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(54) HEAT EXCHANGER AND HEAT EXCHANGE SYSTEM COMPRISING THE HEAT EXCHANGER

(57) The present disclosure relates to a heat exchanger (100) and a heat exchange system comprising the heat exchanger (100). The heat exchanger (100) includes a shell (1) and heat exchange tubes (20) located in the shell (1), and further includes a flow guide device (10) which is disposed in the shell (1) and includes a receiving portion (11) arranged between two adjacent rows of heat exchange tubes (20) and extending substantially horizontally along a length direction of the shell

(1) for receiving liquid, and a guiding portion (12) arranged to guide the liquid received by the receiving portion (11) to a bottom inside the shell (1). The technical solutions of the present disclosure are easy to manufacture, install and maintain. They can overcome the adverse effects caused by inundation effect of tube bundle, save consumables such as heat exchange tubes, and ensure work performance of the system.

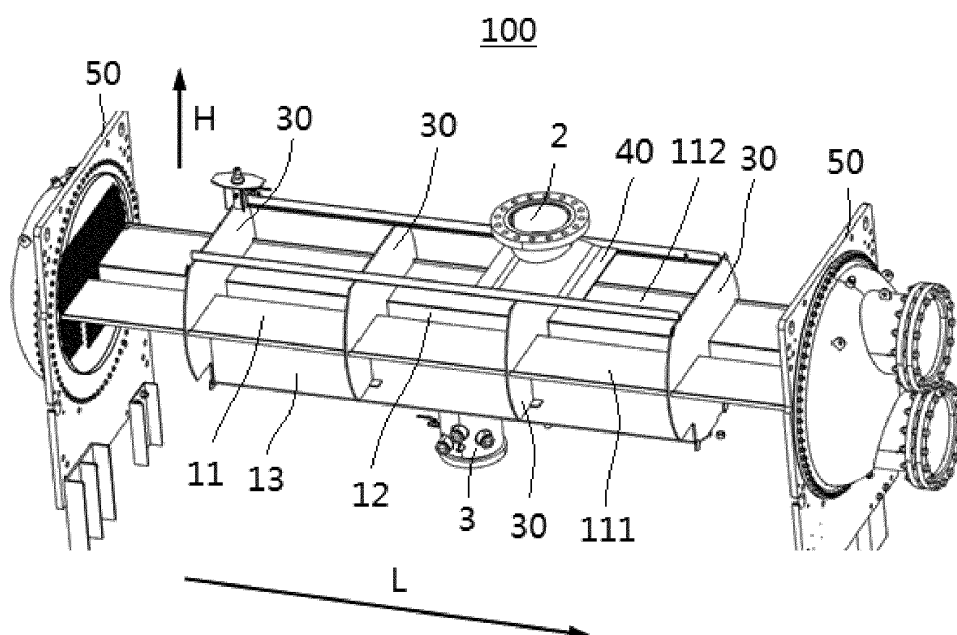


FIG. 1

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Description

FIELD OF THE INVENTION

[0001] The present disclosure relates to the technical field of heat exchange, and more particularly to a heat exchanger and a heat exchange system comprising the heat exchanger.

BACKGROUND OF THE INVENTION

[0002] Various types of heat exchange devices, apparatuses or systems have already emerged in the prior art, which have been widely used in many industrial fields, places, etc., and can bring great convenience. However, these existing heat exchange devices, apparatuses or systems still have some drawbacks and shortcomings in terms of structural configuration, heat exchange effect, work performance, manufacture, installation, maintenance and the like, and can be further improved and optimized. For example, when some centrifugal condensers are in operation, a tube bundle inundation effect may arise to cause a rapid decrease in the value of the tube outside heat transfer coefficient of the heat exchange tubes in the lower half of the condenser, thereby affecting the heat exchange efficiency and safe operation of the system. When the condenser shell has a large size and the number of tube rows is large, the above disadvantages will be more serious.

SUMMARY OF THE INVENTION

[0003] In view of the foregoing, the present disclosure provides a heat exchanger and a heat exchange system comprising the heat exchanger, thereby resolving or at least alleviating one or more of the problems described above as well as problems of other aspects existing in the prior art.

[0004] First, according to an aspect of the present disclosure, a heat exchanger is provided, which comprises a shell and heat exchange tubes located in the shell, wherein the heat exchanger further comprises a flow guide device, which is disposed in the shell and comprises a receiving portion arranged between two adjacent rows of heat exchange tubes and extending substantially horizontally along a length direction of the shell for receiving liquid, and a guiding portion arranged to guide the liquid received by the receiving portion to a bottom inside the shell.

[0005] In the heat exchanger according to the present disclosure, optionally, the receiving portion comprises a first portion and a second portion that are at the same height or different heights in a height direction of the shell, and the guiding portion is arranged to be located between the first portion and the second portion and face a guiding groove at the bottom inside the shell.

[0006] In the heat exchanger according to the present disclosure, optionally, at least a part of the receiving por-

tion is configured to have a contour that urges the liquid to flow toward the guiding portion.

[0007] In the heat exchanger according to the present disclosure, optionally, the receiving portion is configured such that an end portion on at least one side thereof is higher than a middle part of the receiving portion in a height direction of the shell, a gas flow channel is formed between the end portion and an inner wall of the shell, and the guiding portion is connected to the receiving portion and arranged in the middle part of the receiving portion.

[0008] In the heat exchanger according to the present disclosure, optionally, the receiving portion is arranged such that the number of heat exchange tubes located above the receiving portion is not larger than the number of heat exchange tubes located below the receiving portion.

[0009] In the heat exchanger according to the present disclosure, optionally, the receiving portion is arranged to be at a first preset distance from the nearest row of heat exchange tubes located above the receiving portion and at a second preset distance from the nearest row of heat exchange tubes located below the receiving portion, the second preset distance being not smaller than the first preset distance.

[0010] In the heat exchanger according to the present disclosure, optionally, the receiving portion is arranged to extend to tube plates at both ends of the heat exchanger.

[0011] In the heat exchanger according to the present disclosure, optionally, the heat exchanger further comprises:

a support member arranged in the shell for supporting at least part of the heat exchange tubes; and/or

a superheated gas diffuser arranged above the heat exchange tubes for guiding fluid entering from an inlet of the heat exchanger to diverge from both sides of the superheated gas diffuser; and/or

a supercooling chamber arranged inside the shell and communicating with an outlet of the heat exchanger, wherein the liquid at the bottom inside the shell enters the supercooling chamber through an opening at the bottom of the supercooling chamber.

[0012] In the heat exchanger according to the present disclosure, optionally, the heat exchanger is provided with at least two support members and the flow guide device is arranged at least between two adjacent support members.

[0013] Second, according to another aspect of the present disclosure, a heat exchange system is also provided, which comprises any one of the heat exchangers described above.

[0014] From the following detailed description combined with the accompanying drawings, the principles,

features, characteristics and advantages of various technical solutions according to the present disclosure will be clearly understood. For example, as compared with the prior art, the technical solutions of the present disclosure are easy to manufacture, install and maintain, and have a low cost of use. They can overcome the adverse effects caused by the inundation effect of the tube bundle, save consumables such as heat exchange tubes, and effectively ensure and improve work performance, safety and reliability of the system. The present disclosure has significant practicability.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] The technical solutions of the present disclosure will be described in further detail below with reference to the accompanying drawings and embodiments. However, it should be understood that these drawings are designed merely for the purpose of explanation and only intended to conceptually illustrate the structural configurations described herein, and are not required to be drawn to scale.

FIG. 1 is a schematic view of the internal three-dimensional structure of an embodiment of a heat exchanger according to the present disclosure after a shell is removed, in which some parts such as heat exchange tubes are omitted.

FIG. 2 is a schematic side sectional view of the heat exchanger according to the embodiment shown in FIG. 1.

FIG. 3 is a comparative explanatory view, in which "tube bundle inundation effect" in a condenser is schematically demonstrated by experimental test data, and the dashed line in the figure schematically shows an improvement of the tube outside heat transfer coefficient of the heat exchange tubes at the bottom after the embodiment of the heat exchanger of the present disclosure is applied.

DETAILED DESCRIPTION OF THE EMBODIMENT(S) OF THE INVENTION

[0016] First, it should be noted that the structural components, characteristics, advantages and the like of the heat exchanger and the heat exchange system comprising the heat exchanger according to the present disclosure will be specifically described below by way of example. However, it should be understood that all the descriptions are merely given for illustration, and should not be understood as limiting the present disclosure in any way. Herein, the technical terms "first" and "second" are merely used for distinguishing purpose, and are not intended to indicate their order and relative importance. The technical term "connect (or connected, etc.)" covers a situation where a specific component is directly con-

nected to another component and/or indirectly connected to another component. The technical term "substantially" is intended to include non-substantive errors associated with the measurement of a specific quantity (e.g., it may include a range of $\pm 8\%$, $\pm 5\%$ or $\pm 2\%$ of a given value). The technical terms "upper", "lower", "top", "bottom", "inner", "outer" and their derivatives should be associated with the orientations in the drawings. The present disclosure may take various alternative orientations, unless otherwise clearly indicated.

[0017] In addition, for any single technical feature described or implied in the embodiments mentioned herein, the present disclosure still allows for any combination or deletion of these technical features (or equivalents thereof). In addition, for the sake of simplification of the drawings, the same or similar parts and features may only be marked in one or several places in the same drawing.

[0018] Reference is made to FIGS. 1 and 2 in combination, an embodiment of a heat exchanger according to the present disclosure is schematically shown, which can be used as a heat exchange device such as a shell-and-tube type condenser in a heat exchange system according to application requirements.

[0019] As shown in FIGS. 1 and 2, the heat exchanger 100 may include a shell 1, a flow guide device 10, heat exchange tubes 20, support members 30, and a superheated gas diffuser 40. The heat exchange tubes 20 are arranged inside the shell 1. Heat energy transfer is achieved through heat exchange between a first fluid (such as liquid, gas or a mixture thereof) flowing inside these heat exchange tubes 20 and a second fluid (such as liquid, gas or a mixture thereof) flowing into an inner space of the shell 1 from an inlet 2 at the top of the heat exchanger 100 and flowing out of an outlet 3 at the bottom of the heat exchanger 100. In practical applications, the specific number, installation layout, structural dimensions and the like of the heat exchange tubes 20 inside the shell 1 may be set or adjusted according to specific requirements. For example, these heat exchange tubes 20 may be stacked to form a tube bundle array of two, three or more rows, wherein the numbers of heat exchange tubes 20 in different rows may be the same or different from each other.

[0020] Hereinafter, an exemplary description will be given in conjunction with the embodiment shown in the above drawings. As shown in FIG. 2, for the above-mentioned second fluid, it will enter the interior of the heat exchanger 100 via the inlet 2 along the direction indicated by arrow A. Since the superheated gas diffuser 40 (which may, for example, take the form of a baffle or the like) is disposed near the inlet 2 and located above the heat exchange tubes 20, the second fluid will be blocked by the superheated gas diffuser 40 at this position. Therefore, the second fluid will flow downward from both sides of the superheated gas diffuser 40 respectively in the directions indicated by the arrows drawn on both sides of the superheated gas diffuser 40 as shown in FIG. 2, then each contact the heat exchange tubes 20 arranged

in tube bundles under the superheated gas diffuser 40 to achieve heat energy exchange, and finally flows to the outside from the outlet 3 of the heat exchanger 100. In the above heat energy exchange process, the second fluid may directly condense on outer surfaces of at least part of the heat exchange tubes 20 to form a liquid (which, in many cases, may exist in the form of "liquid droplets"). The condensed liquid will increase with the operating time of the system, and will drip to the bottom of the shell 1 and accumulate more and more, so that the heat exchange tubes 20 near the bottom will be affected by the condensed liquid to produce the so-called "tube bundle inundation effect". For example, the outer surfaces of some heat exchange tubes 20 are even completely wrapped by the condensed liquid, which makes the surface heat transfer coefficient of these heat exchange tubes 20 seriously decrease, resulting in a significant decrease in the heat exchange efficiency and working performance of the system.

[0021] In the heat exchanger 100, the above problems can be effectively solved by providing the flow guide device 10. Specifically, as shown in FIGS. 1 and 2, the flow guide device 10 is arranged inside the shell 1, and it may be provided with a receiving portion 11 and a guiding portion 12. The receiving portion 11 and the guiding portion 12 may be connected, but they may not be connected. For example, the guiding portion 12 may be directly arranged below the receiving portion 11 and fixed to the shell 1 or other components in the shell 1, as long as it is ensured that the guiding portion 12 can guide the liquid received by the receiving portion 11 to the bottom 14 of the shell 1. According to different application requirements, the installation position of the receiving portion 11 may be set between any two adjacent rows of heat exchange tubes 20. The receiving portion 11 will extend substantially horizontally along the length direction L of the shell 1 (for example, optionally, it extends in the shell 1 all the way to tube plates 50 at both ends of the heat exchanger 100) to receive the above-mentioned condensed liquid. The liquid received by the receiving portion 11 will then be guided to the bottom 14 of the shell 1 through the guiding portion 12, so that the adverse effects caused by the lower half of the heat exchange tubes 20 due to the existence of the "tube bundle inundation effect" can be effectively reduced.

[0022] In an optional situation, a supercooling chamber 13 can also be provided in the shell 1, and heat exchange tubes are also provided in the supercooling chamber 13. The supercooling chamber 13 is also in communication with the outlet 3 of the heat exchanger, and the liquid entering the supercooling chamber 13 can be discharged to the outside through the outlet 3. The liquid located at the bottom 14 can enter the supercooling chamber 13 through, for example, one or more openings 15 provided at the bottom of the supercooling chamber 13, and then can exchange heat with the first fluid in the heat exchange tubes 20 in the supercooling chamber 13 to generate subcooling, which can increase the cooling capacity. In

practical applications, the supercooling chamber 13 may be configured into any suitable shape to meet various possible needs; for example, structural configuration such as rectangular parallelepiped, cube, cylinder, ellipsoid, or an irregular structure may be used. In addition, the present disclosure also allows the supercooling chamber 13 to be arranged at any suitable position inside the shell 1, such as on a directly lower side, a lower left side, or a lower right side of the interior of the shell 1. As another example, in an optional situation, the supercooling chamber 13 may be arranged to be partially or completely located in an array space formed by the heat exchange tubes 20, so that the space can be fully utilized to for example overcome the problems caused by the above "tube bundle inundation effect". For example, the above arrangement is schematically shown in FIG. 2.

[0023] In addition, the supercooling chamber 13 and the receiving portion 11 may be set to have the same length or different lengths in the length direction L of the heat exchanger 100. For example, the corresponding length of the supercooling chamber 13 may be set to be smaller than the corresponding length of the receiving portion 11.

[0024] With continued reference to FIGS. 1 and 2, in the embodiment given, the receiving portion 11 of the flow guide device 10 is optionally configured to have a first portion 111 and a second portion 112, and the guiding portion 12 is disposed between the first portion 111 and the second portion 112 to form a guiding groove for guiding the liquids received by the first portion 111 and the second portion 112 respectively to the bottom 14 of the shell 1. In the above-mentioned embodiment, the flow guide device 10 adopts a completely symmetrical or substantially symmetrical structural arrangement in the shell 1, that is, the first portion 111 and the second portion 112 are based on the same or substantially the same structure in this situation. They are also at the same height in the height direction H of the shell 1. However, it should be pointed out that in some embodiments, the first portion 111 and the second portion 112 may not only have different structures, but they may also be at different heights in the height direction H; for example, one is arranged at a higher position than the other. In some applications, possibly, this is to meet considerations such as the array arrangement of the heat exchange tubes 20, etc., so it can bring about more advantageous technical effects.

[0025] In addition, in an optional situation, the receiving portion 11 may be partially or entirely configured to have a contour that can urge the liquid that has been received by the receiving portion 11 to flow toward the guiding portion 12 more easily, while simultaneously avoiding outward leakage and overflow of the received liquid from the side of the receiving portion 11. For example, the above-mentioned contour may be of any feasible shape such as a curved arc surface or an inclined surface (such as forming a bent structure) inclined toward the guiding portion 12. For another example, one side end or both side ends of the receiving portion 11 may be set to be

higher than the middle part of the receiving portion 11 in the height direction H, so as to urge the fluid to flow more easily into the guiding portion 12 arranged below the middle part of the receiving portion 11 in this situation. In addition, the receiving portion 11 may be arranged to form a gas flow channel between its two side ends and the inner wall of the shell 1, and the guiding portion 12 located in the middle forms a liquid flow channel, so that the receiving portion 11 and the guiding portion 12 form gas and liquid flow channels that are clearly separated.

[0026] It should be noted that for the receiving portion 11, optionally, it is arranged such that the number of heat exchange tubes 20 located above the receiving portion 11 is not larger than the number of heat exchange tubes 20 located below the receiving portion 11, which can be determined based on application requirements. In addition, as shown in FIG. 2, the receiving portion 11 may be arranged to be at a preset distance S1 from the nearest row of heat exchange tubes 20 located above it and at another preset distance S2 from the nearest row of heat exchange tubes 20 located below it. By setting the above two preset distances S1 and S2, the second fluid can be promoted to flow therebetween, thus avoiding the formation of undesired flow dead zones and helping ensure and improve heat exchange. Their specific design conditions may be flexibly set according to different application requirements. For example, the preset distance S2 may be optionally set to be not smaller than the preset distance S1.

[0027] Although the solutions of the present disclosure have been discussed above in detail in combination with the embodiment shown in FIG. 1 and FIG. 2, it should be understood that many modifications, adjustments or replacements to the solutions of the present disclosure are allowed in practical applications. For example, several support members 30 are simultaneously provided inside the shell 1 of the heat exchanger 100 shown in FIG. 1, and components such as some or all of the heat exchange tubes 20 in the heat exchanger 100 can be supported and protected by these support members 30. FIG. 1 also schematically shows that the flow guide device 10 can be optionally installed between two adjacent support members 30; of course, in some other embodiments, it is also possible to provide no support member 30 or only one support member 30 in the present disclosure, or in some other embodiments, it is also possible to remove the above-mentioned superheated gas diffuser 40 and/or the supercooling chamber 13 in the present disclosure, and the flow guide device 10 may be arranged inside the shell 1 of the heat exchanger 100 in an asymmetric manner.

[0028] As an exemplary illustration, FIG. 3 provides a performance test comparison between an embodiment of the heat exchanger according to the present disclosure and a solution in the prior art. In FIG. 3, the abscissa represents the number of rows of heat exchange tubes arranged in the heat exchanger, and the ordinate represents a ratio of the tube outside heat transfer coefficient

hro(N) of the Nth row of heat exchange tubes and an average tube outside heat transfer coefficient hro(5) of the first five rows of heat exchange tubes. In the comparison test, the above average tube outside heat transfer coefficient hro(5) is used to ensure the accuracy, reliability and comparability of the test data. Except for the innovative setting of the flow guide device in the heat exchanger of the present disclosure, the same structural configuration was used during the test, and different heat exchange conditions (8 different heat exchange amounts of 900-2000 Ton) were implemented. First, the solid-line test data in FIG. 3 shows the "tube bundle inundation effect" occurring in existing condensers: the heat transfer coefficient of the tube bundle located at the lower part of the condenser will attenuate as the number of tube rows increases. Second, the dashed line in FIG. 3 schematically shows that after the present disclosure is applied, the tube outside heat transfer coefficient of the heat exchange tubes located at the lower part of the heat exchanger can be effectively improved.

[0029] It should be pointed out that according to the innovative design of the present disclosure, not only an improvement in the heat transfer performance outside the heat exchange tubes (especially, those at the lower part of the heat exchanger) can be brought about, but also due to the space occupied by the installation of the receiving portion 11 and the guiding portion 12 in the flow guide device, some heat exchange tubes may be omitted. According to a practical application example, the present disclosure can save about 10% of the number of heat exchange tubes and the system can still have the same working performance. Since the heat exchange tubes are usually made of copper material with good heat transfer performance but relatively expensive price, the material saving effect brought by the solutions of the present disclosure can lead to considerable benefits.

[0030] According to another technical solution of the present disclosure, a heat exchange system is also provided, and the heat exchange system can be provided with the heat exchanger designed and provided according to the present disclosure as illustrated above. For example, the heat exchanger can be used as a heat exchange device such as a condenser in the heat exchange system, so as to better solve the problems such as the "tube bundle inundation effect" in the prior art and for example realize the prominent technical advantages of the above-discussed present disclosure that are significantly superior to the prior art.

[0031] The heat exchanger and the heat exchange system comprising the heat exchanger according to the present disclosure have been elaborated above in detail by way of example only. These examples are merely used to illustrate the principles and embodiments of the present invention, rather than limiting the present inventions. Various modifications and improvements can be made by those skilled in the art without departing from the scope of the present invention, which is defined by the claims.

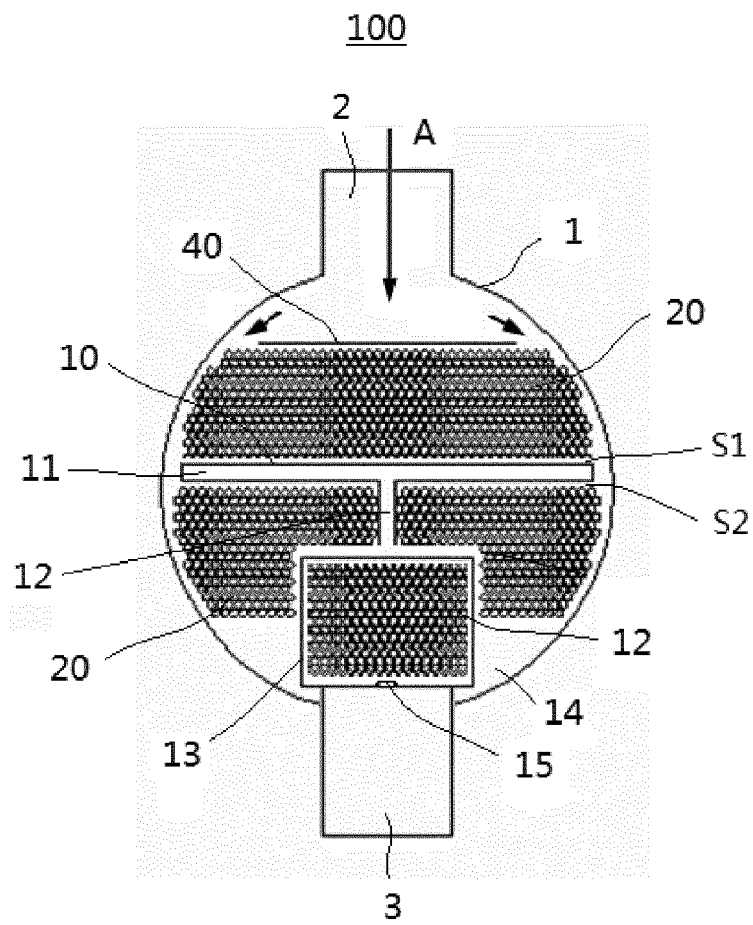
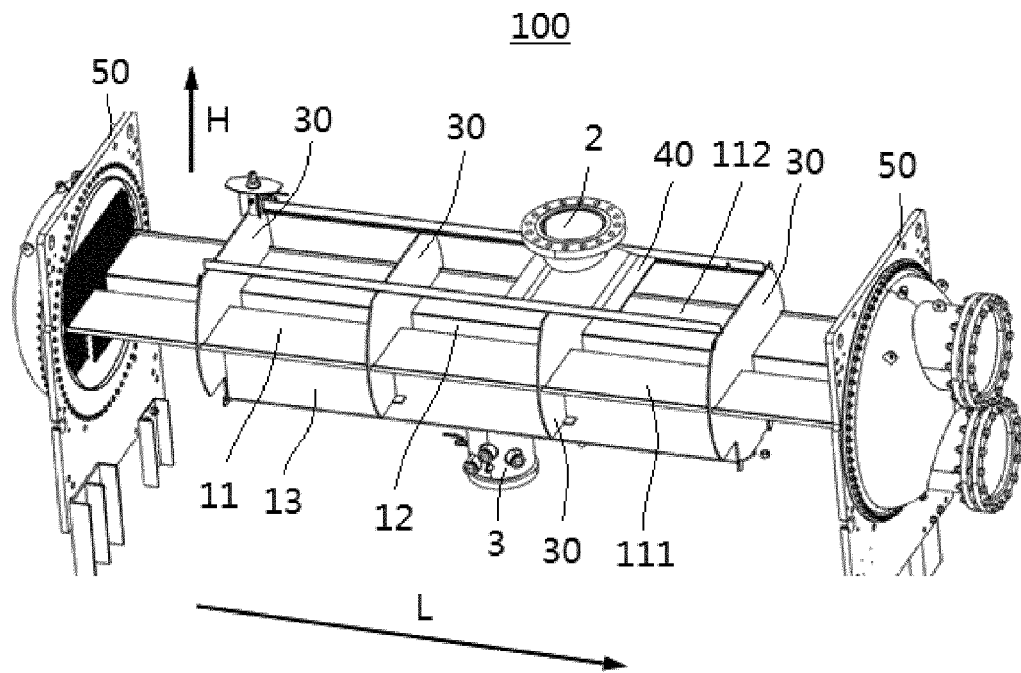
Claims

1. A heat exchanger (100), comprising a shell (1) and heat exchange tubes (20) located in the shell, wherein the heat exchanger further comprises a flow guide device (10), which is disposed in the shell and comprises a receiving portion (11) arranged between two adjacent rows of heat exchange tubes and extending substantially horizontally along a length direction of the shell for receiving liquid, and a guiding portion (12) arranged to guide the liquid received by the receiving portion to a bottom inside the shell. 5
2. A heat exchanger according to claim 1, wherein the receiving portion comprises a first portion (111) and a second portion (112) that are at the same height or different heights in a height direction of the shell, and the guiding portion is arranged to be located between the first portion and the second portion and face a guiding groove at the bottom inside the shell. 10
3. A heat exchanger according to claim 1 or 2, wherein at least a part of the receiving portion is configured to have a contour that urges the liquid to flow toward the guiding portion. 15
4. A heat exchanger according to claim 3, wherein the receiving portion is configured such that an end portion on at least one side thereof is higher than a middle part of the receiving portion in a height direction of the shell, wherein a gas flow channel is formed between the end portion and an inner wall of the shell, and wherein the guiding portion is connected to the receiving portion and arranged in the middle part of the receiving portion. 20
5. A heat exchanger according to any preceding claim, wherein the receiving portion is arranged such that the number of heat exchange tubes located above the receiving portion is not larger than the number of heat exchange tubes located below the receiving portion. 25
6. A heat exchanger according to any preceding claim, wherein the receiving portion is arranged to be at a first preset distance from the nearest row of heat exchange tubes located above the receiving portion and at a second preset distance from the nearest row of heat exchange tubes located below the receiving portion, the second preset distance being not smaller than the first preset distance. 30
7. A heat exchanger according to any preceding claim, wherein the receiving portion is arranged to extend to tube plates (50) at both ends of the heat exchanger. 35
8. A heat exchanger according to any preceding claim, 40

further comprising:

a support member (30) arranged in the shell for supporting at least part of the heat exchange tubes; and/or
 a superheated gas diffuser (40) arranged above the heat exchange tubes for guiding fluid entering from an inlet of the heat exchanger to diverge from both sides of the superheated gas diffuser; and/or
 a supercooling chamber (13) arranged inside the shell and communicating with an outlet of the heat exchanger, wherein the liquid at the bottom inside the shell enters the supercooling chamber through an opening at the bottom of the supercooling chamber. 45

9. A heat exchanger according to claim 8, wherein the heat exchanger is provided with at least two support members and the flow guide device is arranged at least between two adjacent support members. 50
10. A heat exchange system, comprising a heat exchanger according to any preceding claim. 55



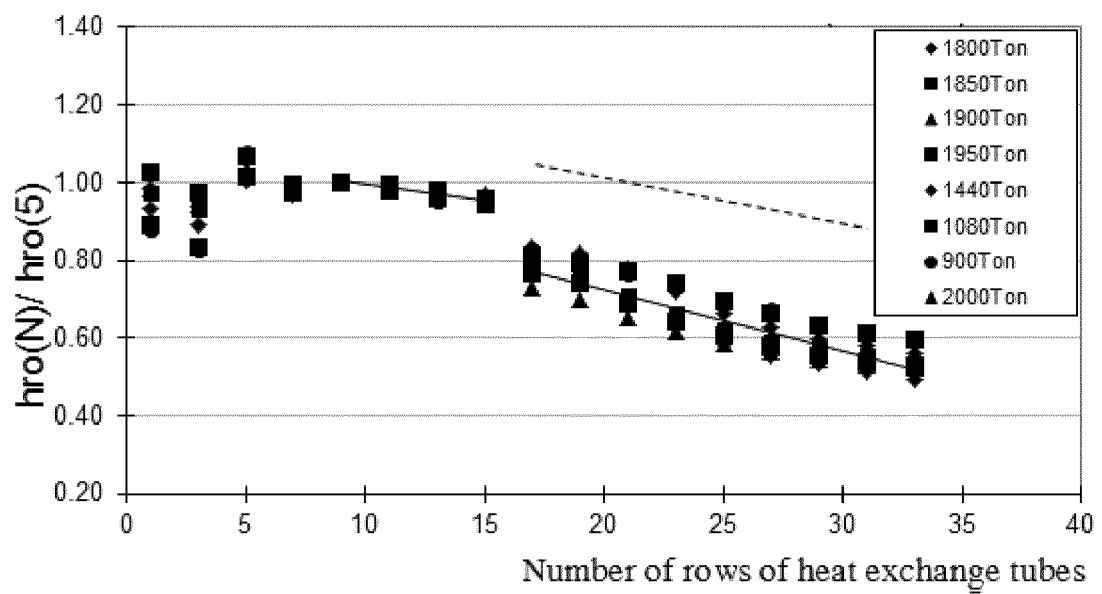


FIG. 3



EUROPEAN SEARCH REPORT

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