

CARGO TEMPERATURE MONITORING AND CONTROL 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 air across the evaporator coil cooling the air and forcing it out into the container.

[0003] The cooled air in typical container system is forced out of the refrigeration unit and along a floor of the container. As the cooled air travels away from the refrigeration unit, its temperature increases and it rises in the container and eventually returns to the refrigeration unit. Temperature of this return air is sensed at the refrigeration unit. This sensed supply air temperature is used by a refrigeration unit control system to determine various settings of the refrigeration unit including switching the compressor on or off, setting the fan speed to high or low or off, or other settings that determine a temperature of the air exiting the refrigeration unit into the container.

[0004] Using the temperature of the supply air to drive operation of the refrigeration unit is inaccurate in maintaining a desired cargo temperature, especially in cases of particularly temperature sensitive cargos, for example, bananas or other fruits, or the like. The air temperature, in most cases, can vary greatly from the actual cargo temperature, making maintaining the desired cargo temperature difficult. Further, the present method cannot determine if localized hot (or cold) spots exist in the container, which can result in spoilage of certain portions of the cargo.

BRIEF DESCRIPTION OF THE INVENTION

[0005] In one embodiment, a method of monitoring and controlling temperature of a cargo in a refrigerated transportation cargo container includes measuring a temperature of a plurality of portions of the cargo located in the cargo container via a plurality of temperature

sensors directed at the portions of the cargo. One or more of the measured cargo temperatures are compared to a preselected cargo temperature threshold. Operation of a refrigeration unit disposed at the cargo container in operable communication with the plurality of temperature sensors is changed based on a result of the comparison.

[0006] In another embodiment, a transportation cargo container refrigeration system includes a plurality of cargo temperature sensors configured to determine a temperature of at least portions of a cargo. The system further includes a refrigeration unit, and a controller operably connected to the refrigeration unit and the plurality of noncontact cargo temperature sensors to control operation of the refrigeration unit based on data received from the plurality of cargo temperature sensors.

[0007] In yet another embodiment, a refrigerated transportation cargo container includes a transportation cargo container and a refrigeration unit configured to cool the cargo container. A plurality of cargo temperature sensors are located in the cargo container to determine a temperature of the cargo. A controller is operably connected to the refrigeration unit and the plurality of noncontact cargo temperature sensors to control operation of the refrigeration unit based on data received from the plurality of cargo temperature sensors.

[0008] 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

[0009] 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:

[0010] FIG. 1 a cutaway view of an embodiment of a refrigerated cargo container; and

[0011] FIG. 2 is a block diagram of an embodiment of a method for monitoring and controlling a cargo temperature in a container.

[0012] 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

[0013] 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 (as schematically shown in FIG. 1) a compressor 16, a condenser 18, an expansion valve 20, an evaporator 22 and an evaporator fan 24 located at, for example, a first end 26 of the container 10. 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 28 through a refrigeration unit outlet 30 into the container 10 to cool the cargo 12. The return airflow 28 may also be supplemented with a fresh airflow 32 introduced to the refrigeration unit 14 via a fresh air inlet 34. The container 10 further includes a second end 36 located opposite the first end 26, and two sidewalls 38, a floor 40 and a roof 44 located between the first end 26 and the second end 36.

[0014] Operation of the refrigeration unit 14 is controlled by a controller 46, which directs such functions of the refrigeration unit 14 as switching the compressor 16 on or off, operation of and speed of the evaporator fan 24, and operation of and speed of a fresh air fan (not shown), used to introduce fresh air into the refrigeration unit 14. The controller 46 operates the refrigeration unit 14 to maintain a selected cargo temperature of the cargo 12. To accurately determine an actual cargo temperature on or more cargo temperature sensors 50 located in the container 10. As shown in FIG. 1, a plurality of cargo temperature sensors 50 may be located through the container 10, to determine a temperature of different localized portions of the cargo 12. Any suitable cargo temperature sensor 50 may be utilized to determine the temperature of the cargo 12. In some embodiments, the cargo temperature sensors 50 may be noncontact sensors, for example, thermal cameras, laser temperature sensors, or the like. In other embodiments, the cargo temperature sensors 50 may be temperature probes or contact sensors, such as thermocouples, placed at the cargo 12. The cargo temperature sensors 50 are utilized to determine the cargo temperature, rather than the temperature of the airflow in the container 10, so that refrigeration unit 14 can be more accurately and beneficially managed by the controller 46.

[0015] For example, referring now to FIG. 2, in step 52, the plurality of cargo temperature sensors 50 each sense a cargo temperature. These cargo temperatures are transmitted to the controller 46, to which the plurality of cargo temperature sensors 50 are operably connected, in step 54. In step 56, the controller 46, or a processor of the controller

46 may manipulate the data provided by the cargo temperature sensors 50, for example, the cargo temperatures provided by the cargo temperature sensors 50 may be averaged, resulting in an average cargo temperature. In step 58, the average cargo temperature is compared to a selected average cargo temperature, or "set point". This set point is a temperature desired for the cargo 12 to minimize undesirable effects on the cargo 12, for example, thawing, spoilage or the like. The set point may include a threshold band around it, for example, a certain number of degrees greater and/or lesser than the set point. If the average cargo temperature varies from the set point, or is outside of the threshold band, the controller 46 takes action by changing the operation of the refrigeration unit 14, in step 60. These changes may include switching the compressor 16 on if the average cargo temperature is higher than allowed by the threshold, or turning the compressor 16 off and/or introducing a greater amount of fresh airflow 32 if the average cargo temperature is lower than the threshold. This process is repeated continuously, as the plurality of cargo temperature sensors 50 constantly monitor the cargo temperature.

[0016] In addition to maintaining a selected average cargo temperature, the refrigeration unit 14, and the cargo temperature sensors 50 monitor the cargo for localized variations in cargo temperature, referred to as "hot spots", where a portion of the cargo 12 is locally undesirably warmer than surrounding or adjacent cargo 12, or "cold spots", where a portion of the cargo 12 is locally undesirably cooler than surrounding or adjacent cargo 12. The controller 46 monitors the cargo temperature data received from the plurality of cargo temperature sensors 50, for individual cargo temperatures that vary from the set point or average cargo temperature outside of a local cargo temperature threshold, in step 62. Such local variation is indicative of a hot spot or cold spot in the cargo 12, and may be addressed by the controller in step 64, by for example, switching the evaporator fan 24 to high speed operation to urge a stronger circulation of airflow 28 throughout the container 10, thereby eliminating the hot spot or cold spot.

[0017] Further, in step 66, the cargo temperature data from the cargo temperature sensors 50 is stored at the controller 46 and may be output as, for example, a cargo temperature history or temperature map 68 once the cargo 12 reaches a destination. The cargo temperature map 68 is useful for a customer to cargo receiver in determining which portions of the cargo, if any, were at a higher or lower temperature, which may affect a remaining time of the cargo 12 portions prior to spoilage or other undesirable effects.

[0018] 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 method of monitoring and controlling temperature of a cargo in a refrigerated transportation cargo container comprising:

measuring a temperature of a plurality of portions of the cargo disposed in the cargo container via a plurality of temperature sensors directed at the portions of the cargo, to measure cargo temperature at a plurality of localized portions of the cargo;

computing an average cargo temperature from the measured cargo temperatures;

comparing the average cargo temperature to an average cargo temperature threshold;

comparing the local cargo temperature to a local cargo temperature threshold;

changing operation of a refrigeration unit disposed at the cargo container in operable communication with the plurality of temperature sensors based on a result of these comparisons; and

transmitting the measured cargo temperatures to a controller in operable communication with the plurality of temperature sensors and with the refrigeration unit, the controller configured to change operation of the refrigeration unit and producing a cargo temperature history or map, such that a cargo receiver is able to determine which portions of the cargo if any, are more susceptible to spoilage or other undesirable effects.

2. The method according to Claim 1, wherein changing operation of the refrigeration unit comprises one or more of changing operation of a compressor, evaporator or fresh air inlet of the refrigeration unit.

3. The method according to Claim 1, wherein the plurality of temperature sensors comprise at least one thermal camera or at least one laser temperature sensor.

4. The method according to Claim 1, wherein changing operation of the refrigeration unit comprises one or more of changing operation of a compressor, evaporator,

evaporator fans, condenser fan or fresh air inlet of the refrigeration unit.

5. The method according to Claim 1, wherein the plurality of cargo temperature sensors measure the cargo temperature substantially continuously.

6. A transportation cargo container refrigeration system, comprising:

 a plurality of cargo temperature sensors configured to determine a temperature of at least portions of a cargo by measuring a cargo temperature at a plurality of localized portions of the cargo;

 a refrigeration unit; and

 a controller operably connected to the refrigeration unit and the plurality of cargo temperature sensors to control operation of the refrigeration unit based on data comparing:

 the average cargo temperature to an average cargo temperature threshold; and

 the local cargo temperature to a local cargo temperature threshold;

received from the plurality of cargo temperature sensors, the measured cargo temperatures being transmittable to the controller, to produce a cargo temperature history or map, such that a cargo receiver is able to determine which portions of the cargo if any, are more susceptible to spoilage or other undesirable effects.

7. The system according to Claim 6, wherein the plurality of temperature sensors comprise at least one thermal camera or at least one laser temperature sensor.

8. The system according to Claim 6, wherein the controller is configured to change operation of one or more components of the refrigeration unit.

9. The system according to Claim 8, wherein the one or more components include refrigeration unit includes a compressor, evaporator, evaporator fans, condenser fan or fresh air inlet of the refrigeration unit.

10. The system according to Claim 6, wherein the plurality of temperature sensors are

configured to measure the cargo temperature substantially continuously.

11. A refrigerated transportation cargo container comprising:

- a transportation cargo container;

- a refrigeration unit configured to cool the cargo container;

- a plurality of cargo temperature sensors disposed in the cargo container to determine a temperature of the cargo by measuring a temperature of a plurality of localized portions of the cargo; and

- a controller operably connected to the refrigeration unit and the plurality of noncontact cargo temperature sensors to control operation of the refrigeration unit based on data comparing:

 - the average cargo temperature to an average cargo temperature threshold; and

 - the local cargo temperature to a local cargo temperature threshold;

received from the plurality of cargo temperature sensors, the measured cargo temperatures being transmittable to the controller, to produce a cargo temperature history or map, such that a cargo receiver is able to determine which portions of the cargo if any, are more susceptible to spoilage or other undesirable effects.

12. The cargo container according to Claim 11, wherein the plurality of temperature sensors comprise at least one thermal camera or at least one laser temperature sensor.

13. The cargo container according to Claim 11, wherein the controller is configured to change operation of one or more components of the refrigeration unit.

14. The cargo container according to Claim 13, wherein the one or more components include refrigeration unit includes a compressor, evaporator, evaporator fans, condenser fan or fresh air inlet of the refrigeration unit.

15. The cargo container according to Claim 11, wherein the plurality of temperature sensors are configured to measure the cargo temperature substantially continuously.