed in a liquid-phase refrigerant stored in a storage portion provided in a lower portion of the housing, and having a plurality of first heat transfer pipes in which a medium to be cooled circulates; a second heat transfer pipe group accommodated in the housing, provided above a liquid surface of the liquid-phase refrigerant stored in the lower portion of the housing, and having a plurality of second heat transfer pipes in which a medium to be cooled circulates and which extend in a predetermined direction; and a refrigerant supply pipe accommodated in

the housing, extending in the predetermined direction, allowing a gas-liquid two-phase-state refrigerant to circulate inside, and supplying the refrigerant from above to the second heat transfer pipe group, in which the refrigerant supply pipe has a closing portion closing at least a lower end portion of an end surface in the predetermined direction and an opening portion formed in the end portion in the predetermined direction and above the closing portion and connecting an inner space of the refrigerant supply pipe and an outer space of the refrigerant supply pipe.

[Advantageous Effects of Invention]

[0008]

According to the present disclosure, heat exchange efficiency can be improved and the performance of the evaporator can be improved.

[Brief Description of Drawings]

[0009]

Fig. 1 is a schematic vertical cross-sectional view of the evaporator according to the present disclosure.

Fig. 2 is a cross-sectional view taken along the II-II arrow of Fig. 1.

Fig. 3 is a cross-sectional view taken along the III-III arrow of Fig. 1.

Fig. 4 is a front view illustrating a refrigerant supply pipe provided in the evaporator of Fig. 1.

Fig. 5 is a side view illustrating the refrigerant supply pipe of Fig. 4.

Fig. 6 is a graph illustrating the relationship between the position of the refrigerant supply pipe in a predetermined direction and the flow speed of a refrigerant at the position.

Fig. 7 is a graph illustrating the relationship between the position of the refrigerant supply pipe in the predetermined direction and the amount of refrigerant supply at the position.

Fig. 8 is a schematic perspective view of a refrigerant supply pipe according to a modification example.

Fig. 9 is a schematic vertical cross-sectional view of a refrigerant supply pipe according to a modification example of the present disclosure.

Fig. 10 is a schematic vertical cross-sectional view of a refrigerant supply pipe according to a modification example of the present disclosure.

Fig. 11 is a schematic vertical cross-sectional view of a refrigerant supply pipe according to a modification example of the present disclosure.

Fig. 12 is a schematic vertical cross-sectional view of a refrigerant supply pipe according to a modification example of the present disclosure.

[Description of Embodiments]

[0010]

Hereinafter, an embodiment of the evaporator according to the present disclosure will be described with reference to Figs. 1 to 12. It should be noted that in the following description and drawings, the vertical up-down direction is the Z-axis direction, the extension direction of a heat transfer pipe is the X-axis direction, and the Y-axis direction is orthogonal to the Z-axis direction and the X-axis direction.

[0011]

An evaporator 10 according to the present embodiment is applied to a centrifugal chiller. The centrifugal chiller includes, for example, a turbo compressor (not illustrated) compressing a refrigerant, a condenser (not illustrated) condensing the refrigerant compressed by the turbo compressor, an expansion valve (not illustrated) expanding the refrigerant condensed by the condenser, and an evaporator evaporating the refrigerant expanded by the expansion valve and is configured in a unit shape. Each device is connected by refrigerant circulation pipe. Used as the refrigerant is, for example, a low-pressure

refrigerant such as R1233zd used at a maximum pressure of less than 0.2 MPaG.

[0012]

As illustrated in Fig. 1, the evaporator 10 has a pressure vessel (housing) 11 forming an outer shell, a refrigerant inlet pipe 12 introducing a refrigerant into the pressure vessel 11, a refrigerant supply pipe 13 provided below the refrigerant inlet pipe 12, a flooded-type heat transfer pipe group (first heat transfer pipe group) 14 immersed in the liquid-phase refrigerant stored in the lower portion of the pressure vessel 11, a liquid film-type heat transfer pipe group (second heat transfer pipe group) 15 provided above a liquid surface S (see Figs. 2 and 3) of the liquid-phase refrigerant stored in the lower portion of the pressure vessel 11, and a refrigerant outlet pipe (refrigerant outlet) 16 discharging the evaporated refrigerant from the pressure vessel 11.

[0013]

As illustrated in Figs. 1 to 3, the pressure vessel 11 integrally has a cylindrical portion 11a with a central axis extending along the X-axis direction and two pipe plates 11b closing both end portions of the cylindrical portion 11a in the direction along the central axis (X-axis direction). The cylindrical portion 11a is disposed so as to have a substantially horizontal central axis.

Each pipe plate 11b is a disk-shaped plate member. In addition, the liquid-phase refrigerant is stored in the lower portion of the pressure vessel 11. Hereinafter, the region where the liquid-phase refrigerant is stored will be referred to as a storage portion 11c.

[0014]

The refrigerant inlet pipe 12 is a cylindrical member extending in the up-down direction and is formed in a substantially linear shape. The refrigerant inlet pipe 12 is provided so as to penetrate the upper portion of the cylindrical portion 11a in the up-down direction. The refrigerant inlet pipe 12 is provided substantially at the center of the cylindrical portion 11a in the X-axis direction. The refrigerant inlet pipe 12 is connected to the pipe (not illustrated) by which the evaporator 10 and the expansion valve are connected. In other words, the refrigerant expanded by the expansion valve is guided into the pressure vessel 11 via the refrigerant inlet pipe 12.

[0015]

The refrigerant supply pipe 13 is accommodated in the pressure vessel 11. The refrigerant supply pipe 13 is provided above the liquid film-type heat transfer pipe group 15. The refrigerant supply pipe 13 extends in the X-axis direction. The lower end of the refrigerant inlet pipe 12 is connected to the upper portion of the

refrigerant supply pipe 13 substantially at the center in the X-axis direction. A gas-liquid two-phase-state refrigerant introduced from the refrigerant inlet pipe 12 circulates in the refrigerant supply pipe 13. A plurality of slits 13a are formed in the lower end portion of the refrigerant supply pipe 13. Each slit 13a is formed such that the Y-axis direction is the longitudinal direction thereof. The plurality of slits 13a are disposed side by side at equal intervals in the X-axis direction. The refrigerant circulating in the refrigerant supply pipe 13 is blown out of each slit 13a. The refrigerant supply pipe 13 supplies the refrigerant blown out of each slit 13a to the liquid film-type heat transfer pipe group 15 from above.

[0016]

The flooded-type heat transfer pipe group 14 is accommodated in the pressure vessel 11. In addition, the flooded-type heat transfer pipe group 14 is immersed in the refrigerant stored in the storage portion 11c. In other words, the flooded-type heat transfer pipe group 14 is disposed below the liquid surface S of the stored refrigerant. The flooded-type heat transfer pipe group 14 has a plurality of first heat transfer pipes extending along the X-axis direction. The plurality of first heat transfer pipes are disposed substantially in parallel.

The plurality of first heat transfer pipes are disposed side by side at predetermined intervals in the up-down direction and the Y-axis direction. Specifically, the plurality of first heat transfer pipes are arranged in a plurality of stages in the up-down direction and in a plurality of rows in the Y-axis direction. Water as a medium to be cooled (hereinafter, referred to as "water to be cooled") circulates in each first heat transfer pipe. In addition, each first heat transfer pipe is formed in a linear shape. In addition, each first heat transfer pipe extends from one end (left end in Fig. 1) to the other end (right end in Fig. 1) of the pressure vessel 11 in the X-axis direction and penetrates each pipe plate 11b. The length of the flooded-type heat transfer pipe group 14 in the X-axis direction is longer than the length of the refrigerant supply pipe 13 in the X-axis direction. It should be noted that in Figs. 1 to 3, for the sake of illustration, the first heat transfer pipes are collectively illustrated as the flooded-type heat transfer pipe group 14 without being illustrated one by one.

[0017]

The liquid film-type heat transfer pipe group 15 is accommodated in the pressure vessel 11. The liquid film-type heat transfer pipe group 15 is disposed above the liquid surface S of the stored refrigerant. The liquid

film-type heat transfer pipe group 15 has a plurality of second heat transfer pipes extending along the X-axis direction. The plurality of second heat transfer pipes are disposed substantially in parallel. The plurality of second heat transfer pipes are disposed side by side at predetermined intervals in the up-down direction and the Y-axis direction. Specifically, the plurality of second heat transfer pipes are arranged in a plurality of stages in the up-down direction and in a plurality of rows in the Y-axis direction. Water as a medium to be cooled circulates in each second heat transfer pipe. In addition, each second heat transfer pipe is formed in a linear shape. In addition, each second heat transfer pipe extends from one end (left end in Fig. 1) to the other end (right end in Fig. 1) of the pressure vessel 11 in the X-axis direction and penetrates each pipe plate 11b. The length of the liquid film-type heat transfer pipe group 15 in the X-axis direction is longer than the length of the refrigerant supply pipe 13 in the X-axis direction. It should be noted that in Figs. 1 to 3, for the sake of illustration, the second heat transfer pipes are collectively illustrated as the liquid film-type heat transfer pipe group 15 without being illustrated one by one.

[0018]

The liquid film-type heat transfer pipe group 15 has a lower liquid film-type heat transfer pipe group 15b provided above the liquid surface S and an upper liquid film-type heat transfer pipe group 15c provided above the lower liquid film-type heat transfer pipe group 15b. The lower liquid film-type heat transfer pipe group 15b and the lower liquid film-type heat transfer pipe group 15b are separated from each other in the up-down direction.

[0019]

One end of the flooded-type heat transfer pipe group 14 and the lower liquid film-type heat transfer pipe group 15b (left end in Fig. 1) is disposed in an introduction portion 17 into which the water to be cooled is introduced. The introduction portion 17 is disposed outside the pressure vessel 11. The water to be cooled is supplied to the introduction portion 17 from a device (not illustrated) supplying the water to be cooled (see arrow A5). The water to be cooled flows from the one end into the flooded-type heat transfer pipe group 14 and the lower liquid film-type heat transfer pipe group 15b (see arrow A6).

[0020]

In addition, the other end of the flooded-type heat transfer pipe group 14 and the lower liquid film-type heat transfer pipe group 15b (right end in Fig. 1) is disposed

in a return portion 18. In addition, the other end of the upper liquid film-type heat transfer pipe group 15c (right end in Fig. 1) is also disposed in the return portion 18. The return portion 18 is disposed outside the pressure vessel 11. The liquid to be cooled that has circulated in the flooded-type heat transfer pipe group 14 and lower liquid film-type heat transfer pipe group 15b is discharged into the return portion 18 from the other end of the flooded-type heat transfer pipe group 14 and the lower liquid film-type heat transfer pipe group 15b (see arrow A7). The liquid to be cooled discharged to the return portion 18 flows into the upper liquid film-type heat transfer pipe group 15c from the other end of the upper liquid film-type heat transfer pipe group 15c (see arrow A8).

[0021]

One end of the upper liquid film-type heat transfer pipe group 15c (left end in Fig. 1) is disposed in a discharge portion 19 where the water to be cooled is discharged. The discharge portion 19 is disposed outside the pressure vessel 11. The water to be cooled is discharged to the discharge portion 19 from the one end of the upper liquid film-type heat transfer pipe group 15c (see arrow A9). The refrigerant that has flowed into the discharge portion 19 is cooled and becomes cold water by

heat exchange with the water in each heat transfer pipe group. This cold water is discharged from the discharge portion 19 (see arrow A10) and is used as, for example, a cold heat medium for air conditioning or industrial cooling water.

[0022]

The refrigerant outlet pipe 16 is a cylindrical member extending in the up-down direction. The refrigerant outlet pipe 16 is provided so as to communicate with the opening that is formed in the upper portion of the cylindrical portion 11a. The refrigerant outlet pipe 16 is provided on the end portion side of the cylindrical portion 11a in the X-axis direction. In other words, the refrigerant outlet pipe 16 is provided in the vicinity of the pipe plate 11b of the pressure vessel 11. The refrigerant evaporated by the evaporator 10 is discharged to the outside of the pressure vessel 11 via the refrigerant outlet pipe 16.

[0023]

Next, details of the refrigerant supply pipe 13 will be described in detail with reference to Figs. 4 and 5.

As illustrated in Fig. 4, the refrigerant supply pipe 13 is a pipe-shaped member extending along the X-axis direction. As illustrated in Fig. 5, the refrigerant supply pipe 13 is formed in a substantially rectangular

shape in a side view. In addition, the refrigerant supply pipe 13 is curved such that the lower end portion protrudes downward in a side view. The slits 13a are formed in substantially the entire area of a curved portion 13b in the Y-axis direction.

[0024]

In addition, closing portions 20 are provided at both ends of the refrigerant supply pipe 13 in the X-axis direction. Each closing portion 20 closes each end surface of the refrigerant supply pipe 13 in the X-axis direction. An opening portion 21 is formed in each closing portion 20. The opening portion 21 is formed in a substantially central portion of the closing portion 20 in the Z-axis direction. In other words, the closing portion 20 has a lower closing portion 20b closing the part below the opening portion 21 of the refrigerant supply pipe 13 (including the lower end portion) and an upper closing portion 20a closing the part above the opening portion 21 of the refrigerant supply pipe 13. In addition, the positions and shapes of the opening portions 21 formed in the closing portions 20 are substantially the same.

[0025]

The opening portion 21 is formed above the lower closing portion 20b. The opening portion 21 is formed so as to penetrate the closing portion 20. In other words,

the opening portion 21 connects the inner space of the refrigerant supply pipe 13 and the outer space of the refrigerant supply pipe 13. The opening area of the opening portion 21 is equal to or greater than the opening area of the slit 13a formed in the endmost portion in the X-axis direction. The opening portion 21 is formed over substantially the entire area of the refrigerant supply pipe 13 in the Y-axis direction. In addition, the length of the opening portion 21 in the Z-axis direction is shorter than half of the length of the refrigerant supply pipe 13 in the Z-axis direction. The length of the opening portion 21 in the Z-axis direction may be approximately one-third of the length of the refrigerant supply pipe 13 in the Z-axis direction. It should be noted that the present disclosure is not limited thereto. The length of the opening portion 21 in the Z-axis direction may be longer than half of the length of the refrigerant supply pipe 13 in the Z-axis direction.

[0026]

The refrigerant supply pipe 13 is supported in the pressure vessel 11 by a support plate (second shielding plate portion) 22. The support plate 22 is disposed so as to have a vertical plate surface. The support plate 22 is fixed to the upper portion and the side portion of the inner peripheral surface of the pressure vessel 11. In

addition, an opening is formed in the support plate 22, and the refrigerant supply pipe 13 is inserted in the opening. The refrigerant supply pipe 13 inserted into the opening is disposed so as not to protrude from the support plate 22. The support plate 22 is positioned above and beside the upper liquid film-type heat transfer pipe group 15c. The height of the lower end of the support plate 22 is substantially the same as the height of the upper end of the lower liquid film-type heat transfer pipe group 15b. In this manner, the support plate 22 is provided between the opening portion 21 and the refrigerant outlet pipe 16.

It should be noted that the support plate 22 may also serve as the end surface of the refrigerant supply pipe 13. In other words, the refrigerant supply pipe 13 may be configured by attaching a pipe-shaped member extending along the X-axis direction to the support plate 22.

It should be noted that the refrigerant supply pipe 13 may be supported in the pressure vessel 11 by other means without providing the support plate 22.

[0027]

A refrigerant or the like circulates as follows in the evaporator 10 configured as described above.

As illustrated in Fig. 1, in the evaporator 10, the refrigerant flows into the pressure vessel 11 from the

refrigerant inlet pipe 12 (see arrow A1). The refrigerant that has flowed into the pressure vessel 11 circulates in the refrigerant supply pipe 13 in the X-axis direction (see arrow A2). The refrigerant circulating in the refrigerant supply pipe 13 is in a gas-liquid two-phase-state. The liquid-phase refrigerant circulating in the refrigerant supply pipe 13 is blown out downward via the multiple slits 13a formed at the lower end of the refrigerant supply pipe 13 (see arrow A3). The liquid-phase refrigerant blown out of the refrigerant supply pipe 13 comes into contact with the second heat transfer pipe disposed in the uppermost stage of the liquid film-type heat transfer pipe group 15 (upper liquid film-type heat transfer pipe group 15c) and covers the outer peripheral surface of the second heat transfer pipe in a film shape. The refrigerant that covers the outer peripheral surface of the second heat transfer pipe in the film shape exchanges heat with the water to be cooled in the second heat transfer pipe. A part of the refrigerant evaporates as a result of the heat exchange, and the unevaporated refrigerant falls to the second heat transfer pipe disposed further below. Such heat exchange is repeated continuously. The refrigerant that does not evaporate even by heat exchange with the water in the second heat transfer pipe disposed in the lowermost portion is stored

in the storage portion 11c provided in the lower portion of the pressure vessel 11. In this manner, a pool of the liquid-phase refrigerant is formed in the pressure vessel 11. The level of the liquid surface of this refrigerant pool is automatically adjusted to a predetermined height. The first heat transfer pipe of the flooded-type heat transfer pipe group 14 is in a state of being immersed in the liquid-phase refrigerant stored in the storage portion 11c. The water to be cooled circulating in the first heat transfer pipe exchanges heat with the refrigerant stored in the storage portion 11c. The refrigerant that has exchanged heat with the first heat transfer pipe evaporates and is guided upward from the liquid surface S. The refrigerant evaporated in the liquid film-type heat transfer pipe group 15 and the flooded-type heat transfer pipe group 14 is guided to the refrigerant outlet pipe 16. The refrigerant guided to the refrigerant outlet pipe 16 is discharged to the outside of the pressure vessel 11 (see arrow A4). The refrigerant discharged from the refrigerant outlet pipe 16 is suctioned and compressed by the turbo compressor.

[0028]

The action and effect of the present embodiment are as follows.

In the present embodiment, the opening portion 21 is formed in the end portion of the refrigerant supply pipe 13. A part of the gas-phase refrigerant that makes up the gas-liquid two-phase-state refrigerant circulating in the refrigerant supply pipe 13 circulates to the end portion of the refrigerant supply pipe 13 and is discharged to the outside from the opening portion 21. As a result, the flow speed of the gas-phase refrigerant circulating in the refrigerant supply pipe 13 is unlikely to decrease even in the end portion. In the refrigerant supply pipe 13, the liquid-phase refrigerant is accompanied by the gas-phase refrigerant. Accordingly, the liquid-phase refrigerant can be easily guided to the end portion. Accordingly, the liquid-phase refrigerant can be suitably supplied to the end portion, and thus the amount of the refrigerant supplied to the liquid film-type heat transfer pipe group 15 can be made uniform in the X-axis direction. Accordingly, heat exchange efficiency can be improved, and thus the performance of the evaporator 10 can be improved.

[0029]

The effect of preventing a decrease in refrigerant amount in the end portion will be described with reference to Figs. 6 and 7. Figs. 6 and 7 are simulation results regarding the refrigerant supply pipe 13 according to the present embodiment.

The horizontal axis of Figs. 6 and 7 indicates the position of the refrigerant supply pipe 13 in the X-axis direction. Specifically, the axis indicates the position from the center to one end (or the other end) in the X-axis direction. 0 on the horizontal axis indicates the center of the refrigerant supply pipe 13 in the X-axis direction, and 1 on the horizontal axis indicates one end (or the other end) of the refrigerant supply pipe 13 in the X-axis direction. In addition, the vertical axis of Fig. 6 indicates the flow speed in the X-axis direction of the refrigerant flowing in the refrigerant supply pipe 13. Specifically, the axis indicates the ratio in a case where the flow speed at the center of the refrigerant supply pipe 13 in the X-axis direction is 1. In addition, the vertical axis of Fig. 7 indicates the amount of the liquid-phase refrigerant blown out of the slit 13a. Specifically, the axis indicates the ratio in a case where the blow-out amount of the refrigerant in a case where the refrigerant is evenly blown out of the slits 13a is 1.

[0030]

As illustrated in Fig. 6, in a case where the opening portion is not formed, the refrigerant flow speed decreases from the center toward the end portion in the X-axis direction, and the flow speed is zero in the end portion in the X-axis direction. As a result, as

illustrated in Fig. 7, the refrigerant blow-out amount is zero in the end portion.

On the other hand, as illustrated in Fig. 6, in a case where the opening portion 21 is formed, the decrease in flow speed is prevented as compared with the case where the opening portion is not formed although the refrigerant flow speed decreases from the center to the end portion in the X-axis direction as in the case where the opening portion is not formed. As a result, the flow speed is not zero in the end portion in the X-axis direction. Accordingly, as illustrated in Fig. 7, the refrigerant blow-out amount in the end portion is also non-zero and the refrigerant is blown out also in the end portion. In this manner, in the present embodiment, the liquid-phase refrigerant can be suitably supplied up to the end portion in the X-axis direction.

[0031]

In addition, in the present embodiment, the closing portion 20 closing the lower end portion of the end surface of the refrigerant supply pipe 13 or the like is provided and the opening portion 21 is formed above the closing portion 20. In the refrigerant supply pipe 13, the liquid-phase refrigerant accompanied by the gas-phase refrigerant easily circulates through the lower portion in the refrigerant supply pipe 13 by gravity (see also a

refrigerant R in Fig. 8). As a result, the liquid-phase refrigerant accompanied by the gas-phase refrigerant moves up to the end surface of the refrigerant supply pipe 13 and collides with the closing portion 20. Accordingly, it is possible to make it difficult for the liquid-phase refrigerant to be discharged from the opening portion 21 of the refrigerant supply pipe 13. Accordingly, it is possible to prevent a decrease in the amount of the refrigerant supplied via the slit 13a to the liquid film-type heat transfer pipe group 15.

[0032]

In addition, in the present embodiment, the opening portion 21 is formed substantially at the center of the refrigerant supply pipe 13 in the height direction. As described above, in the refrigerant supply pipe 13, the liquid-phase refrigerant easily circulates through the lower portion in the refrigerant supply pipe 13. Accordingly, by forming the opening portion 21 substantially at the center, it is possible to make it more difficult for the liquid-phase refrigerant to be discharged from the opening portion 21. Accordingly, it is possible to further prevent a decrease in the amount of the refrigerant supplied to the liquid film-type heat transfer pipe group 15.

[0033]

In addition, in the present embodiment, the support plate 22 is provided between the opening portion 21 and the refrigerant outlet pipe 16. As a result, the gas-phase refrigerant discharged from the opening portion 21 (see arrow A11 in Fig. 1) is once guided downward (see arrow A12 in Fig. 1) and then guided upward, where the refrigerant outlet pipe 16 provided on the pressure vessel 11 is. Accordingly, in a case where the gas-phase refrigerant discharged from the opening portion 21 accompanies the liquid-phase refrigerant, the liquid-phase refrigerant can be separated from the gas-phase refrigerant by gravity. Accordingly, a phenomenon in which the gas-phase refrigerant discharged from the refrigerant outlet pipe 16 to the outside of the pressure vessel 11 accompanies a liquid-phase refrigerant (so-called carryover) can be made unlikely to occur.

[0034]

In addition, the separated liquid-phase refrigerant falls downward. In the present embodiment, the length of the liquid film-type heat transfer pipe group 15 in the X-axis direction is longer than the length of the refrigerant supply pipe 13 in the X-axis direction. In other words, in a plan view, the end portion of the liquid film-type heat transfer pipe group 15 protrudes beyond the end portion of the refrigerant supply pipe 13. As a

result, the liquid-phase refrigerant that has fallen after separation comes into contact with the protruding part of the liquid film-type heat transfer pipe group 15. Accordingly, even in a case where the gas-phase refrigerant discharged from the opening portion 21 accompanies a liquid-phase refrigerant, the accompanied liquid-phase refrigerant can be evaporated.

In addition, although it is usually difficult to supply a refrigerant to the protruding part of the liquid film-type heat transfer pipe group 15, it can be used for heat exchange by coming into contact with the liquid-phase refrigerant discharged from the opening portion 21. Accordingly, the performance of the evaporator 10 can be improved.

[0035]

[Modification Example 1]

It should be noted that the position where the opening portion is provided is not limited to the example described above. It is suitable that the opening portion is formed in the upper portion of the closing portion 20. The upper portion may be substantially the center in the Z-axis direction or above the substantially center. In addition, for example, as illustrated in Fig. 8, more suitable is a case where an opening portion 41 is formed above the position of a quarter from the upper end with

respect to the entire height of the refrigerant supply pipe 13. In the example illustrated in Fig. 8, the opening portion 41 is provided in the vicinity of the upper end portion of the closing portion 20.

In addition, the opening portion may be formed at a part other than the closing portion 20 of the refrigerant supply pipe 13. For example, it may be formed in the upper portion of the end portion of the refrigerant supply pipe 13 (see Fig. 11). In addition, it may be formed in the side portion of the end portion of the refrigerant supply pipe 13.

[0036]

[Modification Example 2]

In addition, a gas-liquid separation structure 50 may be provided in the refrigerant supply pipe 13 as illustrated in Figs. 9 to 11. The gas-liquid separation structure 50 is disposed in the refrigerant supply pipe 13 and in the vicinity of the opening portion 41. For example, as illustrated in Fig. 9, the gas-liquid separation structure includes a baffle plate (first shielding plate portion) 51 disposed closer to the central portion side in the X-axis direction than the opening portion 41 and extending downward from the upper portion of the inner peripheral surface of the refrigerant supply pipe 13, a horizontal surface portion 52 extending from

the lower end of the opening portion 41 to the inner portion side of the refrigerant supply pipe 13, and a vertical portion 53 bent upward and extending from the tip of the horizontal surface portion 52. The baffle plate 51 and the vertical portion 53 face each other and are disposed apart from each other. The lower end of the baffle plate 51 is positioned below the lower end of the opening portion 41.

As a result, a first flow path 54 where a refrigerant heads upward from below is formed between the baffle plate 51 and the vertical portion 53. In addition, a second flow path 55 where the refrigerant heads downward from above is formed by the inner peripheral surface of the refrigerant supply pipe 13, the vertical portion 53, and the horizontal surface portion 52.

[0037]

The action and effect of this modification example are as follows.

As illustrated in Fig. 9, the liquid-phase refrigerant R adheres to the upper portion of the inner peripheral surface of the refrigerant supply pipe 13. The refrigerant that has adhered to the upper portion moves toward the end portion by being accompanied by the circulating gas-phase refrigerant. In this modification example, the baffle plate 51 is provided closer to the

central portion side in the X-axis direction than the opening portion 41. As a result, the liquid-phase refrigerant moving toward the end portion is blocked by the baffle plate 51 and thus does not reach the opening portion 41. Accordingly, it is possible to make it more difficult for the liquid-phase refrigerant to be discharged from the opening portion 41.

In addition, in this modification example, the gas-phase refrigerant circulating in the refrigerant supply pipe 13 is guided to the opening portion 41 by bypassing the baffle plate 51. As a result, the liquid-phase refrigerant accompanied by the gas-phase refrigerant can be centrifuged by the centrifugal force in bypassing the baffle plate 51. Accordingly, it is possible to make it more difficult for the liquid-phase refrigerant to be discharged from the opening portion 41. In addition, in this modification example, the refrigerant can be centrifuged even when guided from the first flow path 54 to the second flow path 55.

[0038]

It should be noted that the gas-liquid separation structure is not limited to the example described above. For example, as illustrated in Fig. 10, the baffle plate 51 may configure the gas-liquid separation structure alone without the horizontal surface portion 52 and the vertical

portion 53 being provided. In addition, as illustrated in Fig. 11, an opening portion 57 may be formed in the upper portion of the end portion of the refrigerant supply pipe 13. Even with the configurations illustrated in Figs. 10 and 11, it is possible to make it difficult for the liquid-phase refrigerant to be discharged from an opening portion.

[0039]

[Modification Example 3]

In addition, as illustrated in Fig. 12, pipe (tube body) 60 may be inserted into the opening portion 21 formed in the closing portion 20. The pipe 60 is inserted so as to protrude into the refrigerant supply pipe 13. With such a configuration, the refrigerant R that has adhered to the upper portion of the inner peripheral surface of the refrigerant supply pipe 13 is blocked by the upper portion of the pipe 60. Accordingly, it is possible to make it more difficult for the liquid-phase refrigerant to be discharged from the opening portion 41.

[0040]

It should be noted that the present disclosure is not limited to the above embodiment and can be appropriately modified without departing from the gist thereof.

For example, the opening area of the opening portion formed in the closing portion 20 on one end side of the refrigerant supply pipe 13 may be different from the opening area of the opening portion formed in the closing portion 20 on the other end side. With such a configuration, the amount of the gas-phase refrigerant discharged from the opening portion differs between the opening portion formed in one end portion and the opening portion formed in the other end portion. Accordingly, the flow speed of the gas-phase refrigerant circulating toward one end portion in the refrigerant supply pipe 13 and the flow speed of the gas-phase refrigerant circulating toward the other end portion in the refrigerant supply pipe 13 are also different. Accordingly, the amount of the liquid-phase refrigerant accompanied by the gas-phase refrigerant is also different, and thus the amount of the liquid-phase refrigerant guided to one end portion side and the amount of the liquid-phase refrigerant guided to the other end portion side can be made different. Accordingly, the amount of the refrigerant guided to each end portion can be adjusted. As a result, the amount of the refrigerant supplied to the liquid film-type heat transfer pipe group 15 can be adjusted along the X-axis direction. Accordingly, heat exchange efficiency can be improved in the liquid film-type heat transfer pipe group

15, and thus the performance of the evaporator 10 can be improved. It should be noted that for example, the opening portion on the side where the heat load of the liquid film-type heat transfer pipe group 15 is high may be formed larger than the opening portion on the side where the heat load of the liquid film-type heat transfer pipe group 15 is low.

[0041]

The evaporator described in the present embodiment described above is, for example, grasped as follows.

An evaporator according to one aspect of the present disclosure includes: a housing (11) forming an outer shell; a first heat transfer pipe group (14) accommodated in the housing, immersed in a liquid-phase refrigerant stored in a storage portion (11c) provided in a lower portion of the housing, and having a plurality of first heat transfer pipes in which a medium to be cooled circulates; a second heat transfer pipe group (15) accommodated in the housing, provided above a liquid surface (S) of the liquid-phase refrigerant stored in the lower portion of the housing, and having a plurality of second heat transfer pipes in which a medium to be cooled circulates and which extend in a predetermined direction; and a refrigerant supply pipe (13) accommodated in the housing, extending in the predetermined direction,

allowing a gas-liquid two-phase-state refrigerant to circulate inside, and supplying a refrigerant from above to the second heat transfer pipe group, in which the refrigerant supply pipe has a closing portion (20) closing at least a lower end portion of an end surface in the predetermined direction and an opening portion (21) formed in an end portion in the predetermined direction (X-axis direction) and above the closing portion and connecting an inner space of the refrigerant supply pipe and an outer space of the refrigerant supply pipe.

[0042]

In the above configuration, the opening portion is formed in the end portion of the refrigerant supply pipe. The gas-phase refrigerant that makes up the gas-liquid two-phase-state refrigerant circulating in the refrigerant supply pipe circulates to the end portion of the refrigerant supply pipe and is discharged to the outside from the opening portion. As a result, the flow speed of the gas-phase refrigerant circulating in the refrigerant supply pipe is unlikely to decrease even in the end portion. In the refrigerant supply pipe, the liquid-phase refrigerant is accompanied by the gas-phase refrigerant. Accordingly, the liquid-phase refrigerant can be easily guided to the end portion. Accordingly, the liquid-phase refrigerant can be suitably supplied to the end portion,

and thus the amount of the refrigerant supplied to the second heat transfer pipe group can be made uniform in the predetermined direction. Accordingly, heat exchange efficiency can be improved, and thus the performance of the evaporator can be improved.

In addition, the closing portion closing the lower end portion of the end surface of the refrigerant supply pipe is provided and the opening portion is formed above the closing portion. In the refrigerant supply pipe, the liquid-phase refrigerant accompanied by the gas-phase refrigerant easily circulates through the lower portion in the refrigerant supply pipe by gravity. As a result, the liquid-phase refrigerant accompanied by the gas-phase refrigerant moves up to the end surface of the refrigerant supply pipe and collides with the closing portion. Accordingly, it is possible to make it difficult for the liquid-phase refrigerant to be discharged from the opening portion of the liquid supply pipe. Accordingly, it is possible to prevent a decrease in the amount of the refrigerant supplied to the second heat transfer pipe group.

[0043]

In addition, in the evaporator according to one aspect of the present disclosure, the opening portion is formed in an upper portion of the refrigerant supply pipe.

[0044]

In the above configuration, the opening portion is formed in the upper portion of the refrigerant supply pipe. As described above, in the refrigerant supply pipe, the liquid-phase refrigerant easily circulates through the lower portion in the refrigerant supply pipe. Accordingly, by forming the opening portion in the upper portion, it is possible to make it more difficult for the liquid-phase refrigerant to be discharged from the opening portion. Accordingly, it is possible to further prevent a decrease in the amount of the refrigerant supplied to the second heat transfer pipe group.

It should be noted that the upper portion of the refrigerant supply pipe may be above the center of the refrigerant supply pipe in the height direction. In addition, more suitably, the portion may be above the position of a quarter from the upper end with respect to the entire height of the refrigerant supply pipe.

[0045]

In addition, in the evaporator according to one aspect of the present disclosure, the refrigerant supply pipe is provided with a first shielding plate portion (51) disposed closer to a central portion side in the predetermined direction than the opening portion and

extending downward from an upper portion of an inner peripheral surface of the refrigerant supply pipe.

[0046]

The liquid-phase refrigerant adheres to the upper portion of the inner peripheral surface of the refrigerant supply pipe. The refrigerant that has adhered to the upper portion moves toward the end portion by being accompanied by the circulating gas-phase refrigerant. In the above configuration, the first shielding plate portion is provided closer to the central portion side in the predetermined direction than the opening portion. As a result, the liquid-phase refrigerant moving toward the end portion is blocked by the first shielding plate portion and thus does not reach the opening portion. Accordingly, it is possible to make it more difficult for the liquid-phase refrigerant to be discharged from the opening portion. Accordingly, it is possible to further prevent a decrease in the amount of the refrigerant supplied to the second heat transfer pipe group.

In addition, in the above configuration, the gas-phase refrigerant circulating in the refrigerant supply pipe is guided to the opening portion by bypassing the first shielding plate portion. As a result, the liquid-phase refrigerant accompanied by the gas-phase refrigerant can be centrifuged by the centrifugal force in bypassing

the first shielding plate portion. Accordingly, it is possible to make it more difficult for the liquid-phase refrigerant to be discharged from the opening portion. Accordingly, it is possible to further prevent a decrease in the amount of the refrigerant supplied to the second heat transfer pipe group.

It should be noted that the lower end of the first shielding plate portion may be positioned below the lower end of the opening portion.

[0047]

In addition, in the evaporator according to one aspect of the present disclosure, a tube body (60) is inserted in the opening portion.

[0048]

In the above configuration, the tube body is inserted in the opening portion. As a result, the refrigerant that has adhered to the upper portion of the inner peripheral surface of the refrigerant supply pipe is blocked by the upper portion of the tube body. Accordingly, it is possible to make it more difficult for the liquid-phase refrigerant to be discharged from the opening portion. Accordingly, it is possible to further prevent a decrease in the amount of the refrigerant supplied to the second heat transfer pipe group.

[0049]

In addition, in the evaporator according to one aspect of the present disclosure, a refrigerant outlet (16) discharging an evaporated refrigerant outward is provided on the housing, a length of the second heat transfer pipe group in the predetermined direction is longer than a length of the refrigerant supply pipe in the predetermined direction, and a second shielding plate portion (22) is provided above the refrigerant supply pipe and between the opening portion and the refrigerant outlet.

[0050]

In the above configuration, the second shielding plate portion is provided between the opening portion and the outlet pipe. As a result, the gas-phase refrigerant discharged from the opening portion is once guided downward and then guided upward, where the refrigerant outlet provided on the housing is. Accordingly, in a case where the gas-phase refrigerant discharged from the opening portion accompanies the liquid-phase refrigerant, the liquid-phase refrigerant can be separated from the gas-phase refrigerant by gravity. Accordingly, a phenomenon in which the gas-phase refrigerant discharged from the refrigerant outlet to the outside of the housing accompanies a liquid-phase refrigerant (so-called carryover) can be made unlikely to occur.

In addition, the separated liquid-phase refrigerant falls downward. In the above configuration, the length of the second heat transfer pipe group in the predetermined direction is longer than the length of the refrigerant supply pipe in the predetermined direction. In other words, in a plan view, the end portion of the second heat transfer pipe group protrudes beyond the end portion of the refrigerant supply pipe. As a result, the liquid-phase refrigerant that has fallen after separation comes into contact with the protruding part of the second heat transfer pipe group. Accordingly, even in a case where the gas-phase refrigerant discharged from the opening portion accompanies a liquid-phase refrigerant, the accompanied liquid-phase refrigerant can be evaporated.

In addition, although it is usually difficult to supply a refrigerant to the protruding part of the second heat transfer pipe group, it can be used for heat exchange by coming into contact with the liquid-phase refrigerant discharged from the opening portion. Accordingly, the performance of the evaporator can be improved.

[0051]

In addition, in the evaporator according to one aspect of the present disclosure, the opening portion is formed in both end portions of the refrigerant supply pipe in the predetermined direction, and an opening area of the

opening portion formed in one end portion in the predetermined direction is different from an opening area of the opening portion formed in the other end portion in the predetermined direction.

[0052]

In the above configuration, the opening area of the opening portion formed in one end portion in the predetermined direction is different from the opening area of the opening portion formed in the other end portion in the predetermined direction. As a result, the amount of the gas-phase refrigerant discharged from the opening portion differs between the opening portion formed in one end portion and the opening portion formed in the other end portion. Accordingly, the flow speed of the gas-phase refrigerant circulating toward one end portion in the refrigerant supply pipe and the flow speed of the gas-phase refrigerant circulating toward the other end portion in the refrigerant supply pipe are also different. Accordingly, the amount of the liquid-phase refrigerant accompanied by the gas-phase refrigerant is also different, and thus the amount of the liquid-phase refrigerant guided to one end portion side and the amount of the liquid-phase refrigerant guided to the other end portion side can be made different. Accordingly, the amount of the refrigerant guided to each end portion can be adjusted,

and thus the amount of the refrigerant supplied to the second heat transfer pipe group can be adjusted along the predetermined direction. Accordingly, heat exchange efficiency can be improved in the second heat transfer pipe group, and thus the performance of the evaporator can be improved.

It should be noted that for example, the opening portion on the side where the heat load of the second heat transfer pipe group is high may be formed larger than the opening portion on the side where the heat load of the second heat transfer pipe group is low.

[Reference Signs List]

[0053]

10: evaporator

11: pressure vessel (housing)

11a: cylindrical portion

11b: pipe plate

11c: storage portion

12: refrigerant inlet pipe (refrigerant inlet)

13: refrigerant supply pipe

13a: slit

13b: curved portion

14: flooded-type heat transfer pipe group (first heat transfer pipe group)

15: liquid film-type heat transfer pipe group
(second heat transfer pipe group)

15b: lower liquid film-type heat transfer pipe group

15c: upper liquid film-type heat transfer pipe group

16: refrigerant outlet pipe (refrigerant outlet)

17: introduction portion

18: return portion

19: discharge portion

20: closing portion

20a: upper closing portion

20b: lower closing portion

21: opening portion

22: support plate (second shielding plate portion)

41: opening portion

50: gas-liquid separation structure

51: baffle plate (first shielding plate portion)

52: horizontal surface portion

53: vertical portion

54: first flow path

55: second flow path

57: opening portion

60: pipe (tube body)

R: refrigerant

S: liquid surface

Claims

[Claim 1]

An evaporator comprising:

a housing forming an outer shell;

a first heat transfer pipe group accommodated in the housing, immersed in a liquid-phase refrigerant stored in a storage portion provided in a lower portion of the housing, and having a plurality of first heat transfer pipes in which a medium to be cooled circulates;

a second heat transfer pipe group accommodated in the housing, provided above a liquid surface of the liquid-phase refrigerant stored in the lower portion of the housing, and having a plurality of second heat transfer pipes in which a medium to be cooled circulates and which extend in a predetermined direction; and

a refrigerant supply pipe accommodated in the housing, extending in the predetermined direction, allowing a gas-liquid two-phase-state refrigerant to circulate inside, and supplying the refrigerant from above to the second heat transfer pipe group,

wherein the refrigerant supply pipe has a closing portion closing at least a lower end portion of an end surface in the predetermined direction and an opening portion formed in the end portion in the predetermined

direction and above the closing portion and connecting an inner space of the refrigerant supply pipe and an outer space of the refrigerant supply pipe.

[Claim 2]

The evaporator according to Claim 1, wherein the opening portion is formed in an upper portion of the refrigerant supply pipe.

[Claim 3]

The evaporator according to Claim 1 or 2, wherein the refrigerant supply pipe is provided with a first shielding plate portion disposed closer to a central portion side in the predetermined direction than the opening portion and extending downward from an upper portion of an inner peripheral surface of the refrigerant supply pipe.

[Claim 4]

The evaporator according to any one of Claims 1 to 3, wherein a tube body is inserted in the opening portion.

[Claim 5]

The evaporator according to any one of Claims 1 to 4, wherein

a refrigerant outlet discharging an evaporated refrigerant outward is provided on the housing,

a length of the second heat transfer pipe group in the predetermined direction is longer than a length of the refrigerant supply pipe in the predetermined direction, and

a second shielding plate portion is provided above the refrigerant supply pipe and between the opening portion and the refrigerant outlet.

[Claim 6]

The evaporator according to any one of Claims 1 to 5, wherein

the opening portions are formed in both end portions of the refrigerant supply pipe in the predetermined direction, and

an opening area of the opening portion formed in one end portion in the predetermined direction is different from an opening area of the opening portion formed in the other end portion in the predetermined direction.