

[54] REFRIGERATION SYSTEM

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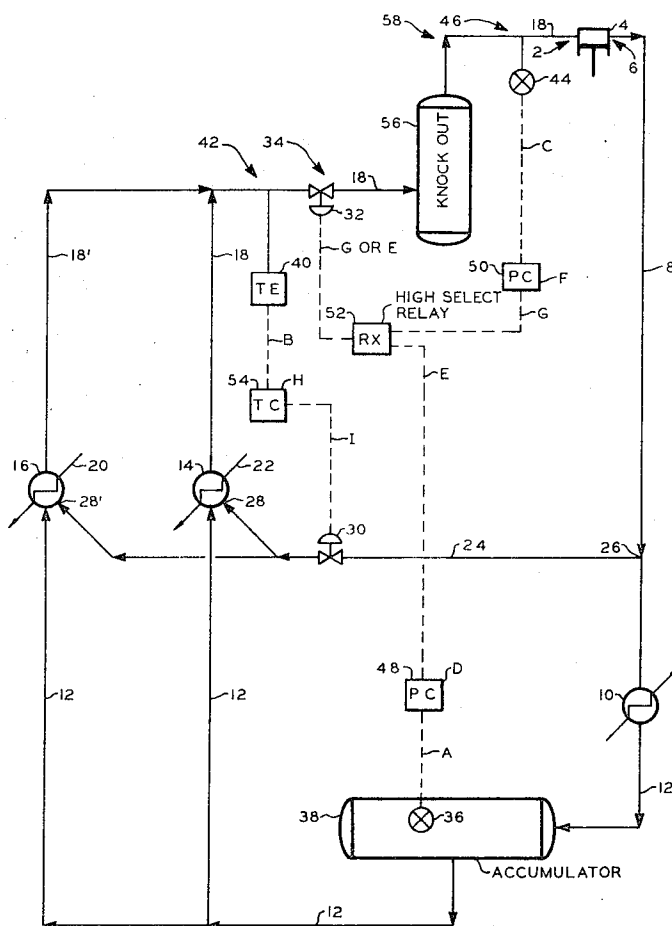
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[57] ABSTRACT

In an improved refrigeration system having a refrigerant stream, a compressor, a condenser, and a heat exchanger, the temperature of the heat exchanger is maintained at a value greater than a preselected value by controllably passing a portion of the refrigerant stream from a location upstream of the condenser to the refrigerant stream at a location downstream of the condenser and the pressures of the refrigerant stream at locations adjacent preselected locations are maintained at values less than respective preselected values by controlling the flow rate of the refrigerant stream between the heat exchanger and the compressor.

7 Claims, 1 Drawing Figure



REFRIGERATION SYSTEM

In a refrigeration system, it is often desirable to automatically control the temperature of the heat exchanger and the pressures at selected locations in the system. An example of a situation in which such automatic controlling is desirable is in a refrigeration system in a natural gasoline recovery plant for cooling one or more fluid streams of the plant wherein the construction of the heat exchanger has a metallurgical minimum temperature limit, the compressor has a maximum inlet pressure requirement and other locations in the system have maximum desirable pressure limitations.

This invention therefore resides in an improved refrigeration system in which the temperature of the heat exchanger is automatically maintained at values greater than a preselected temperature by controllably passing a portion of the refrigerant stream from a location upstream of the condenser to the refrigerant stream at a location downstream of the condenser and the pressures of the refrigerant stream at locations adjacent preselected locations are maintained at values less than respective preselected values by controlling the flow rate of the refrigerant stream between the heat exchanger and the compressor.

Other aspects, objects, and advantages of the present invention will become apparent from a study of the disclosure, the appended claims, and the drawing.

The drawing is a diagrammatic view of a refrigeration system with the apparatus of this invention.

Referring to the drawing, a compressor 2 having an inlet 4 and an outlet 6 is connected by a first conduit 8 to a condenser 10. The condenser is connected by a second conduit 12 to one or more heat exchangers 14,16, for example, and the heat exchangers 14,16 are connected by third conduits 18,18' to the inlet 4 of the compressor 2. Operation of the compressor 2, as known in the art, cycles a refrigerant stream from the outlet 6 of the compressor 2, through the condenser 10, from the condenser 10 through the heat exchangers 14,16, for example, and from the heat exchangers 14,16 back to the compressor 2 via the inlet 4 of the compressor 2.

For simplicity of description, the heat exchangers 14,16 will hereafter be referred to as heat exchanger 14 but it should be understood that a plurality of heat exchangers can be employed in the refrigeration system. It should be understood that one or more fluids 20,22 that are desired to be cooled by the refrigeration system can be passed through the heat exchanger structures of the system in any operable manner.

A bypass line 24 having an inlet 26 and an outlet 28 is in fluid communication with the refrigerant stream. The bypass line 24 is connected at the inlet 26 to the first conduit 8 and at the outlet 28 at one of the second conduits 12 and the heat exchanger 14 for controllably bypassing the condenser 10 with a portion of the refrigerant stream discharging from the compressor 2. It should be understood that the bypassing refrigerant stream portion is controllably passed to the heat exchanger 14 for maintaining the temperature of the gaseous refrigerant leaving the heat exchanger at a temperature greater than a preselected value and for this reason the outlet 28 of the bypass line 24 is necessarily connected in fluid communication with the refrigerant stream at or upstream of the heat exchanger

but downstream of the condenser 10. Where there are a plurality of heat exchangers, it should be understood that the outlet 28,28' can be connected at various locations so long as the connections are at or upstream of the heat exchanger but downstream of the condenser 10.

A first control valve 30 is positioned in the bypass line 24 and a second control valve 32 is positioned in the third conduit 18. The second control valve 32 is positioned in the third conduit 18 at a first location 34 between heat exchanger 14 and the compressor 2.

A first pressure measuring-transmitting element 36, such as is available from numerous manufacturers of automatic control equipment, The Foxboro Company, Foxboro, Mass. for example, is associated with the refrigerant stream 12 between the condenser 10 and the outlet 28 of the bypass line 24. Element 36 can be connected to the second conduit 12, or a refrigerant stream accumulator 38 can be positioned in the second conduit 12 with the element 36 operably connected to said accumulator 38. Element 36 measures the pressure of the refrigerant stream and delivers a signal A in response to said measurement.

A temperature measuring-transmitting element 40 is connected to the third conduit 18 at a second location 42 that is downstream of the heat exchanger 14 and upstream of the first location 34. Element 40 measures the temperature of the refrigerant stream at that location and delivers a signal B in response to said measurement.

A second pressure measuring-transmitting element 44 is connected to the third conduit 18 at a third location 46 that is between the first location 34 and the compressor 2. Element 44 measures the pressure of the refrigerant stream at that location and delivers a signal C in response thereto.

A first pressure controller 48 has a set point D and is connected to the first pressure measuring-transmitting element 36 for receiving signal A, comparing said signal A to the set point D, and delivering a signal E in response to said comparison.

A second pressure controller 50 has a set point F and is connected to the second pressure measuring-transmitting element 44 for receiving signal C, comparing said signal C to the set point F, and delivering a signal G in response to said comparison.

A hi-select relay 52 is connected to the second control valve 32 and first and second pressure controllers 48,50 for receiving respective signals E and G, comparing said signals one to the other, and delivering the larger one of said signals G and E to the second control valve 32 in response to said comparison.

A temperature controller 54 has a set point H and is connected to the first control valve 30 and the temperature measuring-transmitting element 40 receiving the signal B, comparing said signal B to the set point H, and delivering a signal I to the first control valve 30 in response to said comparison.

A liquid knockout 56, such as a tank or trap, is preferably positioned in the third conduit 18 at a fourth location 58 between the first and third locations 34,46 to remove entrained liquid from the gaseous refrigerant stream prior to the entry of said stream into the compressor 2. If liquid is permitted to remain in the refrigerant stream, damage to the compressor 2 may result.

In the operation of the invention, the refrigerant cycles through the compressor 2, condenser 10, heat exchanger 14, and back to the compressor 2 as set forth above. In this cyclic route, the refrigerant stream in the first conduit 8 and the bypass line 24 is relatively hot and in the vapor phase. The refrigerant stream in the third conduit 18 is relatively cool, in the vapor phase, and sometimes has liquid droplets entrained therein, and the refrigerant stream in the second conduit 12 between the condenser and the outlet 28 of the bypass line 24 is in the liquid phase.

In view of the refrigerant employed, for example relatively high purity propane, set point D is representative of a preselected pressure which the equipment in that segment, such as the accumulator 38, should not exceed, for example 225 psig. The set point F is representative of a preselected pressure at which the compressor 2 will function at optimum conditions for the prevention of overloading the compressor 2, such as for example 20 psig.

By utilizing the hi-select relay 52 and passing the higher of the signals E and G to the second control valve 32, the flow rate of the refrigerant through the third conduit 18 to the compressor 2 is controlled by one of the said pressures measured and maintained at its set point value D or F, the other measured pressure being below its set point value.

The employment of one of two alternative pressure control systems is desirable so that the system may accommodate itself to periodically changing conditions of refrigerant composition and heat discharge via condenser 10, and still provide maximum capacity for removing process heat via heat exchanger 14.

The set point H is representative of a minimum preselected temperature at which it is desired to operate the heat exchanger. The first control valve 30 is generally in a closed or somewhat throttled position. As the temperature of the heat exchanger effluent vapor decreases to a value approaching the preselected set point, the first control valve 30 begins to open in response to the signal I to maintain the heat exchanger temperature at a safe, minimum value by controllably passing relatively hot uncondensed vapors to the heat exchanger 14. An example minimum temperature to which the heat exchanger is desired to be limited is -20° F., again, in a controlled fashion, accommodating system operations to varying thermal duties.

By so controlling the refrigeration system by the apparatus and method of this invention, one of the pressure at the inlet 4 of the compressor 2 and the pressure between condenser 10 and the heat exchanger 14 upstream of the outlet 28 of the bypass line 24 is automatically maintained at values less than respective preselected maximum values and by controlling the flow rate of the bypassed refrigerant portion, the heat exchanger is automatically maintained at a temperature greater than a preselected minimum value. The refrigeration system will thus operate at more optimum conditions while potentially unsafe operating conditions of the system are avoided by exercising this form of automatic control.

It should be understood that the second location 42 at which the temperature measurement B is made can be in the heat exchanger 14 as opposed to in the third conduit 18, but for reasons of easy access, it is preferred that the temperature be measured in the refrigerant stream flowing through the conduit 18.

Other modifications and alterations of this invention will become apparent to those skilled in the art from the foregoing discussion and accompanying drawing, and it should be understood that this invention is not to be unduly limited thereto.

What is claimed is:

1. In a refrigeration system for treating at least one fluid passing through at least one heat exchanger, said system having a compressor having an inlet and an outlet, a condenser connected to the outlet of the compressor by a first conduit, the condenser connected to the heat exchanger by a second conduit, and the heat exchanger connected to the inlet of the compressor by a third conduit for the cyclic flow of a refrigerant stream from the outlet of the compressor, through the condenser, from the condenser through the heat exchanger, and from the heat exchanger back to the compressor via the inlet thereof, the improvement comprising:

a bypass line having an inlet and an outlet and being in fluid communication with the refrigerant stream, said bypass inlet being connected to the first conduit and said bypass outlet being connected to one of the second conduit and the heat exchanger for bypassing the condenser with a portion of the refrigerant stream discharging from the compressor;

first means for measuring the pressure of the refrigerant stream flowing through the second conduit at a location upstream of the bypass outlet and delivering a signal A in response thereto;

second means for measuring the temperature of the refrigerant stream flowing through the third conduit at a second location downstream of the heat exchanger and upstream of a first location between the heat exchanger and the compressor;

third means for measuring the pressure of the refrigerant stream flowing through the third conduit at a third location between the first location and the compressor and delivering a signal C in response thereto;

means for receiving the signal A, comparing said signal A to a set point D, and delivering a signal E in response to said comparison;

means for receiving the signal C, comparing said signal C to the set point F, and delivering a signal G in response to said comparison;

a hi-select relay connected to the second control valve and the first and second pressure controllers for receiving signals G and E, comparing said signals one to the other, and delivering the larger one of said signals G and E to the second control valve in response to said comparison for controlling the flow rate of the refrigerant passing through the third conduit to the compressor inlet in response to said received signal for maintaining the pressures at the inlet of the compressor and between the condenser and the heat exchanger at a value less than a respective preselected value; and

means responsive to the measured temperature for controlling the flow rate of refrigerant passing through the bypass line at a preselected value.

2. An apparatus, as set forth in claim 1, including an accumulator positioned in the second conduit at a location upstream of the outlet of the bypass conduit and being connected to the first means.

3. An apparatus, as set forth in claim 1, including a liquid knockout positioned in the third conduit at a fourth location between the first and third locations.

4. An apparatus, as set forth in claim 1, including a plurality of heat exchangers each being connected in fluid communication to the second conduit, the third conduit, and the bypass line.

5. In a method for cooling at least one fluid passing through at least one heat exchanger by compressing a refrigerant stream in a compression zone, passing the compressed refrigerant through a condenser, passing the refrigerant from the condenser through the heat exchanger, and recycling the refrigerant discharging from the heat exchanger to the compression zone, the improvement comprising:

passing a portion of the compressed refrigerant from between the compressor and the condenser into the refrigerant stream at a mixing location between an outlet of the condenser and an outlet of the heat exchanger;

measuring the pressure of the refrigerant passing from the condenser to the heat exchanger at a location upstream of the mixing location and delivering a signal A in response to said measurement;

comparing signal A to a set point signal D and delivering a signal E in response to said comparison;

measuring the pressure of the refrigerant passing from the heat exchanger to the compression zone at a third location and delivering a signal C responsive to said measurement;

comparing signal C to a set point signal F and delivering a signal G in response to said com-

parison;
comparing signals G and E one to the other and delivering the larger one of said signals G and E in response to said comparison;

controlling the flow rate of the refrigerant stream passing from the heat exchanger to the compression zone in response to one of said signals G and E for maintaining the pressures at an inlet of the compression zone and between the condenser and the heat exchanger at values less than respective preselected values, said controlling of the flow rate being at a first location between the third location and the heat exchanger;

measuring the temperature of the refrigerant stream passing between the heat exchanger and the compression zone at a second location downstream of the heat exchanger and upstream of the first location and delivering a signal B in response to said temperature measurement;

comparing signal B to a set point H and delivering a signal I in response to said comparison; and

controlling the flow rate of the refrigerant portion in response to said signal I for maintaining the heat exchanger at a temperature greater than a preselected value.

6. A method, as set forth in claim 5, including removing liquid from the refrigerant stream at a location between the first location and the third location.

7. A method, as set forth in claim 5, including passing the refrigerant stream and the removed portion of the refrigerant stream through a plurality of heat exchangers.

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