

Capacity Boosting During Pulldown

Technical Field

[0001] This invention relates generally to transport refrigeration systems and, more particularly, to a method for boosting compressor capacity during pulldown operating conditions.

Background of the Invention

[0002] In transcritical refrigeration systems as for example when using CO₂ as the refrigerant, the capacity at high evaporating temperatures is limited compared to more conventional subcritical refrigerants due to the thermodynamic properties of the fluid in use. Pulldown, the process of starting the system at a high evaporating temperature and pulling heat out of the area to be refrigerated, is a critical phase which requires high capacity and accomplishment in a reasonable time.

Disclosure of the Invention

[0003] In accordance with one aspect of the invention, during periods of operation of a transcritical refrigeration system in a pulldown mode, a second compressor is caused to operate in parallel with the primary compressor to temporarily boost the capacity of the system.

[0004] In accordance with another aspect of the invention, a two-stage compressor arrangement has a plurality of valves that are operated in such a way as to cause the two-stages to operate in parallel rather than in series operation to thereby boost the capacity of the system.

[0005] In the drawings as hereinafter described, a preferred embodiment is depicted; however, various other modifications and alternate constructions can be made thereto without departing from the scope of the invention.

Brief Description of the Drawings

[0006] FIG. 1 is a schematic illustration of a transcritical refrigeration system with the present invention incorporated therein.

[0007] FIG. 2 is a schematic illustration of one embodiment thereof.

[0008] FIGS. 3 and 4 are a schematic illustrations of another embodiment thereof.

Detailed Description of the Invention

[0009] Shown in FIG. 1, is a CO₂ refrigerant vapor compression system which includes a primary compression device 11 driven by a motor 12 operatively associated therewith, a refrigerant heat rejecting heat exchanger 13, and a refrigerant heat absorbing heat exchanger 14, also referred to herein as an evaporator, all connected in a closed loop refrigerant circuit in series refrigerant flow arrangement by various refrigerant lines 16, 17 and 18. Additionally, the refrigerant vapor compression system 10 includes a filter drier 19 and a flash tank receiver 21 disposed in refrigerant line 17 of the refrigerant circuit downstream with respect to refrigerant flow of the refrigerant heat rejecting heat exchanger 13 and upstream with respect to refrigerant flow of the evaporator 14, and an evaporator expansion device 22, operatively associated with the evaporator 14, disposed in refrigerant line 17 downstream with respect to refrigerant flow of the flash tank receiver 21 and upstream with respect to refrigerant flow of the evaporator 14.

[0010] The primary compression device 11 functions to compress and circulate CO₂ refrigerant through the refrigerant circuit, and may be a single or a multi-stage compressor such as, for example, a scroll compressor or a reciprocating compressor. In the case of a multiple stage compressor, both compression stages would be driven by the single motor 12 operatively associated in driving relationship with the compression mechanism of the compressor 11.

[0011] The CO₂ refrigerant vapor compression system is designed to operate in a subcritical cycle. Thus, the refrigerant heat rejecting heat exchanger 13 is designed to operate as a refrigerant condensing heat exchanger through which hot, high pressure refrigerant vapor discharge from the compression device 11 passes in heat exchange relationship with a cooling medium to condense the refrigerant passing therethrough from a refrigerant vapor to refrigerant liquid. The refrigerant heat rejecting heat exchanger 13, which may also be referred to herein as a gas cooler or a condenser, may comprise a finned tube heat exchanger, such as, for example, a fin and round tube heat exchange coil or a fin and flat mini-channel tube

heat exchanger. In transport refrigeration system applications, the typical cooling medium is ambient air passed through the condenser 13 in heat exchange relationship with the refrigerant by means of fan(s) 31 operatively associated with the condenser 13.

[0012] The evaporator 14 constitutes a refrigerant evaporating heat exchanger which, in one form, may be a conventional finned tube heat exchanger, such as, for example, a fin and round tube heat exchange coil or a fin and mini-channel flat tube heat exchanger, through which expanded refrigerant, having traversed the expansion device 22, passes in heat exchange relationship with a heating fluid, whereby the refrigerant is vaporized and typically superheated. The heating fluid passed in heat exchange relationship with the refrigerant in the evaporator 14 may be air passed through the evaporator 14 by means of fan(s) 24 operatively associated with the evaporator 14, to be cooled and also commonly dehumidified, and thence supplied to a climate controlled environment which may include a perishable cargo, such as, for example, refrigerated or frozen food items, placed in a storage zone associated with a transport refrigeration system.

[0013] The expansion device 22, which is normally an electronic expansion valve, operates to control the flow of refrigerant through the refrigerant line 33 to the evaporator 14 in response to the refrigerant suction temperature and pressure sensed by the sensors (not shown) on the suction side of the compression device 11. A bypass valve 27 is provided to supplement the refrigerant flow through the expansion device 22 when higher mass flow is required by the refrigeration system. During normal operation, the primary compression device 11 is sufficient to meet the capacity requirements of the system.

[0014] A control logic diagram is shown in Fig. 2 to illustrate this operation.

[0015] During normal operation, which is indicated in block 33, the controller 28 causes the motor 11 to drive the primary compression device 11 only. When operation is desired in the pulldown mode, the controller 28 moves to block 36 so as to then operate the motor 29 to drive the booster compressor 31, in parallel with and in addition to the primary compression device 11. When the pulldown mode operation is completed, the control 28 then proceeds to block 33 for normal operation.

[0016] Having described the invention in one form as comprising two separate compressors, another embodiment thereof is shown in Figs. 3 and 4, wherein a single, two-stage compressor is operated in such a manner as to perform as a pair of compressors operating in parallel.

[0017] The two-stage compressor is shown generally at 38 and comprises a first stage 39 and a second stage 41. A valve 42 is disposed therebetween. During normal operation, the valve 42 is open and the two-stage compressor 38 operates as a conventional two-stage compressor. Also provided are valves 43 and 44, which are arranged in parallel relationship with the stage one 39 and stage two 41, respectively. When the operational needs are such that higher capacities are required, such as at pulldown operating conditions, the valve 42 is closed and the valves 43 and 44 are opened. The effect is to place the two stages 39 and 41 in parallel relationship as shown in Fig. 4 to thereby temporarily boost capacity of the system.

[0018] When operating in the above manner, with either the Fig. 1 or Fig. 3 embodiments, a smaller main compressor is allowed to be used for normal operating conditions, which is desirable in terms of overall power consumption.

[0019] Operating in parallel stages will increase the system mass flow and thereby improve capacity of the system. The multi-stages compressor can be turned into a regular compressor when the pulldown is achieved or almost achieved, or when the distance between the suction and discharge pressures are too high and causing overheating of the discharge gas.

[0020] While the present invention has been particularly shown and described with reference to the preferred mode as illustrated in the drawing, it will be understood by one skilled in the art that various changes in detail may be effected therein without departing from the spirit and scope of the invention as defined by the claims.

We Claim:

1. A method of operating a transport refrigeration system of the type having CO₂ as the refrigerant, comprising the steps of:
during normal operation, compressing the refrigerant in the system by the operation of only a first compression unit; and
only during operation under pulldown conditions, operating a second compressor unit in parallel with said first compression unit to thereby increase the system mass flow and improve the overall capacity thereof.
2. A method as set forth in claim 1 wherein said first compression unit is a single stage compressor.
3. A method as set forth in claim 1 wherein said second compression unit is a single stage compressor.
4. A method as set forth in claim 1 wherein said first and second compression units comprise first and second stages of a two stage compressor, and further wherein valving is provided to selectively cause the two stages to operate either in series or parallel relationship.
5. A method as set forth in claim 4 wherein said valving includes a valve between the first and second stage, and a valve connected in parallel across each of said stages.
6. A method as set forth in claim 5 wherein, during normal operation, the valve between the two stages is open and other valves are closed, and during pulldown operation, the valve between the two stages are closed, and the other two valves are open.

7. A transport refrigeration system comprising:

a vapor compression system including a compression unit, a condenser, an expansion device and an evaporator connected in serial refrigeration flow relationship and adapted to operate with CO₂ as the refrigerant;

said compression unit being a two stage compressor and including valving apparatus capable of being selectively operated such that during normal operation the refrigerant flows through the two stages in series relationship and during periods of operation in which greater capacities are desired the refrigerant flows through the two stages in parallel relationship to thereby boost the capacity of the system.

8. A transport refrigerant system as set forth in claim 7 wherein said valving apparatus includes a first valve between the two stages and second and third valves connected in parallel with the respective stages, such that for normal operation said first valve is opened and said second and third valves are closed wherein during periods in which higher capacities are desired said first valve is closed and said second and third valves are opened.