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(54) **BATCH FREEZER WITH CRYOGENIC PRECOOLING APPARATUS AND METHOD**

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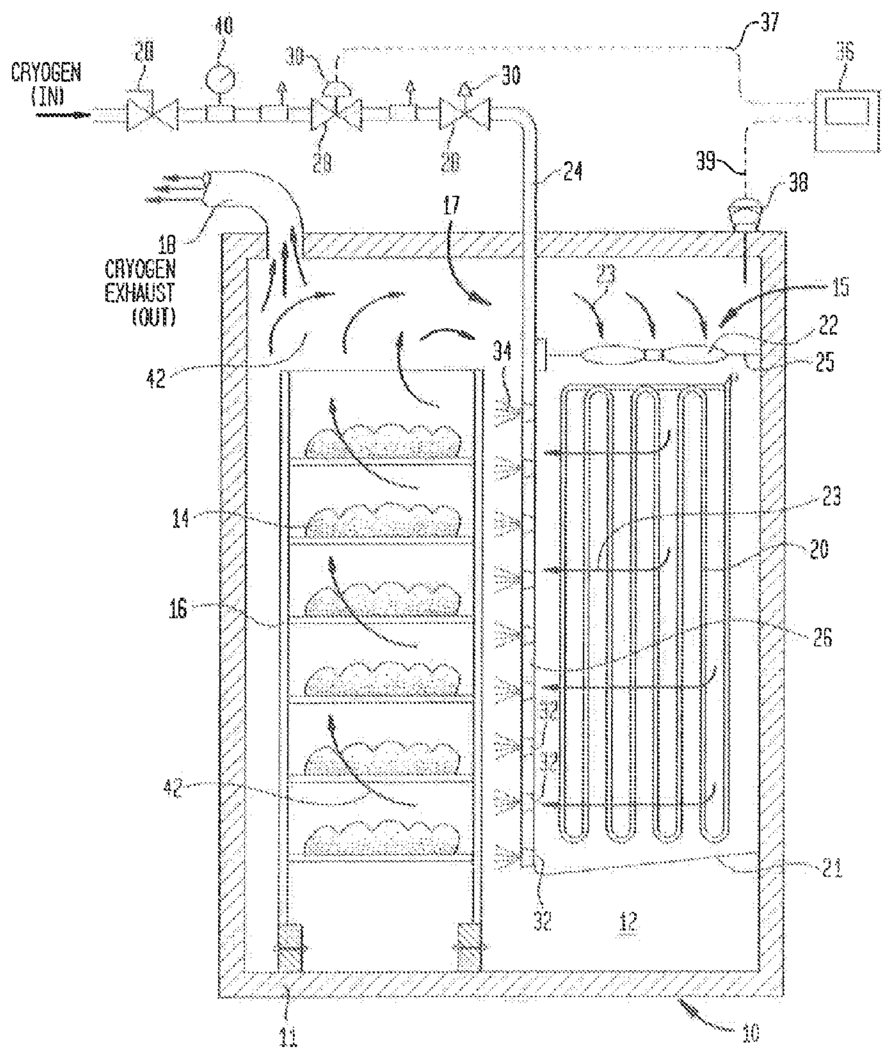
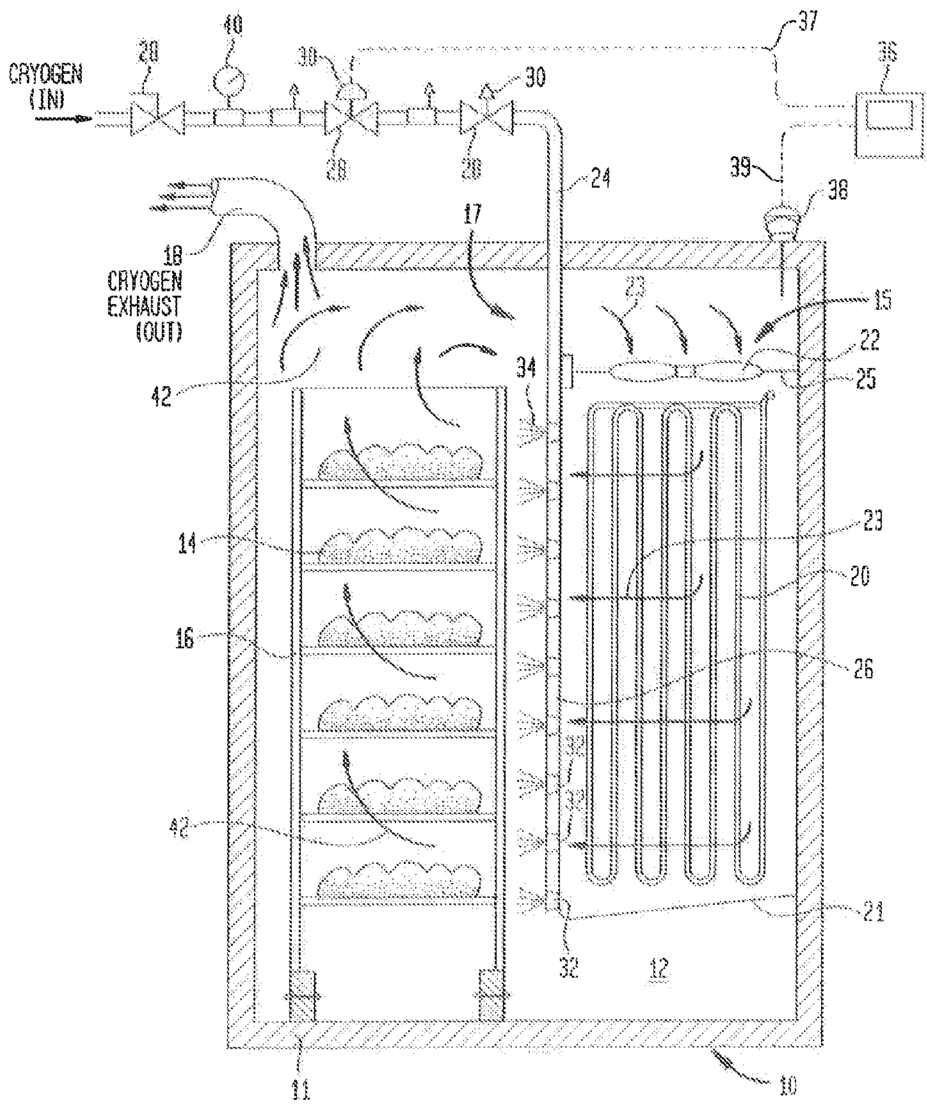
(57) **ABSTRACT**

A freezer for a product includes a housing having a chamber therein with an atmosphere for reducing a temperature of the product; a cryogen refrigeration apparatus operationally associated with the chamber during a first cycle to pre-cool the atmosphere in the chamber; and a mechanical refrigeration apparatus operationally associated with the chamber during a second cycle to cool the atmosphere in the chamber when the first cycle is completed. A process is also provided.




CRYOGEN (IN)
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BATCH FREEZER WITH CRYOGENIC PRECOOLING APPARATUS AND METHOD

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. Provisional Application No. 61/859,335, filed Jul. 29, 2013.

BACKGROUND OF THE INVENTION

[0002] The present inventive embodiments relate to batch freezers, and chilling and freezing processes provided by same.

[0003] The initial cool down time of known batch freezer systems from room (or ambient) temperature to operating temperature restricts the usable operating time of the system during the day. Cool down times for a batch freezer can exceed one (1) hour. This limitation reduces the amount of product which can be frozen during a single shift or day and therefore, reduces overall efficiency of a plant freezing or chilling process.

[0004] During the initial cool down period of a mechanical batch freezer using conventional mechanical refrigeration (such as for example heat exchangers and condensers), the air inside the freezer (chilling or freezing atmosphere) is cooled by passing it across internal refrigeration coils. These coils are colder than the dew point temperature of the air inside the batch freezer. As a result, moisture from the air collects on these coils and freezes until the internal temperature of the system is cold enough so that all moisture in the air drops out. The accumulation of ice and snow on the refrigeration coils reduces the convective heat transfer between the internal air and the cods, which in turn results in significant inefficiencies in the mechanical refrigeration process.

[0005] In addition, moisture from the product is also released into the internal air during the initial cool down process of the mechanical batch freezer. Product dehydration is directly related to the duration of cool down from ambient to operating temperature of the batch freezer. If the freezer can be cooled down faster, the product experiences less dehydration which results in a more desirable final, saleable product for the customer and less moisture accumulation on the refrigeration coils.

BRIEF DESCRIPTION OF THE DRAWING

[0006] The FIGURE shows a sideview in cross-section of a batch freezer embodiment according to the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0007] To overcome the deficiencies of distinct mechnical and cryogenic freezers, there is provided a combined mechanical and cryogen freezer apparatus or assembly. The batch freezer embodiment of the present invention uses cryogen to provide 100% of the refrigeration for the initial cool down of the freezer and the product. Once the freezer reaches the desired operating temperature, the cryogenic apparatus portion shuts down and the mechanical refrigeration apparatus starts and operates for the duration of the production run. When a new batch of warm product is placed into the apparatus, the process outlined above repeats.

[0008] For purposes of the embodiments herein, mechanical refrigeration with a freezer assembly or apparatus is, for example, an apparatus or process by which heat is removed from a location using a heat exchanger over which a fluid flow is directed to provide a chilling and/or freezing flow from heat sink coils for a product such as for example a food product. That is, mechanical freezing provides refrigeration usually with a closed loop refrigeration cycle. The major components of a mechanical refrigeration apparatus or system include a compressor, condenser, expansion valve and evaporator. Electricity provides the power to the compressor which drives refrigerant through the closed loop cycle of the apparatus. Ammonia may be used as the refrigerant, but other substances can be used as well for the refrigerant. Mechanical temperature ranges usually can be brought down to −80° F.

[0009] For purposes of the embodiments herein, a cryogen freezer assembly or apparatus is for example one in which a cryogenic substance, such as liquid nitrogen or carbon dioxide, is provided such as by injection or spray, to a product to chill and/or freeze the product, such as a food product. Cryogenic freezing can provide refrigeration using a cryogenic fluid such as liquid nitrogen or carbon dioxide. Cryogenic freezing includes direct contact freezing of the product by having the refrigeration substance sprayed directly on to a surface of the product to be chilled or frozen, or in some applications submerged in the cryogen. Cryogen apparatus or systems are relatively simple to operate, easier to maintain and less costly than a comparable mechanical refrigeration apparatus or system. Cryogen refrigeration apparatus temperature ranges can be brought down to about −300° F. The cryogenic refrigerant may be dry ice, solid carbon dioxide (CO_2), liquid CO_2 or liquid nitrogen. The liquid cryogen can be sprayed directly onto the product, or the liquid cryogen can be sprayed or injected into a compartment where the products are contacted by the cryogen. The liquid may change phase to a gaseous mixture which can be circulated throughout the compartment.

[0010] The present freezer apparatus provides an initial cryogenic injection cycle during cool down or a pre-cool cycle which reduces such cool down time to be only 5-10 minutes, thereby providing the customer with greater opportunity for production during an operating day.

[0011] The independent cryogenic refrigeration injection assembly of the present embodiments is used to cool down the batch freezer apparatus. As the mechanical refrigeration system is not operating during the initial cryogen cool down period, no moisture will collect on the refrigeration coils. When the process reaches the desired operating temperature, the cryogenic system shuts off and the mechanical apparatus starts for a cool-down cycle. In effect, the cryogen assembly and the mechanical refrigeration assembly of the freezer apparatus are never in operation at the same time. All of the moisture in the air of the batch freezer has therefore dropped out and there is no possibility of accumulation on the mechanical refrigeration coils.

[0012] The rapid cryogenic pre-cool cycle or period provided by the present embodiments will bring the product surface temperature through the freeze point faster and minimize the overall dehydration loss of the food product within the process. Once the product's surface temperature is cooled past the freeze point, no more dehydration can occur and accordingly, the mechanical refrigeration assembly can be started.

[0013] Referring to the FIGURE, a batch freezer is shown generally at **10** and includes walls **11** (which can be insulated) to define a chamber **12** within the freezer for chilling or freezing of products **14**, such as food products, therein. The chamber **12** includes a chilling and/or freezing atmosphere for the products **14**. The food product **14** is chilled or frozen by being introduced into the chamber **12**, usually by way of a moveable rack and tray assembly **16**. Such rack assemblies **16** are known. The assembly **16** can support a plurality of the food products **14** for a freezing operation, after which the assembly is removed from the chamber **12**, possibly to a remote location, for subsequent processing, such as packaging; while another assembly containing additional food products for freezing is rolled into the chamber for a subsequent freezing operation. An exhaust **18** is in communication with the chamber **12**. The exhaust can be connected for operation with a blower (not shown) to remove cryogenic gas in the chamber **12** to an environment external to the freezer **10**.

[0014] Disposed at one side of the chamber **12** is a heat exchanger **20** or mechanical condenser coils, and an air circulation device **22** such as at least one fan mounted, such as by way of example only, proximate and above the heat exchanger. Reference herein to an air circulation device **22** or fan includes the singular and plural of such elements. The fan **22** includes a housing **25** mounted within the chamber. The housing **25** supports the fan **22** to draw airflow to pass over the heat exchanger **20**. The fan **22** can also be mounted below the heat exchanger **20** or in any other position for use in association with the heat exchanger and to sufficiently circulate atmosphere within the chamber **12**. The heat exchanger **20** is charged with ammonia or a refrigerant such as R404A. The heat exchanger **20** and the fan **22** provide a mechanical refrigeration apparatus **15** or assembly.

[0015] A cryogen such as liquid nitrogen or carbon dioxide is introduced into the chamber **12** through cryogen piping **24** which extends to a cryogen injection manifold **26** disposed in the chamber. The cryogen piping **24** is provided with at least one valve **28** and if necessary a plurality of valves to each of which is mounted a transceiver **30** for a purpose to be described hereinafter. The cryogen injection manifold **26** includes at least one nozzle **32** and for many applications a plurality of nozzles mounted thereto for providing, by injection or otherwise, a cryogen spray **34** into the chamber **12** in a direction generally toward a position in the chamber where the rack and tray assembly **16** bearing the food products **14** is disposed. The cryogen piping **24**, injection manifold **26** and spray nozzles **32** provide a cryogen refrigeration apparatus **17** or assembly. Such assembly can include for example the valves **28** and transceivers **30**.

[0016] In effect, one embodiment of the present invention calls for the mechanical refrigeration apparatus **15** and the cryogen refrigeration apparatus **17** to be substantially disposed inside the freezer **12** for each such apparatus to be operationally associated with the chamber. Such construction provides for a unitary freezer apparatus **10** which can be moved or transported to alternate or remote locations for application and/or maintenance and repair as necessary. One such embodiment of the present invention has the cryogen injection manifold **26** disposed in the chamber **12** between the heat exchanger **20** and the rack and tray assembly **16** for efficient use of the volume of the chamber. It is understood that the position of the cryogen injection manifold **26** will be contingent upon the size of the heat exchanger **20** and the size of the rack and tray assembly **16**, such that there is sufficient room for each and optimum coaction in order to realize the cool down and subsequent freezing of the food product **14**.

[0017] A controller (PLC) **36** is provided to be in communication via a connection **37** with the transceivers **30** at the valves **28**. The controller **36** is also in communication with a temperature sensor **38** which is in communication with an atmosphere in the chamber **12**. The sensor **38** senses the temperature of the chamber **12** and communicates the temperature via a signal connection **39** to the controller **36**.

[0018] In operation, the rack and tray assembly **16** containing the food product(s) **14** is positioned inside the chamber **12** of the apparatus **10**. A door (not shown) to the chamber is shut. A temperature of the chamber **12** is sensed and communicated by the temperature sensor **38** via the connection **39** to the controller **36** which signals the transceivers **30** via the connection **37** to open the respective valves **28** to permit introduction of the cryogen through the piping **24** and into the cryogen injection manifold **26**, wherein the cryogen is directed through the spray nozzles **32** as a spray **34** to impact the food product **14** and also charge the air flow **23** (a first cycle). A pressure or flow gauge **40** is in fluid communication with the cryogen in the piping **24** to indicate pressure of the cryogen or flow rate transiting the piping.

[0019] An air flow shroud **21** is disposed in the chamber **12** for coaction with the heat exchanger **20** and cryogen injection manifold **26**. The shroud **21** is disposed in one embodiment proximate a lower portion of the heat exchanger **20** and, as shown in the FIGURE, extends from an inner surface of the wall **11** to the manifold **26**. Such an arrangement of the air flow shroud **21** will direct air flow **23** drawn into the heat exchanger **20** to be deflected to pass in proximity to the cryogen injection manifold **26** to thereby be charged by the cryogen spray **34** to provide a cryogen chilled air flow **42** which is subsequently circulated by the fans **22** to be drawn again into the heat exchanger. The cryogen apparatus **17**, shroud **21** and fan(s) **22** can be installed in different types of mechanical batch freezers and so the shroud and fan configurations can vary between manufacturers.

[0020] The controller **36** has been preset with the necessary temperature that the particular food product **14** will need for the duration of time that it will take in order to be sufficiently chilled or frozen to the specification required. For many applications, the controller **36** is set to achieve a temperature lower than the freezing point of the food product. The controller **36** will determine the length of time (e.g., 5-10 minutes) the cryogen is to be introduced into the manifold **26**, either based upon a time sequence or when the temperature sensor **38** indicates that the temperature of the chamber **12** has reached a sufficiently low enough temperature to commence freezing operations. During the introduction of the cryogen into the chamber **12**, neither the fan **22** nor the heat exchanger **20** is in operation, except however that the fan may be in operation during the initial cool down period or only a portion of the time during the initial cool down. During the initial cool down with the cryogen, the mechanical refrigeration apparatus **15** of the freezer apparatus **10** is not in operation.

[0021] As soon as the controller **36** senses that a desired or sufficient pre-cool down temperature has been reached by the introduction only of the cryogen, the controller **36** stops introduction of the cryogen, immediately after which the fan **22** and the heat exchanger **20**—the mechanical refrigeration assembly **15**—commences operation (the second cycle). During this time period of the second cycle there is no use of the cryogen. Also, for a process where cool down times for the product are known and repeatable, a timer (not shown) can be used to switch from cryogenic to mechanical operation, and back to cryogenic in a continuous, timed manner. For purposes of the embodiments herein, the pre-cool and cooling cycles may each begin when the previous cycle is completed or substantially completed. That is, the mechanical refrigeration cycle may commence when the cryogenic pre-cool cycle has completely ended, or upon cessation of the cryogenic pre-cool cycle such that same is coming to an end or winding down but has not completely finished or ended. Since the embodiments herein promote the efficient use of cryogen, the refrigeration permits the operator of the freezer to determine the most suitable time when to cease one cycle and commence with the other cycle.

[0022] The fans **22** draw the air flow **42** to pass over the heat exchanger as the air flow **23**. The air flow **42** having been previously precooled by the earlier introduction of the cryogen, continues to be cooled as it passes across the coils of the heat exchanger **20** and is subsequently directed onto the food product **14** as the air flow **42**, until such time as the designated amount of time has elapsed for sufficient chilling or freezing of the food product **14**.

[0023] When the food product **14** has been sufficiently chilled or frozen, the cryogen exhaust **18** will vent the cryogen gas from the chamber **12**. The cryogen is usually venting throughout the entire cool down process. When the atmosphere in the chamber **12** is vented and safe enough to enter, the fans **22** are stopped and the door is opened for removal of the rack and tray assembly **16** for subsequent processing. Another rack and tray assembly with other product for being chilled or frozen is moved into the chamber **12**, the door is shut and the process begins again with the temperature controller **36** determining the amount of cryogen necessary for the precooling for the first cycle. After the cryogen precooling occurs, the introduction of cryogen is stopped and the fans **22** and mechanical heat exchanger **20** are activated to continue with the cool down or freezing of the food product **14** during the second cycle.

[0024] The present embodiments provide for the increased utilization of a mechanical batch freezer which results inasmuch as a 75% reduction in the amount of time necessary to cool down the food product for the required chilling or freezing. The cryogen delivery apparatus and method of the present embodiments increases the efficiency of the initial cool down of the food product because, in part, it is operating when the mechanical (heat exchanger and fans) portion of the freezer is not operating. There is therefore little if any snow or ice build up on coils of the heat exchanger **20**. This results in increased efficiencies for the heat exchanger and the air flow **23** being moved over same.

[0025] In addition, the combined cryogen and mechanical freezing aspect of the present inventive embodiments provide for increased operating times of the mechanical refrigeration system because the snow and ice build up on the coils is substantially reduced if not eliminated. Therefore, the mechanical refrigeration components are able to maintain the set point temperature for a longer period of time so as to chill or freeze the food product to the temperature desired.

[0026] Moreover, food products frozen with the present apparatus **10** utilizing this process experience less dehydration. Since manufacturers sell food products by weight, less dehydration means a more saleable product for the end use customer.

[0027] It will be understood that the embodiments described herein are merely exemplary, and that one skilled in the art may make variations and modifications without departing from the spirit and scope of the invention. All such variations and modifications are intended to be included within the scope of the invention as described and claimed herein. Further, all embodiments disclosed are not necessarily in the alternative, as various embodiments of the invention may be combined to provide the desired result.

What is claimed is:

1. A freezer for a product, comprising:

a housing having a chamber therein and an atmosphere in said chamber for reducing a temperature of the product;

a cryogen refrigeration apparatus operationally associated with the chamber during a first cycle to pre-cool the atmosphere in the chamber; and

a mechanical refrigeration apparatus operationally associated with the chamber during a second cycle to cool the atmosphere in the chamber when the first cycle is completed.

2. The freezer of claim **1**, wherein the cryogen refrigeration apparatus and the mechanical refrigeration apparatus are disposed in the chamber.

3. The freezer of claim **1**, wherein the cryogen refrigeration apparatus comprises a pipe extending into the chamber for introducing a cryogen into the atmosphere.

4. The freezer of claim **3**, further comprising a manifold connected to the pipe and having at least one outlet for the cryogen.

5. The freezer of claim **1**, wherein the mechanical refrigeration apparatus comprises a heat exchanger disposed in the chamber.

6. The freezer of claim **1**, further comprising an atmosphere circulation device disposed in the chamber for directing a flow of the atmosphere to contact the mechanical refrigeration apparatus.

7. The freezer of claim **6**, wherein the atmosphere circulation device is disposed proximate to the mechanical refrigeration apparatus.

8. The freezer of claim **1**, further comprising a shroud disposed in the chamber to direct airflow from the mechanical refrigeration apparatus to the cryogen refrigeration apparatus.

9. The freezer of claim **8**, wherein the shroud extends in the chamber from an inner sidewall of the housing to the cryogen refrigeration apparatus.

10. The freezer of claim **1**, further comprising:

a cryogen inlet pipe in fluid communication with the cryogen refrigeration apparatus;

at least one valve in the cryogen inlet pipe for controlling delivery of cryogen through said inlet pipe: and

a controller in electronic communication with the at least one valve for controlling delivery of the cryogen through the cryogen inlet pipe.

11. The freezer of claim **10**, further comprising a temperature sensor in communication with the chamber and in electronic communication with the controller for providing a temperature signal to said controller.

12. A process for reducing a temperature of a product in an atmosphere of a freezer, comprising:

cryogenically reducing the temperature of the atmosphere with a cryogenic refrigeration apparatus operating during a first cycle for pre-cooling the atmosphere; and

mechanically reducing the temperature of the atmosphere with a mechanical refrigeration apparatus operating during a second cycle for cooling the atmosphere when the first cycle is not operating.

13. The process of claim **12**, further comprising suspending the first cycle prior to commencing the second cycle.

14. The process of claim **12**, further comprising directing a flow of the atmosphere to contact the mechanical refrigeration apparatus.

15. The process of claim **14**, wherein the directing the flow is during the second cycle.

16. The process of claim **12**, further comprising sensing a temperature of the atmosphere for determining the operating of the first and second cycles.

17. The process of claim **12**, wherein the product comprises a food product.

18. The process of claim **12**, wherein the cryogenic refrigeration apparatus comprises a cryogen selected from the group consisting of liquid nitrogen and carbon dioxide.

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