

SUPPLY AIR DISCHARGE FOR A REFRIGERATED CONTAINER

BACKGROUND OF THE INVENTION

[0001] The subject matter disclosed herein relates to refrigeration systems. More specifically, the subject matter disclosed herein relates to refrigeration of containers utilized to store and ship cargo.

[0002] A typical refrigerated cargo container, such as those utilized to transport a cargo via sea, rail or road, is a container modified to include a refrigeration unit located at one end of the container. The refrigeration unit includes a compressor, condenser, expansion valve and evaporator coil, all located at the end of the container. A volume of refrigerant circulates throughout the refrigeration unit, and one or more evaporator fans of the refrigeration unit blow a flow of supply air across the evaporator coil cooling the supply air and forcing it out into the container.

[0003] The supply air flow in many applications is subject to stringent temperature requirements. For example, it may be necessary to provide supply air in a range of $\pm 0.25^{\circ}$ Celsius. To meet such requirements, the compressor of the refrigeration unit is often a variable speed compressor, and supply air temperature is varied and controlled by changing speed of the compressor. Use of variable speed compressors, however, still often results in supply air temperature fluctuation and temperature undershoot that is unacceptable to customers shipping very temperature sensitive cargo. Alternatively, other compressor modulating schemes are utilized, such as suction modulation or the use of a digital compressor. Variable speed or digital compressors are costly, and relatively inefficient.

BRIEF DESCRIPTION OF THE INVENTION

[0004] In one embodiment, a transportation cargo refrigeration system includes a refrigeration unit to provide a flow of supply air for a refrigerated cargo container. A refrigeration system outlet allows the flow of supply air into the cargo container. A mixing chamber is located between the refrigeration unit and the refrigeration system outlet for mixing of the flow of supply air thereby reducing supply air temperature fluctuation at the refrigeration system outlet.

[0005] In another embodiment, a method of operating a refrigeration system for a refrigerated cargo container includes flowing air through a refrigeration unit thereby reducing a temperature of the supply air. The supply air is directed into a mixing chamber and mixed

in the mixing chamber until a selected supply air temperature is achieved. The supply air is directed through a refrigeration system outlet and into an interior of a cargo container.

[0006] In yet another embodiment, a refrigerated transportation cargo container includes a transportation cargo container and a refrigeration unit to provide a flow of supply air for the transportation cargo container. A refrigeration system outlet allows the flow of supply air into the transportation cargo container. A mixing chamber is located between the refrigeration unit and the refrigeration system outlet for mixing of the flow of supply air thereby reducing supply air temperature fluctuation at the refrigeration system outlet.

[0007] These and other advantages and features will become more apparent from the following description taken in conjunction with the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] The subject matter, which is regarded as the invention, is particularly pointed out and distinctly claimed in the claims at the conclusion of the specification. The foregoing and other features, and advantages of the invention are apparent from the following detailed description taken in conjunction with the accompanying drawings in which:

[0009] FIG. 1 is a schematic illustration of an embodiment of a refrigerated cargo container;

[0010] FIG. 2 is a schematic illustration of an embodiment of a refrigeration system for a container;

[0011] FIG. 3 is another schematic illustration of an embodiment of a refrigeration system for a container; and

[0012] FIG. 4 is a schematic illustration of another embodiment of a refrigeration system for a container.

[0013] The detailed description explains embodiments of the invention, together with advantages and features, by way of example with reference to the drawing.

DETAILED DESCRIPTION OF THE INVENTION

[0014] Shown in FIG. 1 is an embodiment of a refrigerated cargo container 10. The cargo container 10 is configured to maintain a cargo 12 located inside the cargo container 10 at a selected temperature through the use of a refrigeration unit 14 located at the container 10. The cargo container 10 is mobile and is utilized to transport the cargo 12 via, for example, a truck, a train or a ship. The refrigeration unit 14 includes a compressor 16, a condenser 18, an

expansion valve 20, an evaporator 22 and an evaporator fan 24 (shown in FIG. 2) located at, for example, a first end 26 of the container 10.

[0015] Referring to FIG. 2, the refrigeration unit 14 flows return airflow 28 across the evaporator 22 via the evaporator fan 24, thus cooling the airflow 28 to a selected temperature and urges the cooled return airflow, now referred to as supply air 38, through a refrigeration unit outlet 30 into the container 10 via, for example, openings 32 in one or more T-bars 34 extending along a base 36 of the container 10 to cool the cargo 12.

[0016] During operation of the refrigeration unit 14, the compressor 16 is cycled “on” and “off” for cost efficient compressor capacity modulation. When the compressor 16 is cycled on/off, however, there may be a high degree of fluctuation in the supply air 38 temperature, since the supply air produced while the compressor 16 is on is of significantly lower temperature than the supply air 38 produced when the compressor 16 is off. To reduce the fluctuation in temperature prior to being urged through the refrigeration unit outlet 30, the supply air 38 is held in a mixing chamber 40 upstream of the outlet 30. The mixing chamber 40 may be located at a lateral side of the refrigeration unit 14 as shown, or alternatively at any other suitable location between the refrigeration unit 14 and an interior of the container 10.

[0017] Referring to FIG. 3, the supply air 38 is retained in the mixing chamber 40 by a closure, for example, a movable door 42 positioned across the outlet 30. The supply air 38 is retained in the mixing chamber 40 for a selected duration of time, for example, one complete on/off cycle of the compressor 16, at which point the supply air 38 is mixed to the desired temperature. Alternatively, one or more temperature sensors 44 (shown in FIG. 2) may be positioned in the mixing chamber 40 to detect a temperature of the supply air 38. The supply air 38 is retained until the selected supply air 38 temperature is detected by the temperature sensors 44. The supply air 38 is released from the mixing chamber 40 by opening the door 42 and flows through the outlet 30 and through the openings 32 in the T-bars 34 and into an interior of the container 10. Operation of the door 42 may be controlled by a control unit 46 linked to the compressor 16 and/or the temperature sensors 44. Further, in some embodiments, a mixing fan 48 is located in the mixing chamber 40 to aid in mixing of the supply air 38 so that a homogeneous mixture of supply air 38 at a selected temperature is reached more quickly.

[0018] Another embodiment is shown in FIG. 4. In this embodiment, a portion of return airflow 28 bypasses the evaporator 22 and is injected into the mixing chamber 40. In the mixing chamber 40, the injected return airflow 28 mixes with supply airflow 38 provided

from the refrigeration unit 14 via the evaporator 22. The result of this mixing of return airflow 28 and supply airflow 38 is mixed supply airflow 48 at a desired temperature, which is flowed from the mixing chamber 40 and through the openings 32 in the T-bars 34 and into the interior of the container 10. In some embodiments, the injection of return airflow 28 into the mixing chamber 40 is synchronized with operation of the compressor 16. When the compressor 16 is on, the supply air provided is at a lower temperature than when the compressor 16 is off. Thus, injection of the higher temperature return air 28 is done when the compressor 16 is on to raise the temperature of the supply air 38, and injection of the return air 28 into the mixing chamber 40 is reduced or stopped entirely when the compressor 16 is turned off.

[0019] Mixing of the supply air 38 in the mixing chamber 40, and in some embodiments mixing the supply air 38 with a flow of return air 28 in the mixing chamber 40 reduces temperature fluctuation of the supply air 38 when it reaches the interior of the container 10. Reduced temperature fluctuation reduces risk to and damage to temperature sensitive cargo 12. Further, the reduction in temperature fluctuation is achieved through flow mixing in the mixing chamber 40, rather than through modulation at, or changing operation of the compressor 16. The compressor 16 in the embodiments described herein is operated only in either an “on” position or an “off” position, without costly and relatively inefficient variable operating speeds or other modulation.

[0020] While the invention has been described in detail in connection with only a limited number of embodiments, it should be readily understood that the invention is not limited to such disclosed embodiments. Rather, the invention can be modified to incorporate any number of variations, alterations, substitutions or equivalent arrangements not heretofore described, but which are commensurate with the spirit and scope of the invention. Additionally, while various embodiments of the invention have been described, it is to be understood that aspects of the invention may include only some of the described embodiments. Accordingly, the invention is not to be seen as limited by the foregoing description, but is only limited by the scope of the appended claims.

CLAIMS:

1. A transportation cargo refrigeration system comprising:
 - a refrigeration unit to provide a flow of supply air for a refrigerated cargo container;
 - a refrigeration system outlet to allow the flow of the supply air into the cargo container; and
 - a mixing chamber disposed between the refrigeration unit and the refrigeration system outlet for mixing the flow of supply air and thereby reducing supply air temperature fluctuation at the refrigeration system outlet.
2. The refrigeration system of Claim 1, wherein the refrigeration system outlet includes a movable closure to retain the flow of supply air in the mixing chamber to enhance mixing.
3. The refrigeration system of Claim 1, wherein the moveable closure remains closed for at least one on/off cycle of a compressor of the refrigeration system.
4. The refrigeration system of Claim 1, further comprising a temperature sensor disposed in the mixing chamber.
5. The refrigeration system of Claim 1, further comprising a fan disposed in the mixing chamber to improve mixing of the supply air.
6. The refrigeration system of Claim 1, wherein a flow of return air from the cargo container is directed into the mixing chamber to mix with the supply air.
7. The refrigeration system of Claim 6, wherein the flow of return air bypasses the refrigeration unit.
8. The refrigeration system of Claim 7, wherein the flow of return air is directed into the mixing chamber when a compressor of the refrigeration unit is operating.
9. The refrigeration system of Claim 7, wherein the flow of return air is not directed into the mixing chamber when a compressor of the refrigeration unit is not operating.
10. A method of operating a refrigeration system for a refrigerated cargo container comprising:
 - flowing supply air through a refrigeration unit thereby reducing a temperature of the supply airflow;
 - directing the supply air into a mixing chamber;
 - mixing the supply air in the mixing chamber until a selected supply air temperature is achieved; and

directing the supply air through a refrigeration system outlet and into an interior of a cargo container.

11. The method of Claim 10, further comprising retaining the supply air in the mixing chamber via a movable closure to facilitate mixing of the supply air.

12. The method of Claim 11, wherein the moveable closure remains closed for at least one one/off cycle of a compressor of the refrigeration system.

13. The method of Claim 10, further comprising detecting a supply air temperature in the mixing chamber via a temperature sensor.

14. The method of Claim 10, enhancing mixing of the supply air in the mixing chamber via a fan.

15. The method of Claim 10, further comprising:

directing a flow of return air from the cargo container into the mixing chamber; and

mixing the return air and the supply air in the mixing chamber.

16. The method of Claim 15, wherein the flow of return air bypasses the refrigeration unit.

17. The method of Claim 15, further comprising directing the flow of return air into the mixing chamber when a compressor of the refrigeration unit is operating.

18. The method of Claims 17, further comprising stopping the flow of return air into the mixing chamber when a compressor of the refrigeration unit is not operating.

19. A refrigerated transportation cargo container comprising:

a transportation cargo container;

a refrigeration unit to provide a flow of supply air for the transportation cargo container;

a refrigeration system outlet to allow the flow of supply air into the transportation cargo container; and

a mixing chamber disposed between the refrigeration unit and the refrigeration system outlet for mixing of the flow of supply air thereby reducing supply air temperature fluctuation at the refrigeration system outlet.

20. The transportation cargo container of Claim 19, wherein the refrigeration system outlet includes a movable closure to retain the flow of supply air in the mixing chamber to enhance mixing.

21. The transportation cargo container of Claim 20, wherein the moveable closure remains closed for at least one one/off cycle of a compressor of the refrigeration unit.

22. The transportation cargo container of Claim 19, wherein a flow of return air from the cargo container is directed into the mixing chamber to mix with the supply air.

23. The transportation cargo container of Claim 22, wherein the flow of return air into the mixing chamber is stopped when a compressor of the refrigeration unit is not operating.