

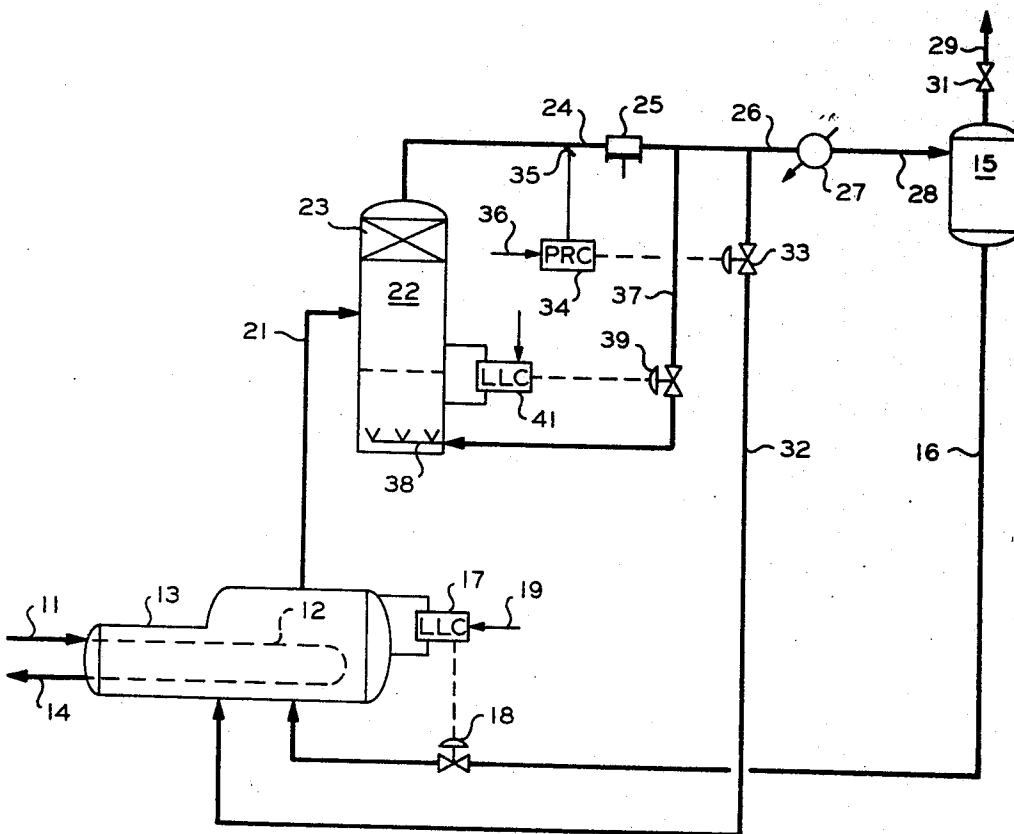
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RECOVERY OF ENTRAINED LIQUID REFRIGERANT

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1

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RECOVERY OF ENTRAINED LIQUID
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10 Claims

ABSTRACT OF THE DISCLOSURE

Refrigerant vapor containing entrained liquid refrigerant is passed from a vaporizer to a knock-out vessel to remove the entrained liquid. Refrigerant vapor essentially free of entrained liquid is passed from the knock-out drum to the inlet of a compressor. A first portion of the hot compressed vapor is condensed and returned to the vaporizer at a rate responsive to the level of liquid refrigerant in the vaporizer. A second portion of the hot compressed vapor is introduced as vapor into the vaporizer at a rate responsive to the compressor inlet pressure. A third portion of the hot compressed vapor is introduced into the bottom of the knock-out drum at a rate responsive to the liquid level therein to vaporize the liquid refrigerant.

In the operation of refrigeration systems, knock-out drums are generally positioned in the vapor line from the vaporizer to the inlet of the compressor. The knock-out drum is utilized to collect any entrained liquid refrigerant in the vapor stream in order to prevent such entrained liquid entering the compressor and thereby damaging the compressor. The liquid refrigerant collected in the bottom of the knock-out drum is periodically withdrawn and discarded and make-up refrigerant is added to the system as required. However, in many installations make-up refrigerant is expensive or not readily available or the amount of the liquid withdrawn and discarded from the knock-out drum represents a significant cost factor. Accordingly, it has become desirable to recover the liquid refrigerant contained in the bottom of the knock-out drum for further use in the refrigeration system.

In accordance with the present invention, it has been discovered that the liquid refrigerant collected in the knock-out drum can be most effectively and efficiently recovered by passing a portion of the hot compressed vapor from the compressor outlet into heat exchange with the body of liquid refrigerant in the bottom of the knock-out vessel. In accordance with the presently preferred embodiment of the invention, the heat exchange is effected by introducing the hot compressed vapors directly into the body of liquid refrigerant to obtain the greater efficiency of direct contact. The partially cooled refrigerant vapor and the vapor resulting from the vaporization of liquid refrigerant is withdrawn from the knock-out drum as a part of the vapor stream going to the compressor.

Accordingly, it is an object of the invention to minimize refrigerant losses in a refrigeration system. It is a further object of the invention to recover the entrained liquid refrigerant from a refrigerant vapor stream for further use in the system while protecting the compressor against the presence of entrained liquid in the inlet stream thereto. It is an object of the invention to effectively and efficiently recover liquid refrigerant collected in a knock-out drum.

Other objects, aspects and advantages of the invention will be apparent from a study of the specification, the drawing and the appended claims to the invention.

In the drawing there is illustrated a schematic representation of a refrigeration system embodying the present invention. A process stream to be cooled is passed through

2

conduit 11 into and through loop 12 of indirect heat exchanger 13 and is withdrawn therefrom by way of conduit 14. While shell and tube heat exchanger 13 represents a chiller for the process fluid, it is a vaporizer for the refrigeration system and will hereafter be referred to as a vaporizer. Liquid refrigerant from surge tank 15 is passed through conduit 16 into the shell of vaporizer 13. Liquid level controller 17 determines the level of liquid refrigerant in the shell of vaporizer 13 and regulates valve 18, located in conduit 16, to maintain the refrigerant liquid level in the shell of vaporizer 13 at the desired value represented by set point 19. Generally the liquid refrigerant level will be above loop 12. The heat exchange with the process fluid causes the liquid refrigerant to vaporize. The resulting refrigerant vapor containing entrained liquid refrigerant droplets is withdrawn from vaporizer 13 and passed by way of conduit 21 into knock-out vessel 22. Vessel 22 is shaped and sized to permit a separation of the entrained liquid from the vapor feed by gravitational force and inertial force as the refrigerant vapor flowpath changes to an upward direction. A demister 23 is located in the upper portion of vessel 22 to capture any small particles of liquid refrigerant which remain entrained in the vapor after the change in direction of the vapor flow path. A vapor stream essentially free of entrained liquid is withdrawn from an upper portion of knock-out vessel 22 and passed by way of conduit 24 to the inlet of a compressor 25. A first portion of the hot compressed vapors is passed from the outlet of compressor 25 through conduit 26 into and through indirect heat exchanger 27 wherein the refrigerant vapor is condensed. The resulting liquid refrigerant is passed through conduit 28 into surge tank 15. Surge tank 15 is provided with a vent conduit 29 containing a valve 31 to permit the removal of noncondensable gas from tank 15. A second portion of the hot compressed refrigerant vapors is passed from the outlet of compressor 25 through conduit 32 into the shell of vaporizer 13. A valve 33, located in conduit 32, is manipulated by pressure recorder controller 34 responsive to a comparison of the actual pressure of the vapor stream passing through conduit 24 to the inlet of compressor 25 as indicated by pressure sensor 35 with the desired pressure represented by set point 36. A third portion of the hot compressed refrigerant vapor is passed from the outlet of compressor 25 through conduit 37 into sparger 38 positioned in the body of liquid refrigerant collected in the bottom of knock-out vessel 22. Valve 39, located in conduit 37, can be manipulated by liquid level controller 41 to maintain the liquid level of the body of liquid refrigerant in vessel 22 substantially constant at a desired value or within a range between a lower limit and an upper limit. The partially cooled refrigerant vapor and the vapor resulting from the vaporization of liquid refrigerant in separator 22 pass upwardly through separator 22 and are withdrawn as part of the vapor stream going through conduit 24 to compressor 25. As these vapors are coming from a body of boiling refrigerant maintained at a pressure very close to the pressure in vaporizer 13, there is no significant change in the temperature or pressure of the vapor in conduit 24 upon passage of hot compressed vapor through conduit 37. The constant temperature and pressure at the inlet of compressor 25 increases the efficiency of the compressor. While the means for introducing the hot compressed refrigerant vapor into the body of liquid refrigerant has been illustrated as a sparger, other means can be utilized. For example the hot compressed refrigerant vapor could be passed through a length of tubing for indirect heat exchange in the lower portion of the body of liquid refrigerant prior to being released directly into the upper portion of the body of liquid refrigerant.

3

The following example is presented in further illustration of the invention and should not be construed in undue limitation of the invention.

EXAMPLE

A refrigerant comprising 4.63 mol percent ethane and 95.37 mol percent propane is utilized in the refrigeration system of the drawing under the following process conditions:

Stream:	Pressure, p.s.i.a.	Temperature, ° F.	Flow Rate, lb./hr.
21.....	75	35	52,000
24.....	74	35	52,500
25.....	195	130	36,000
28.....	190	90	36,000
16 ¹	190	90	36,000
32 ¹	195	130	16,000
32 ²	76	120	16,000
37 ¹	195	130	503
37 ²	76	120	500

¹ Upstream of valve.

² Downstream of valve.

Under normal operating conditions valve 39 can be manually opened for a sort time at periodic intervals. However, to prevent excessive accumulation of liquid in vessel 22 during system upsets, valve 39 can be automatically manipulated by controller 41.

Reasonable variations and modifications are possible within the scope of the foregoing disclosure, the drawing and the appended claims to the invention.

I claim:

1. In a process wherein a feed stream comprising a first portion thereof in the form of vapor and a second portion thereof in the form of entrained liquid is passed into a liquid-vapor separation zone to separate said entrained liquid from said vapor, the thus separated liquid collects as a liquid body in a lower portion of said liquid-vapor separation zone, a vapor stream essentially free of entrained liquid is withdrawn from said liquid-vapor separation zone and compressed, the improvement comprising passing a first portion of the resulting hot compressed vapor into heat exchange with said liquid body to vaporize a portion of said liquid body.

2. A process in accordance with claim 1 wherein said first portion of said resulting hot compressed vapor is passed into direct heat exchange with said liquid body and the resulting vaporized vapor and the partially cooled compressed vapor are withdrawn from said liquid-vapor separation zone as a portion of said vapor stream essentially free of entrained liquid.

3. A process in accordance with claim 2 further comprising manipulating the flow of said first portion of said resulting hot compressed vapor into said liquid body responsive to the liquid level of said liquid body.

4. A process in accordance with claim 3 wherein said feed stream comprises a refrigerant obtained from a vaporization zone wherein liquid refrigerant is vaporized by indirect heat exchange with a fluid to be cooled, further comprising passing a second portion of said hot compressed vapor to a condensing zone and therein condensing said second portion, and passing the resulting liquefied second portion to said vaporization zone as the supply of liquid refrigerant at a rate responsive to the level of liquid refrigerant in said vaporization zone.

4

5. A process in accordance with claim 4 further comprising passing a third portion of said hot compressed vapor directly into said vaporization zone at a rate responsive to the pressure of said vapor stream.

6. Apparatus comprising a liquid-vapor separation vessel, a demister positioned in an upper portion of said liquid-vapor separation vessel, first conduit means for introducing into said liquid-vapor separation vessel at a point below said demister a first vapor stream containing entrained liquid, a compressor having an inlet and an outlet, second conduit means connected between said inlet of said compressor and said liquid-vapor separation vessel at a point above said demister, third conduit means connected between the lower portion of said liquid-vapor separation vessel and said outlet of said compressor to pass a portion of the hot compressed vapor from said outlet of said compressor into heat exchange relationship with a body of liquid in the lower portion of said liquid-vapor separation vessel, means for indicating the liquid level of said body of liquid in the lower portion of said liquid-vapor separation vessel, and valve means operatively positioned in said third conduit means to vary the flow of hot compressed vapor through said third conduit means.

7. Apparatus in accordance with claim 6 further comprising a sparger located in said lower portion of said liquid-vapor separation vessel, said third conduit means being connected to the inlet of said sparger.

8. Apparatus in accordance with claim 7 further comprising a liquid level controller for manipulating said valve means responsive to the indicated liquid level of said body of liquid.

9. Apparatus in accordance with claim 8 further comprising a vaporizing vessel, said first conduit means being connected to an upper portion of said vaporizing vessel, fourth conduit means for passing a fluid to be cooled through said vaporizing vessel in indirect heat exchanging relationship with the fluid contents of said vaporizing vessel, a condenser having an inlet and an outlet, fifth conduit means connected between said outlet of said compressor and said inlet of said condenser, and sixth conduit means connected between said outlet of said condenser and said vaporizing vessel.

10. Apparatus in accordance with claim 9 further comprising a second valve means located in said sixth conduit means, liquid level control means for manipulating said second valve means responsive to the liquid level of the contents of said vaporizing vessel, seventh conduit means connected between said outlet of said compressor and said vaporizing vessel, a third valve means located in said seventh conduit means, and pressure control means for manipulating said third valve means responsive to the fluid pressure in said second conduit means.

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