Title: REFRIGERANT DEHUMIDIFICATION SYSTEM WITH VARIABLE CONDENSER UNLOADING

Abstract: A condenser in a refrigerator system is provided with a plurality of refrigerant circuits, with at least one of the plurality of circuits being equipped with a shut off device. A reheat coil is also incorporated into the refrigerator system to provide enhanced dehumidification functionality. By selectively shutting off at least one of the active refrigerant circuits in the condenser, the amount of heat rejected by the condenser as well as by the reheat coil can be controlled shifting the heat load between the condenser and reheat coil. In this manner, and in combination with operation of the reheat cycle, incremental dehumidification and cooling/heating can be provided and humidity and temperature can be precisely controlled.
REFRIGERANT DEHUMIDIFICATION SYSTEM WITH VARIABLE CONDENSER UNLOADING

BACKGROUND OF THE INVENTION

This invention relates to a refrigerant system incorporating a reheat function and a condenser comprising a number of refrigerant passages, with at least some of the passages being selectively shut off to control the total heat rejection distribution between the condenser (outdoor section) and reheat coil (indoor section).

Refrigerant systems are utilized to control the temperature and humidity of air in various indoor environments to be conditioned. In a typical refrigerant system operating in the cooling mode, a refrigerant is compressed in a compressor and delivered to a condenser (or an outdoor heat exchanger in this case). In the condenser, heat is exchanged between outside ambient air and the refrigerant. From the condenser, the refrigerant is passed to an expansion device, at which the refrigerant is expanded to a lower pressure and temperature, and then to an evaporator (or an indoor heat exchanger). In the evaporator, heat is exchanged between the refrigerant and the indoor air, to condition the indoor air. When the refrigerant system is operating, the evaporator cools the air that is being supplied to the indoor environment. In addition, as the temperature of the indoor air is lowered, moisture usually is taken out of the air as well. In this manner, the humidity level of the indoor air can also be controlled.

Another way of controlling an environment in the conditioned space with a refrigerant system is the utilization of a reheat coil. Typically, a reheat coil is provided in the path of air that has been blown over the evaporator. The air passes over the reheat coil to regain heat from a refrigerant that is at a temperature higher than the temperature of air leaving the evaporator. The reheat coil is thus able to raise the temperature of the air leaving the evaporator. Hence, the air is dehumidified and overcooled in the evaporator and then is reheated back to a comfortable temperature level in the reheat coil.

Another option with known refrigerant systems is to use a bypass line to reroute the refrigerant flow around the condenser. In this manner, at least a portion of
refrigerant may bypass the condenser, which will lower its cooling potential as it approaches the evaporator. The condenser bypass has been employed in the prior art systems in combination with the reheat coil to control the thermodynamic state of the refrigerant entering the reheat coil. On the other hand, the condenser passages are typically sized to handle the normal volume of refrigerant flowing through the condenser, and how much refrigerant passes through each circuit should be carefully managed at a wide spectrum of environmental and operating conditions for proper system functionality and reliable operation. Further, pulsating flow in the bypass line (in case pulse width modulation method is used) may introduce some undesired instabilities within the refrigerant circuit that may be difficult to control. Consequently, the condenser bypass alone has a restricted range of applications limited by efficiency, head pressure control, oil holdup and other considerations.

Thus, there is a need in a refrigerant dehumidification system that would have a variable reheat capacity and provide reliable and efficient operation without further complexity and at marginal cost.

SUMMARY OF THE INVENTION

In a disclosed embodiment of this invention, a condenser, within a refrigerant system incorporating a reheat function, has a plurality of refrigerant passages with at least some of these passages being provided with shut off devices. Thus, as fewer passages are open to allow refrigerant flow through the main condenser, less heat is rejected by the condenser and more reheat capacity is provided at the reheat coil.

This increase in the reheat capacity can be accomplished by selectively turning off some of the condenser circuits. Thus, the condenser size and condenser load can be reduced in stages in accordance with application requirements and design constraints.

Another side benefit of this proposed concept is that a head pressure control is naturally provided by varying the number of active refrigerant circuits in the condenser, regardless of the mode of operation. Obviously, the pressure drop through the condenser has to be maintained within design guidelines, and in one disclosed embodiment, a bypass line around the condenser may be included for additional
operational flexibility. The bypass line could also have an application in combination with the reheat cycle.

These and other features of the present invention can be best understood from the following specification and drawings, the following of which is a brief description.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 shows a first schematic incorporating the present invention.

Figure 2 shows an alternate schematic.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

A refrigerant system 20 is illustrated in Figure 1 including a compressor 22 compressing refrigerant and delivering it to a downstream condenser 24. An expansion device 26 is located downstream of the condenser 24, and an evaporator 28 is positioned downstream of the expansion device 26. The refrigerant returns from the evaporator 28 to the compressor 22. As shown, a number of parallel refrigerant passages (or circuits) 30, 32 and 34 pass through the condenser 24. Shutoff devices such as valves 36 are placed on two of the three circuits 32 and 34. A control operates to open or close the shutoff valves 36, as will be explained below. A bypass line 38 includes a valve 40 for selectively allowing bypass at least a portion of refrigerant around the condenser 24.

A three-way valve 42 selectively routes refrigerant into a line 44 and through a reheat heat exchanger 46. A fan 48 pulls air over the evaporator 28 and then over the reheat heat exchanger 46. Also, a check valve 140 is placed downstream of the reheat heat exchanger 46 within the reheat loop.

As is known, the reheat loop is utilized when dehumidification is desired. Essentially, the evaporator is controlled to cool air to a temperature level lower than the temperature that would be desired by an occupant of a space to be conditioned by the refrigerant system 20 in order to remove sufficient amount of moisture from the air stream. This cold and dehumidified air then passes over the reheat coil 46, which will be at a higher temperature (while in operation) than the air exiting the evaporator
28. The reheat coil thus reheats the air up toward the temperature desired by the occupant of the space to be conditioned. The control of the reheat coil is known. At times, it may be desirable to vary the amount of cooling and/or dehumidification being provided. By limiting the number of refrigerant circuits passing through the condenser 24, the amount of heat rejected by the main condenser 24 and reheat provided by the reheat coil 46 can be controlled. In the refrigerant system 20, the incremental steps of reheat control can be achieved by either shutting the valves 36, opening the valve 40, or both. In this manner, the amount of heat load placed on the condenser as well as the amount of refrigerant circulating through the condenser can be varied, and the total heat rejected can be shifted between the main condenser 24 and the reheat coil 46. By decreasing the amount of heat exchanged in the condenser 24, the amount of cooling and dehumidification achieved in the evaporator 28 can also be adjusted.

For instance, if a higher air temperature is desired downstream of the reheat heat exchanger 46 then some of the refrigerant circuits 36 passing through the main condenser 24 will be shut off or taken off-line. As a result, a smaller heat transfer surface will be utilized in the condenser 24, and the pressure differential of the refrigerant circulating through the remaining circuits 30 may simultaneously increase. Consequently, although condensation temperature (or discharge pressure) will rise, the net effect would be such that heat rejected by the main condenser 24 will diminish. Since the temperature difference in the reheat coil 46 will increase and the refrigerant leaving the main condenser 24 may have higher enthalpy, the heat rejected in the reheat coil 46 will rise providing the desired higher temperature of the air supplied to the conditioned environment. Further, the valve 40 could be used in combination with the valves 36 to assure precise control as well as safe and reliable operation. Finally, the number of circuits incorporating shutoff devices 36 may vary and is determined by the equipment type and practical considerations.

Thus, a control in this invention operates the valves 36 and 40 in combination with the valve 42 to achieve desired levels of cooling and dehumidification, while the refrigerant system 20 is operating in the reheat mode.

A worker of ordinary skill in the art would recognize under what conditions these several valves mentioned above should be opened and/or closed. Another side
benefit of this invention is that a head pressure control is naturally provided by varying the number of active refrigerant circuits in the main condenser, regardless of the mode of operation.

Figure 2 shows another system 50 wherein a reheat line 52 taps refrigerant from a three-way valve 54, and returns the refrigerant through a reheat heat exchanger 46 and a check valve 140 back to a main refrigerant circuit upstream of a condenser 56 (as well as upstream of a pair of refrigerant circuits 58 and 60 passing through the condenser 56). A shut off valve 62 is shown only on the circuit 60. Once again, a number of circuits incorporating valves 62 may vary.

This refrigerant system is controlled similarly to the refrigerant system 20. Essentially, the valve 62 is opened and closed to change the heat load on the condenser 56 and consequently on the reheat coil 46.

While two basic reheat concepts are shown in Figures 1 and 2, a multitude of other system configurations can equally benefit from this invention.

Although preferred embodiments of this invention have been disclosed, a worker of ordinary skill in the art would recognize that certain modifications would come within the scope of this invention. For that reason, the following claims should be studied to determine the true scope and content of this invention.
CLAIMS

We claim:

1. A refrigerant system comprising:
   a compressor, said compressor delivering a refrigerant to a downstream condenser through a discharge line, said discharge line communicating with a plurality of parallel flow paths passing through said condenser, and at least one of said plurality of flow paths having a shut off device;
   a line communicating downstream of said condenser to an expansion device, and downstream of said expansion device to an evaporator, and a line communicating from said evaporator back to said compressor; and
   a reheat circuit incorporated into said refrigerant system, said reheat circuit receiving a refrigerant, and passing said received refrigerant through a reheat heat exchanger, and from said reheat heat exchanger back into a main refrigerant circuit, an air-moving device for moving air over said evaporator, and over said reheat heat exchanger, and a control for selectively opening said shutoff device to achieve desired control in combination with said reheat circuit.

2. The refrigerant system as set forth in claim 1, wherein a bypass line allows selectively bypass at least a portion of refrigerant around said condenser, and said bypass line also includes a bypass valve, with said control selectively controlling said bypass valve.

3. The refrigerant system as set forth in claim 1, wherein said reheat circuit taps refrigerant from a location downstream of said condenser.

4. The refrigerant system as set forth in claim 1, wherein said reheat circuit taps refrigerant from a location upstream of said condenser.

5. The refrigerant system as set forth in claim 4, wherein said discharge line from said compressor branches into said plurality of parallel flow paths, and said reheat circuit taps refrigerant from a location upstream of a branching point.
6. The refrigerant system as set forth in claim 1, wherein there are at least three of said flow paths, and at least two of said at least three flow paths having shut off devices.

7. A method of controlling a refrigerant system comprising:
   providing a compressor, said compressor delivering a compressed refrigerant to a downstream condenser through a discharge line, said discharge line communicating with a plurality of parallel flow paths passing through said condenser, and at least one of said plurality of flow paths having a shut off device;
   communicating refrigerant downstream of said condenser to an expansion device, and downstream of said expansion device to an evaporator, and communicating refrigerant from said evaporator back to said compressor; and
   a reheat circuit incorporated into said refrigerant system, said reheat circuit receiving a refrigerant, and passing said received refrigerant through a reheat heat exchanger, and from said reheat heat exchanger back into a main refrigerant circuit, an air-moving device moving air over said evaporator, and over said reheat heat exchanger, and a control selectively opening said shutoff device to achieve desired control in combination with said reheat circuit.

8. The method as set forth in claim 7, wherein a bypass line allows selectively bypass at least a portion of refrigerant around said condenser, and said bypass line also includes a bypass valve, with said control selectively controlling said bypass valve.

9. The method as set forth in claim 7, wherein said reheat circuit taps refrigerant from a location downstream of said condenser.

10. The method as set forth in claim 7, wherein said reheat circuit taps refrigerant from a location upstream of said condenser.
11. The method as set forth in claim 10, wherein said discharge line from said compressor branches into said plurality of parallel flow paths, and said reheat circuit taps refrigerant from a location upstream of a branching point.

12. The method as set forth in claim 7, wherein there are at least three of said flow paths, and at least two of said at least three flow paths having shut off devices.
We claim:

1. A refrigerant system comprising:
   a compressor, said compressor delivering a refrigerant to a downstream condenser through a discharge line, said discharge line communicating with a plurality of parallel flow paths passing through said condenser, and at least one of said plurality of flow paths having a shut-off device;
   a line communjating downstream of said condenser to an expansion device, and downstream of said expansion device to an evaporator, and a line communicating from said evaporator to said compressor; and
   a reheat circuit incorporated into said refrigerant system, said reheat circuit receiving a refrigerant, and passing said received refrigerant through a reheat heat exchanger, and from said reheat heat exchanger back into a main refrigerant circuit air-moving device for moving air over said evaporator, and over said reheat heat exchanger, and a control for selectively opening said shut-off device to achieve desired control in combination with said reheat circuit.

2. The refrigerant system as set forth in claim 1, wherein a bypass line allows selective bypass of at least a portion of refrigerant around said condenser, and said bypass line also includes a bypass valve, with said control selectively controlling said bypass valve.

3. The refrigerant system as set forth in claim 1, wherein said reheat circuit taps refrigerant from a location downstream of said condenser.

4. The refrigerant system as set forth in claim 1, wherein said reheat circuit taps refrigerant from a location upstream of said condenser.

5. The refrigerant system as set forth in claim 4, wherein said discharge line from said compressor branches into said plurality of parallel flow paths, and said reheat circuit taps refrigerant from a location upstream of a branching point.
6. The refrigerant system as set forth in claim 1, wherein there are at least three of said flow paths, and at least two of said at least three flow paths having shut-off devices.

7. The refrigerant system as set forth in claim 1, wherein said control operating said shut-off device to block flow of refrigerant through said at least one of said plurality of flow paths when less cooling is desired.

8. The refrigerant system as set forth in claim 7, wherein said control operates said shut-off device to block the flow of refrigerant through said at least one of said plurality of flow paths to achieve a desired amount of dehumidification, with lesser cooling, when less cooling is desired.

9. The refrigerant system as set forth in claim 1, wherein said control shuts said shut-off device to block flow of refrigerant through at least one of said plurality of flow paths, while still allowing flow through at least one other of said plurality of flow paths to reduce the cooling load provided by refrigerant passing through the condenser.
10. A method of controlling a refrigerant system comprising:
    providing a compressor, said compressor delivering a compressed refrigerant
to a downstream condenser through a discharge line, said discharge line
communicating with a plurality of parallel flow paths passing through said condenser,
and at least one of said plurality of flow paths having a shut off device;
    communicating refrigerant downstream of said condenser to an expansion
device, and downstream of said expansion device to an evaporator, and
communicating refrigerant from said evaporator back to said compressor; and
    a reheat circuit incorporated into said refrigerant system, said reheat circuit,
receiving a refrigerant, and passing said received refrigerant through a reheat heat
exchanger, and from said reheat heat exchanger back into a main refrigerant circuit,
an air-moving device moving air over said evaporator, and over said reheat heat
exchanger, and a control selectively opening said shutoff device to achieve desired
control in combination with said reheat circuit.

11. The method as set forth in claim 10 wherein a bypass line allows selective
bypass of at least a portion of refrigerant around said condenser, and said bypass line
also includes a bypass valve, with said control selectively controlling said bypass
valve.

12. The method as set forth in claim 10, wherein said reheat circuit taps refrigerant
from a location downstream of said condenser.

13. The method as set forth in claim 10, wherein said reheat circuit taps refrigerant
from a location upstream of said condenser.

14. The method as set forth in claim 13, wherein said discharge line from said
compressor branches into said plurality of parallel flow paths, and said reheat circuit
taps refrigerant from a location upstream of a branching point.

15. The method as set forth in claim 10, wherein there are at least three of said
flow paths, and at least two of said at least three flow paths having shut off devices.
16. The method as set forth in claim 10, wherein said control operating said shut-off valve device to block flow of refrigerant through said at least one of said plurality of flow paths when less cooling is desired.

17. The method as set forth in claim 10, wherein said control operating said shut-off device to block flow of refrigerant through said at least one of said plurality of flow paths when less cooling is desired.
18. The method as set forth in claim 10, wherein said control operates said shut-off device to block the flow of refrigerant through said at least one of said plurality of flow paths to achieve a desired amount of dehumidification, with lesser cooling, when less cooling is desired.

19. The method as set forth in claim 10, wherein said control shuts said shut-off device to block flow of refrigerant through at least one of said plurality of flow paths, while still allowing flow through at least one other of said plurality of flow paths to reduce the cooling load provided by refrigerant passing through die condenser.
INTERNATIONAL SEARCH REPORT

A CLASSIFICATION OF SUBJECT MATTER

According to International Patent Classification (IPC) or to both national classification and IPC

B FIELDS SEARCHED

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

C DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
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<tr>
<th>Category*</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No</th>
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<td>US 6,941,770 B1 (TARAS) 13 September 2005 (13 09 2005), see columns 2-5 and figure 1a</td>
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<td>US 6,986,262 B2 (TAKASUGI) 17 January 2006 (17 01 2006), see abstract and figure 1</td>
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Date of the actual completion of the international search

14 February 2006

Name and mailing address of the ISA/US

Mail Stop PCT, Attn: ISA/US, Commissioner for Patents
pO Box 1450, Alexandria, Virginia 22313-1450
Facsimile No 571-273-3201

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[Handwritten Signature]

Name of designated office

Lee W Young

TelephoneNumber No 571-272-1609

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