Abstract: An evaporator for a refrigeration system wherein a water makes a plurality of passes therethrough, includes a tube bundle assembly having a known tube bundle portion associated with each of a plurality of passes of water therethrough, each of a plurality of tubes of a tube bundle portion associated with a first water pass having a lesser diameter than the diameter of tubes of tube bundle portions associated with successive passes of water. A method of forming an evaporator is further included.
SHELL AND TUBE EVAPORATOR

Technical Field

The present invention relates to refrigeration systems. More particularly, the present invention relates to evaporators for use in a refrigeration system.

Background of the Invention

Centrifugal chillers, which are the workhorses of the comfort cooling industry, have very few moving parts (Prior Art Figure 1). Therefore, they usually offer high reliability and low maintenance requirements. A moving part is the compressor. A centrifugal compressor of the centrifugal chiller acts very much like a centrifugal fan, compressing the vapor flowing through it by spinning it from the center of an impeller wheel radially outward, allowing centrifugal forces to compress the vapor. Some machines use multiple impellers to compress the refrigerant in stages.

The compressor is in fluid communication with a shell and tube evaporator, as depicted in prior art Fig. 2. The evaporator acts to change the state of a refrigerant from a liquid to a vapor by warming the refrigerant. Warm water passes into the evaporator tube bundle and warms the liquid refrigerant, causing the refrigerant to change state to a vapor. The refrigerant vapor exits the evaporator at a suction nozzle under the motive force of a suction applied thereto by the compressor. Heat extracted from the liquid refrigerant acts to cool the water in the tube bundle. It should be noted that the prior art evaporator has a plurality of tubes contained within a shell. The tubes are all the same diameter.

There is a need in the industry to minimize the pressure drop on the water side of the chiller refrigeration system. Further, there is a need to reduce the cost of refrigeration systems without compromising performance.
Summary of the Invention

The present invention meets the aforementioned needs of the industry. By employing greater diameter tubes for each successive pass of the water through the evaporator, pressure loss in the evaporator is advantageously reduced as compared to prior art evaporators. Further, by employing smaller diameter tubes for the initial pass and increasing the size of the tubes for successive passes, the tube cost of an evaporator is reduced by about ten percent as compared to a comparable capability evaporator constructed in the manner of the prior art, as exemplarily depicted in Figs. 1 and 2.

The present invention is an evaporator for a refrigeration system wherein a flow of water makes a plurality of passes therethrough. The evaporator includes a tube bundle assembly having a known tube bundle portion associated with each of a plurality of passes of water therethrough, each of a plurality of tubes of a tube bundle portion associated with a first water pass having a lesser diameter than the diameter of tubes of tube bundle portions associated with successive passes of water. The present invention is further a method of forming an evaporator.

Brief Description of the Drawings

Figure 1 is a perspective view of a partial cut away centrifugal chiller system; Figure 2 is a partially cut away depiction of a prior art evaporator; and Figure 3 is an end sectional view of an evaporator of the present invention depicting the tube bundle.

Detailed Description of the Drawings

The evaporator of the present invention is shown generally at 10 in Figure 3. The evaporator 10 is constructed generally in accordance with the construction of the evaporator of the prior art depicted in Figure 2. Reference may be made to prior art
Figure 2 for the general portion of the description of the evaporator 10.

Generally, the evaporator 10 is of the shell and tube type construction. Accordingly, the evaporator 10 has a cylindrical shell 12 and a tube bundle 14.

The cylindrical shell 12 is preferably an elongate cylinder formed of a metallic material. The evaporator 10 is designed to be mounted in a horizontal disposition. Accordingly, a plurality of base supports (not shown) may be fixed to the underside of the cylindrical shell 12 for mounting the evaporator 10 in such disposition.

An insulation jacket 18 may be disposed immediately interior to the cylindrical shell 12. The insulation jacket 18 preferably has a fluid-tight interior liner 19. The cylindrical shell 12 is sealingly capped at either end by shell head 28.

A water inlet 20 and a water outlet 22 are coupled to a one of the endplates 28. Preferably, the water inlet 20 is disposed lower than the water outlet 22.

A refrigerant inlet 24 and a refrigerant outlet 26 (also known as a suction nozzle) are coupled to the cylindrical shell 12. As noted, the refrigerant outlet 26 is in fluid communication with the centrifugal compressor, depicted in Fig. 1. Liquid refrigerant enters the shell through inlet 24 and the bottom of the shell 40.

Referring to Figure 3 for the particulars of the present invention, the tube bundle assembly 14 includes endplates 30 disposed at either end of the tube bundle assembly 14. Each of the endplates 30 is spaced apart from the adjacent shell head 28 in order to define a fluid passage for communication of the water from the first pass to the second pass. Each of the endplates 30 has a plurality of tube ends 32 sealingly disposed therein.

As depicted in Figure 3, the first pass tube bundle portion 36 is disposed in the lower portion of the cavity 40 defined within the cylindrical shell 12. The second pass tube bundle portion 38 is disposed above the first pass tube bundle portion 36. It is understood the certain evaporators employ a side to side flow of the refrigerant. There
are preferably fewer of the second pass tubes 44 in the second pass tube bundle portion 38 than there are first pass tubes 42 in the first pass tube bundle portion 36. The diameter of each of the first pass tubes 42 is preferably 0.50 inches in diameter to 1.0 inches in diameter and is most preferably 0.75 inches diameter. The diameter of the second pass tubes 44 is always greater than the diameter of the first pass tubes 42. Preferably, the diameter of the second pass tubes 44 is 0.75 inches to 1.5 inches and most preferably is 1.0 inches diameter. In a preferred configuration of the evaporator 10, the diameter of the first pass tubes 42 is 0.75 inches and the diameter of the second pass tubes 44 is 1.0 inches. Preferably, the total area (the total area being arrived at by taking the inside cross section area of each tube in the tube bundle portion and multiplying it by the total number of tubes in the tube bundle portion) of all the first pass tubes 42 is substantially equal to the total area of all the second pass tubes 44. In evaporators 10 having more than two passes, each successive tube portion for successive passes has a greater tube diameter than the tubes of the previous pass and has a substantially equal total area as that of the tube bundle portion of the preceding pass and, in fact all other tube bundle portions.

In operation, liquid refrigerant flows into the refrigerant inlet 24 and floods the cavity 40, thereby, submerging the tube bundle assembly 14. Warm water is pumped into the water inlet 20 and into the first pass tubes 42 of the first pass tube bundle portion 36. As the warm water passes through the first pass tube bundle portion 36, it acts to vaporize the liquid refrigerant. The refrigerant must be in a vapor state in order to be compressed by the compressor.

After passing through the first pass tube bundle portion 36, the water temperature reduces and enters the second pass tubes 44 of the second pass tube bundle portion 38. As the water passes through both the first pass tube bundle portion 36 and
the second pass tube bundle portion 38, the refrigerant transitions from a liquid state to a vapor state. Heat energy is transferred from water to refrigerant by vaporizing the liquid refrigerant. The now cooled water then exits the second pass tubes 44 of the second pass tube bundle portion 38 and passes out of the evaporator 10 by the water outlet 22. It should be understood that a third or a fourth pass could be made by the water by installing a third and fourth bundle portion above the second pass tube bundle portion 38. As noted above, the third pass bundle portion would be greater in diameter than the diameter of the second pass tubes 44 and lesser in diameter than the tubes comprising the fourth bundle portion, but each pass bundle portion would have the same total area and therefore the same flow volume, as noted above.

The above disclosure is not intended as limiting. Those skilled in the art will readily observe that numerous modifications and alterations of the device may be made while retaining the teachings of the invention. Accordingly, the above disclosure should be construed as limited only by the restrictions of the appended claims.
CLAIMS

1. An evaporator for a refrigeration system wherein a flow of water makes a plurality of substantially sequential end to end passes therethrough, comprising:

   a tube bundle assembly having a known tube bundle portion associated with each of a plurality of passes of water therethrough, each of a plurality of tubes of a tube bundle portion associated with a first water pass having a lesser diameter than the diameter of tubes of tube bundle portions associated with successive passes of water.

2. The evaporator of claim 1 wherein the diameter of tubes of tube bundle portions associated with each successive pass of water is greater than the diameter of tubes of tube bundle portion associated with a previous pass of water.

3. The evaporator of claim 1 wherein a flow rate of all of the tubes of the tube bundle portions associated with each of the passes of water is substantially equal.

4. The evaporator of claim 1 having the tube bundle portion associated with a first water pass and a tube bundle portion associated with a second water pass.

5. The evaporator of claim 4, a plurality of tubes comprising the tube bundle portion associated with the first water pass having a diameter of substantially 0.50 to 1.0 inches.

6. The evaporator of claim 4, a plurality of tubes comprising the tube bundle portion associated with the first water pass having a diameter of substantially 0.75 inches.
7. The evaporator of claim 4, a plurality of tubes comprising the tube bundle portion associated with the second water pass having a diameter of substantially 0.75 to 1.5 inches.

8. The evaporator of claim 4, a plurality of tubes comprising the tube bundle portion associated with the second water pass having a diameter of substantially 1.0 inches.

9. A method of forming an evaporator for a refrigeration system wherein a flow of water makes a plurality of substantially sequential end to end passes therethrough, comprising:
   forming a tube bundle assembly, a known tube bundle portion being formed associated with each of the plurality of passes of water therethrough, and forming each of a plurality of tubes of a tube bundle portion associated with a first water pass of a lesser diameter than a diameter of tubes of tube bundle portions associated with successive passes of water.

10. The method of claim 9 including forming the diameter of tubes of tube bundle portions associated with each successive pass of water with a greater diameter than the diameter of tubes of a tube bundle portion associated with a previous pass of water.

11. The method of claim 9 including substantially equalizing a flow rate of all of the tubes of the tube bundle portions associated with each of the passes of water.

12. The method of claim 9 including forming the tube bundle portion associated with a first water pass and forming a tube bundle portion associated with a second water pass.

13. The method of claim 12, including forming a plurality of tubes comprising the tube bundle portion associated with the first water pass having a diameter of substantially 0.50 to 1.0 inches.
14. The method of claim 12, including forming a plurality of tubes comprising the tube bundle portion associated with the first water pass having a diameter of substantially 0.75 inches.

15. The method of claim 12, including forming a plurality of tubes comprising the tube bundle portion associated with the second water pass having a diameter of substantially 0.75 to 1.5 inches.

16. The method of claim 12, including forming a plurality of tubes comprising the tube bundle portion associated with the second water pass having a diameter of substantially 1.0 inches.