

**GAS COOLER CONFIGURATION INTEGRATED
INTO HEAT PUMP CHASSIS**

BACKGROUND OF THE INVENTION

[0001] The present invention relates to a gas cooler and chassis for a transcritical heat pump water heater.

[0002] One type of transcritical heat pump water heater uses a heat pump cycle that utilizes CO₂ as the working fluid. The heat pump may be located indoors or on the exterior of a building, for example, mounted on a roof top of a building. Numerous components are located within a chassis that supports the components, which includes for example a compressor, a gas cooler, an expansion device, an evaporator, an accumulator, and other various components.

[0003] In a CO₂ heat pump water heating system, super critical CO₂ rejects heat in the gas cooler to water, and sub-critical CO₂ absorbs heat in the evaporator from the outdoor air. The heat pump system must operate desirably under a wide range of conditions. For example, the outdoor air temperature may vary from -10°F in the winter to the 120°F in the summer. A draft fan is usually used to force the airflow through the evaporator fin side to supply heat to the refrigerant flowing in the tube side of the evaporator. Insuring the maximum possible flow through the evaporator enables the heat pump to operate desirably throughout various airflow conditions.

[0004] Previously, the gas cooler was designed only to efficiently achieve its function without consideration to the gas cooler's impact on the efficiency of other components. The gas cooler is often packaged as a rather large box-like component having insulation around the interior fluid passages to reduce heat loss. The box extends a significant distance into the cavity defined by the chassis, which also houses

the various heat pump components. As a result, the gas cooler blocks and significantly inhibits the air flow through the chassis compromising the efficiency of the heat pump evaporator and ability of the evaporator to perform desirably under the various operating conditions. Therefore, what is needed is an improved gas cooler and chassis arrangement that minimizes the negative impact of the gas cooler on the evaporator as well as system performance, i.e. minimizing airflow blockage.

SUMMARY OF THE INVENTION

[0005] The present invention relates to a gas cooler and chassis integration design suitable for a transcritical heat pump water heater. The heat pump system includes a chassis for supporting such system components as a gas cooler and evaporator. The gas cooler includes a water supply and return opening and a refrigerant inlet and outlet opening with associated passages running through the gas cooler. The water and refrigerant passages are positioned in relationship to one another such that heat from the compressed refrigerant is transferred to the water flowing through the water passage to provide heated water to a water tank.

[0006] The dimensions of the gas cooler are designed to minimize the impact that the gas cooler has on the cooling capacity of the evaporator by reducing the amount of air flow that the gas cooler blocks. This is achieved by optimizing the way to package the gas cooler, for example, by reducing the depth that the gas cooler extends into the chassis cavity. As a result, the height and/or width of the gas cooler is increased compared to other similar volume gas coolers while still providing comparable water heating capacity. As a result, a shorter length of the evaporator coils is affected by the blocked airflow.

[0007] A typical heat pump chassis includes spaced apart vertical and horizontal walls supported by the vertical and horizontal supports that define the dimension of the chassis. The walls and supports generally define an outer shape. The chassis provides not only support to the components of the heat pump water heater but also forms the access interface for operation and maintenance purpose. Various components of the heat pump are arranged and interconnected inside the chassis to form a closed refrigerant loop. In one example, a face of the gas cooler is located adjacent to a substantial portion of the wall, for example, greater than 50 percent.

[0008] In an example shown, four sides of the gas cooler are located proximate to the spaced apart horizontal and vertical supports providing a gas cooler having a thin profile that does not extend very deeply into the chassis cavity. Additionally, the gas cooler may provide one of the exterior sides of the chassis, eliminating a separate wall used in the prior art. Preferably, the depth of the gas cooler is less than the width and/or the height. Also, the chassis may incorporate one or more guides so that the thin-profiled inventive gas cooler may be removably received within a portion of the housing preferably proximate to an outer wall of the chassis.

[0009] Accordingly, the present invention provides an improved gas cooler and chassis arrangement that minimizes the negative impact the gas cooler has on the evaporator and system performance by blocking the airflow to the evaporator .

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] Other advantages of the present invention can be understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein:

[0011] Figure 1 is a perspective view of a prior art heat pump water heater with several of the walls removed to provide an unobstructed view to the chassis cavity.

[0012] Figure 2 is a schematic of a prior art air source heat pump water heater system.

[0013] Figure 3 is a partial perspective view of the inventive gas cooler in relationship to the heat pump system chassis.

[0014] Figure 4 is a partial perspective view of the inventive heat pump chassis having structure permitting the thin-profiled gas cooler to be removably received within the chassis near the exterior.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0015] Figures 1 and 2 depict prior art heat pump systems. Figure 1 illustrates a heat pump water heater 110 having a chassis 112 constructed from multiple vertical 114 and horizontal 116 supports forming a box-like structure for housing the components of the heat pump system 110. Walls 118 are typically supported on the supports 114 and 116 to enclose the components and protect them from the exterior environment. However, the walls 118 are also considered vertical and horizontal supports and together define an outer shape. One of the walls 118 supports a fan 154 for moving air through the chassis to ensure desired operation of

an evaporator located within. Maximizing the air flow through the evaporator enables desired heat pump performance during extreme operating conditions.

[0016] As can be seen in Figure 1, the prior art gas cooler 124 extends a considerable depth into the cavity of the chassis 112 such that it obstructs a significant amount of air flow inhibiting the desired operation of the evaporator. The gas cooler 124 is shown supported on the floor and is only proximate to a small portion of one of the vertical supports 114 and a portion of one of the horizontal support 116. The prior art gas cooler 124 is adjacent to significantly less than half of the area defined between the vertical 114 and horizontal 116 support on one side of the chassis 112. Moreover, the width, height and depth of the gas cooler 124 are approximately equal providing a cube or box-like structure.

[0017] Figure 2 illustrates an example prior art vapor compression system 120 that includes a compressor 122, a heat rejecting heat exchanger (a gas cooler in transcritical cycles) 124, an expansion device 126, and a heat accepting heat exchanger (an evaporator) 128. Refrigerant circulates through the closed circuit system 120.

[0018] The refrigerant exits the compressor 122 at a high pressure and a high enthalpy. The refrigerant then flows through the gas cooler 124 at a high pressure. A fluid medium 130, such as water or air, flows through a heat sink 132 of the gas cooler 124 and exchanges heat with the refrigerant flowing through the gas cooler 124. In the gas cooler 124, the refrigerant rejects heat into the fluid medium 130, and the refrigerant exits the gas cooler 124 at a low enthalpy and a high pressure. A water pump 134 pumps the fluid medium through the heat sink 132. The cooled fluid medium 130 enters the heat sink 132 at the heat sink inlet or return 136 and flows in a direction opposite to the direction of the flow of the refrigerant. After

exchanging heat with the refrigerant, the heated water 138 exits the heat sink 130 at the heat sink outlet or supply 140. The heated water can be stored in a water tank 164. In one example, the water tank 164 is sized to meet expected peak demand at all times. The refrigerant then passes through the expansion valve 126, which expands and reduces the pressure of the refrigerant. The expansion device 126 can be an electronic expansion valve or other known type of expansion device.

[0019] After expansion, the refrigerant flows through the passages 180 of the evaporator 128 and exits at a high enthalpy and a low pressure. In the evaporator 128, the refrigerant absorbs heat from the outdoor air 144, heating the refrigerant. The outdoor air 144 flows through a heat sink 146 and exchanges heat with the refrigerant passing through the evaporator 128 in a known manner. The outdoor air 144 enters the heat sink 146 through the heat sink inlet or return 148 and flows in a direction opposite to or cross to the direction of flow of the refrigerant. After exchanging heat with the refrigerant, the cooled outdoor air 150 exits the heat sink 146 through the heat sink outlet or supply 152. The temperature difference between the outdoor air 144 and the refrigerant in the evaporator 128 drives the thermal energy transfer from the outdoor air 144 to the refrigerant as the refrigerant flows through the evaporator 128. A fan 154 moves the outdoor air 144 across the evaporator 128, maintaining the temperature difference and evaporating the refrigerant. The refrigerant then reenters the compressor 122, completing the cycle.

[0020] The system 120 transfers heat from the low temperature energy reservoir (ambient air) to the high temperature energy sink (heated hot water). The transfer of energy is also achieved with the aid of electrical energy input at the compressor 122, fan 154 and pump 134.

[0021] The system 120 can also include an accumulator 156. The accumulator 156 stores excess refrigerant from the system 120 to control the high pressure of the system 120, and therefore the coefficient of performance.

[0022] Referring to Figure 3, the inventive thin-profiled gas cooler 24 is shown mounted to the chassis 12. The depth D of the gas cooler 24 is significantly less than the height H2 and width W2 of the gas cooler. Moreover, the height H2 and width W2 are approximately equal to the height H1 and width W1 defined by the vertical 14 and horizontal 16 supports of the chassis 12. That is, it is preferable that the dimensions of the gas cooler 24 are sized such that the sides of the gas cooler 24 extend to the vertical 14 and horizontal 16 supports to the greatest extent possible. In this manner, the depth D is reduced to the smallest dimension to minimize any obstruction the gas cooler creates from extending into the cavity chassis 12, which inhibits the airflow through the evaporator 28 located within the chassis 12.

[0023] Furthermore, as depicted in Figure 3, the gas cooler 24 provides the exterior side or wall 18 thereby eliminating the need of a separate chassis wall. It should also be understood that the gas cooler may provide just a portion of the exterior wall 18. A sheet of material is connected to the gas cooler 24 in such a configuration to complete the exterior wall 18. Although the gas cooler 24 is shown in Figure 3 as providing a side wall, the gas cooler 24 may also provide the top or bottom wall of the chassis 12.

[0024] The inventive features of the gas cooler 24 and its relationship relative to the chassis 12 may be expressed in any number of ways. Referring to Figure 4, for example, the area A2 of the outer side of the gas cooler 24 is adjacent to a substantial portion of the area A1 of the chassis which, in the example shown, is defined by an area bounded by the vertical 14 and horizontal 16 supports on one side

of the chassis, preferably next to the wall 18. The gas cooler 24 is shown removed from the chassis.

[0025] In one example, the area A2 is at least 50 percent of the area A1. In the example shown in Figure 4, the area A2 is approximately equal to the area A1. Expressed in another way, the width W2 and/or height H2 are substantially greater than the depth D of the gas cooler 24, for example, twice the length. While the inventive gas cooler 24 is shown arranged near a side wall, one of ordinary skill will appreciate that it may also be arranged at the top or bottom of the chassis 12.

[0026] Referring to another feature of Figure 4, the inventive gas cooler 24 is removably installed into the chassis 12 at one side adjacent to a wall 18. In the example shown, the gas cooler 24 is top loaded into the chassis 12, but it may also be side- or bottom-loaded. One or more guides 70 are used to locate the gas cooler 24 in a desired location during installation of the gas cooler 24 into the chassis 12. In the example shown, opposing sides of the gas cooler 24 are retained by opposing vertical members 14 and opposing vertical guides 70.

[0027] It should also be understood that the removable gas cooler configuration shown in Figure 4 may also provide the exterior wall 18 in a similar manner to that shown in Figure 3.

[0028] The inventive gas cooler 24 reduces the blockage of air to the evaporator coil so that the negative impact on the evaporator and subsequently the water heat performance is minimized. In addition, the configuration of the gas cooler 24 within the chassis 12 provides user access to the components within the chassis, in particular, the arrangement shown in Figure 4.

[0029] The invention has been described in an illustrative manner, and it is to be understood that the terminology that has been used is intended to be in the

nature of words of description rather than of limitation. Obviously, many modifications and variations of the present invention are possible in light of the above teachings. It is, therefore, to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

CLAIMS

What is claimed is:

1. A heat pump system comprising:
a chassis having multiple supports generally defining an outer shape with a side having a first area; and
a gas cooler supported by said chassis said gas cooler including a water supply and return openings and refrigerant inlet and outlet openings, said gas cooler including a surface having a second area proximate to a substantial portion of said first area.
2. The system according to claim 1, wherein said gas cooler includes a width and height defining said second area, and a depth substantially less than said width and height.
3. The system according to claim 2, wherein said depth extends into a cavity of said outer shape away from said side.
4. The system according to claim 2, wherein said gas cooler includes four sides providing said width and height, said four sides proximate to said outer shape.

5. The system according to claim 1, wherein said gas cooler provides a bottom of said outer shape.

6. The system according to claim 1, wherein a compressor, evaporator and expansion device are arranged in the chassis.

7. The system according to claim 1, wherein the gas cooler includes cooling passages filled with a refrigerant including carbon dioxide.

8. A heat pump system comprising:

a chassis defining a cavity including an evaporator located within said cavity;
and

a gas cooler supported by said chassis said gas cooler including a water supply and return openings and refrigerant inlet and outlet openings, said gas cooler including a width, height and depth with said depth extending into said cavity, said depth substantially less than at least one of said width and said height minimizing air flow obstruction to said evaporator through said chassis.

9. The system according to claim 8, wherein said at least one of said width and height is at least approximately twice said depth.

10. The system according to claim 8, wherein said depth is approximately at least half of said width and height.

11. The system according to claim 8, wherein said gas cooler includes four sides providing said width and height, said four sides proximate to four walls of said chassis.

12. The system according to claim 11, wherein said four walls define a first area and said width and height define a second area, said second area substantially equal to said first area.

13. The system according to claim 8, wherein said gas cooler provides a portion of an exterior wall of said chassis.

14. The system according to claim 13, wherein said gas cooler substantially provides said exterior wall.

15. The system according to claim 8, wherein a compressor and an expansion device are arranged in the chassis.

16. The system according to claim 8, wherein the gas cooler includes cooling passages filled with a refrigerant including carbon dioxide.

17. A heat pump system comprising:

a chassis having multiple supports defining a first area in a cavity of said chassis; and

a gas cooler supported by said chassis said gas cooler including a water supply and return openings and refrigerant inlet and outlet openings, said gas cooler including a surface having a first area defined by a width and height, and depth extending away from said area, said depth less than at least one of said width and height.

18. The system according to claim 17, wherein said chassis includes a guide spaced from said area defining a space between said area and said guide removably receiving said gas cooler in said space.

19. The system according to claim 17, wherein said at least one of said width and height is at least approximately twice said depth.

20. The system according to claim 17, wherein said depth is approximately at least half of said width and height.

21. The system according to claim 17, wherein said gas cooler includes four sides deforming said width and height, said four sides proximate to four walls of said chassis.

22. The system according to claim 21, wherein said four walls define a first area and said width and height define a second area, said second area substantially equal to said first area.

23. The system according to claim 17, wherein a compressor, evaporator and expansion valve are arranged in the chassis.

24. The system according to claim 17, wherein the gas cooler includes cooling passages filled with a refrigerant including carbon dioxide.