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(54) **SYSTEM AND METHOD FOR RAPIDLY FREEZING FLAT COLD PACKS**

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(57) **ABSTRACT**

A system and method for freezing cold packs. The system includes two or more plates containing a low-temperature refrigerant and a mechanical refrigeration system. The system is configured to receive a cold pack between two of the plates and simultaneously freeze the cold pack on two faces of the cold pack.

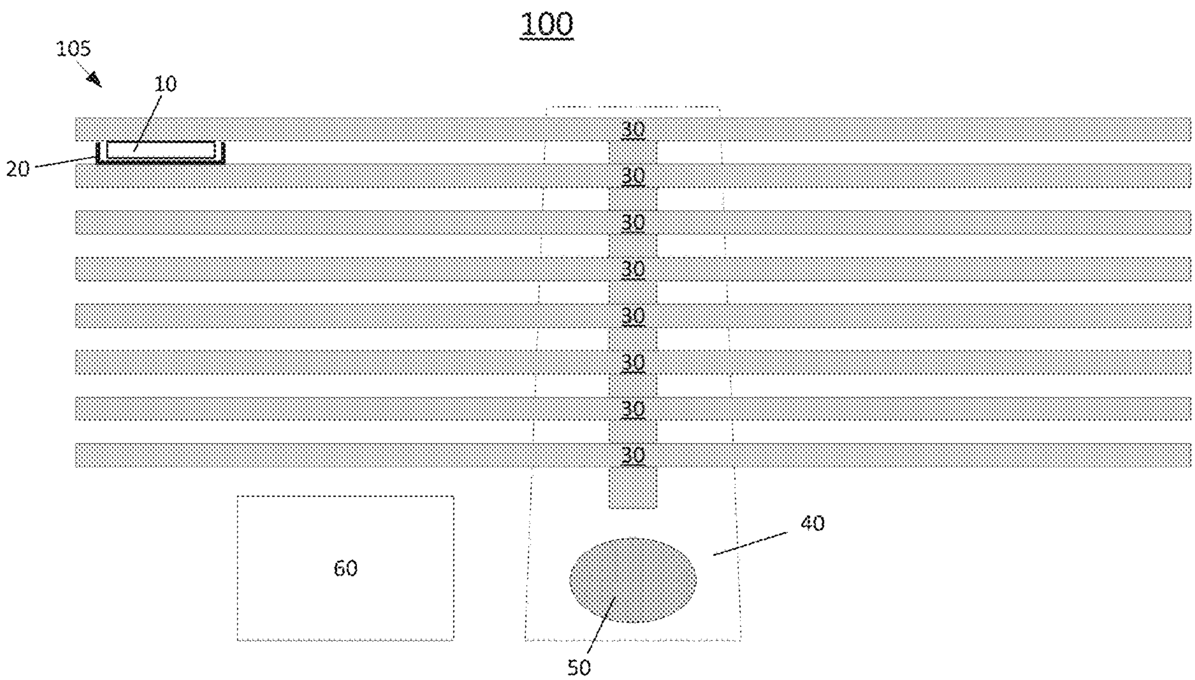


Fig. 1

100

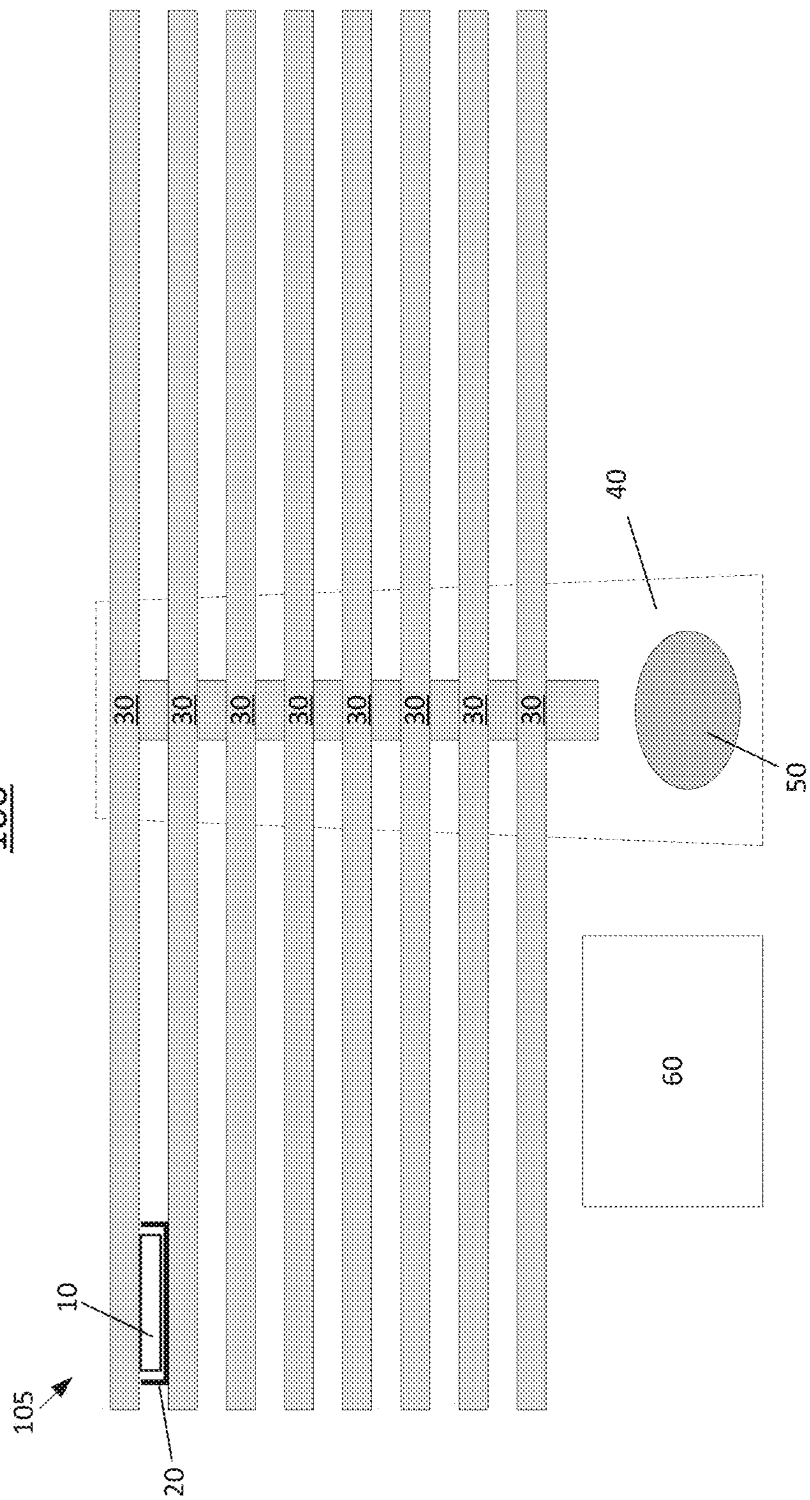


Fig. 2

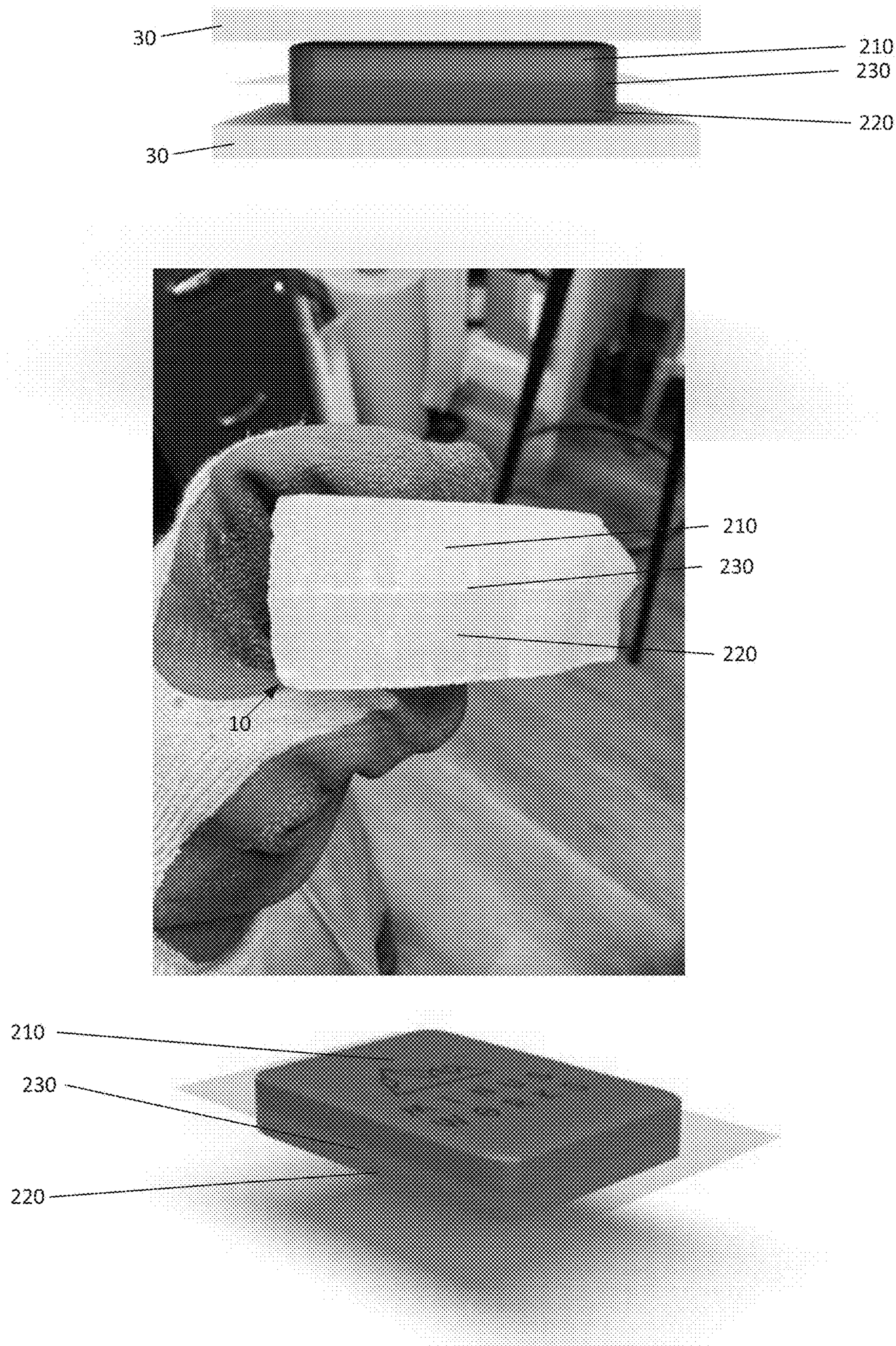
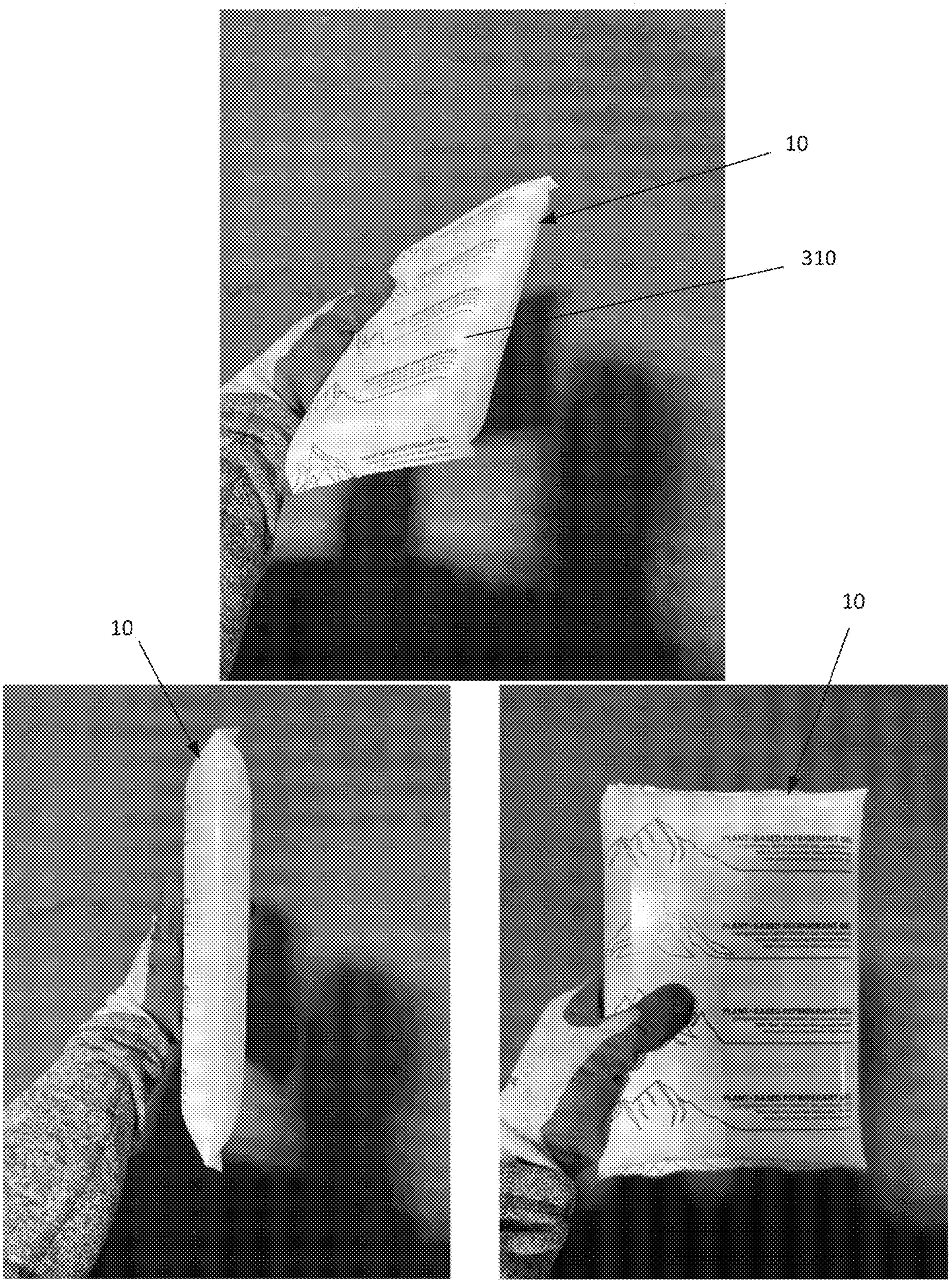


Fig. 3



SYSTEM AND METHOD FOR RAPIDLY FREEZING FLAT COLD PACKS

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] The present application claims the benefit of and priority to U.S. provisional application No. 63/551,595, filed on Feb. 9, 2024, the entire contents of which are hereby incorporated by reference in their entirety.

TECHNICAL FIELD

[0002] The present disclosure generally relates to systems and methods for rapidly freezing cold packs. The method may result in at least two flat faces and an ice grain boundary along the horizontal plane, creating two distinct ice layers within the cold pack material. The cold pack may contain a water-based gel encapsulated in a flexible material. The freezing system may utilize hollow plates containing low temperature refrigerant. The low temperature refrigerant may be delivered to the plates from a traditional mechanical refrigeration cycle. The plates may contact the cold pack on at least one of a top and bottom face, causing heat to be transferred efficiently and the cold pack to freeze rapidly.

BACKGROUND

[0003] Unless otherwise indicated herein, the materials described in this section are not prior art to the claims in this application and are not admitted being prior art by inclusion in this section.

[0004] The proliferation of eCommerce has resulted in a rapid rise of online generated deliveries and shipments. This trend may also be driving an increased demand for packaging materials. The shipping of perishables and temperature sensitive items may require specialty thermal packaging products (i.e., insulation, refrigerant cold packs, box liners). With grocery stores and pharmacies moving more business online and with the rise in delivered meal-kits, prepared meals, and curated food boxes, this has resulted in a rise in specialty thermal packaging products such as cold packs being used.

[0005] Cold packs may be passive refrigerants used to keep payloads within specified temperature ranges. Cold packs may be water based due to the excellent phase change properties of water. Water has a Latent Heat of Fusion of 334 J/g as it changes phase from solid (ice) to liquid. This high Latent Heat of Fusion allows water, through changes in its phase, to absorb a significant amount of heat per unit mass and thus keep elements in its environment cool or cold.

[0006] Before using a cold pack, the cold pack must be frozen. Given the high Latent Heat of Fusion of water, freezing water-based cold packs is an energy intensive process that takes a long time when traditional refrigeration is used. At large scales, a pallet of cold packs put into a cold storage freezer may require several weeks to fully freeze. Given the traditional long lead-time freezing cycle, it may be difficult to align cold pack supply with shipment demand. As such, customers may bear extra costs associated with buffer frozen inventory or expediting fees or the inability to ship product. The inflexibility of the frozen cold pack supply chain may result in a higher total cost of the traditional cold pack.

[0007] Cold packs may be used in many applications including parcel shippers where a tight pack-out is important for optimizing the cost of the shipment and ensuring the lack of voids or dead space in the parcel, which may have an adverse effect on the shipment's thermal stability. The dimensional consistency and flatness of a cold pack may be a valuable product feature.

[0008] The typical cold pack may use a liquid refrigerant gel and thus will take on a frozen shape similar to its shape just before freezing. Cold packs may be shipped in pallet quantities to cold storage facilities where they are frozen. During transit to the cold storage facility, cold packs may shift or lump together, thereby producing a frozen cold pack that has an uneven or irregular shape. Cold pack users often have tight packing requirements for their shipment parcels and irregularly shaped cold packs may not fit or may produce uneven cooling effects.

SUMMARY

[0009] Existing challenges associated with the foregoing, as well as other challenges, are overcome by the presently described system and method for rapidly freezing flat cold packs.

[0010] One embodiment of the present disclosure is a system where a cold pack is placed between two or more hollow plates and is in direct or indirect (via a thermally conductive layer) contact with plates. The plates are hollow and may contain low temperature refrigerant that acts to remove heat from the cold pack, thus freezing the cold pack. The system may include a mechanical refrigeration system that works to compress the refrigerant gas, then cool the gas and allow it to condense into a liquid refrigerant, then allow the liquid refrigerant to expand as it enters the plates, thereby converting back to a gas refrigerant and absorbing heat in the process.

[0011] The rapid freezing system may also comprise hydraulic, pneumatic, or servo actuated systems that press the plates together against two or more sides of the cold pack.

[0012] The cold pack is frozen with a freeze gradient moving from the plate through the cold pack toward the middle of the cold pack. The freeze gradients from the top and bottom plates will meet towards the middle of the cold pack along a horizontal plane, creating two distinct layers in the cold pack when the cold pack is fully frozen.

[0013] Another embodiment of the present disclosure includes a thermally conductive tray that conveys the cold pack onto the plates for freezing and off of the plates when frozen. The freeze gradient emanating from the bottom plate translates through the tray to the cold pack.

[0014] The frozen cold pack is frozen very rapidly given the high efficiency of heat transfer in a conduction-based process.

[0015] The high efficiency of heat transfer also allows for an energy efficient process with the majority of the refrigeration duty focused on the cold pack target.

[0016] The resulting frozen cold pack is flat on its two major faces, producing a block-like shape that is dimensionally appealing for packaging applications.

[0017] The frozen cold packs produced in this process have very high consistency of shape given the constraints of the plate on the cold pack's two major faces.

BRIEF DESCRIPTION OF THE FIGURES

[0018] The foregoing and other features of this disclosure will become more fully apparent from the following description and appended claims, taken in conjunction with the accompanying drawings. Understanding that these drawings depict only several embodiments in accordance with the disclosure and are, therefore, not to be considered limiting of its scope, the disclosure will be described with additional specificity and detail through use of the accompanying drawings, in which:

[0019] FIG. **1** illustrates an example system for freezing flat cold packs in accordance with the present disclosure;

[0020] FIG. **2** shows side cross section views of a frozen cold pack in accordance with the present disclosure; and

[0021] FIG. **3** includes a top perspective view, side view and top view of a resulting cold pack in accordance with the present disclosure.

DETAILED DESCRIPTION

[0022] The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting of the disclosure. As used herein, the term "and/or" includes any and all combinations of one or more of the associated listed items. As used herein, the singular forms "a," "an," and "the" are intended to include the plural forms as well as the singular forms, unless the context clearly indicates otherwise. It will be further understood that the terms "comprises" and/or "comprising," when used in this specification, specify the presence of stated features, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, steps, operations, elements, components, and/or groups thereof.

[0023] Unless otherwise defined, all terms (including technical and scientific terms) used herein have the same meaning as commonly understood by one having ordinary skill in the art to which this disclosure belongs. It will be further understood that terms, such as those defined in commonly used dictionaries, should be interpreted as having a meaning that is consistent with their meaning in the context of the relevant art and the present disclosure and will not be interpreted in an idealized or overly formal sense unless expressly so defined herein.

[0024] In describing the disclosure, it will be understood that a number of techniques and steps are disclosed. Each of these has individual benefit and each can also be used in conjunction with one or more, or in some cases all, of the other disclosed techniques. Accordingly, for the sake of clarity, this description will refrain from repeating every possible combination of the individual steps in an unnecessary fashion.

[0025] Nevertheless, the specification and claims should be read with the understanding that such combinations are entirely within the scope of the disclosure and the claims.

[0026] Novel methods for rapidly freezing flat cold packs are discussed herein. In the following description, for purposes of explanation, numerous specific details are set forth in order to provide a thorough understanding of the present disclosure. It will be evident, however, to one skilled in the art that the present disclosure may be practiced without these specific details.

[0027] In the following detailed description, reference is made to the accompanying drawings, which form a part hereof. In the drawings, similar symbols typically identify similar components, unless context dictates otherwise. The illustrative embodiments described in the detailed description, drawings, and claims are not meant to be limiting. Other embodiments may be utilized, and other changes may be made, without departing from the spirit or scope of the subject matter presented herein. It will be readily understood that the aspects of the present disclosure, as generally described herein, and illustrated in the Figures, can be arranged, substituted, combined, separated, and designed in a wide variety of different configurations, all of which are explicitly contemplated herein.

[0028] FIG. **1** illustrates an example system for freezing flat cold packs, arranged in accordance with at least some embodiments presented herein. System **100** may include trays **20**, freezing plates **30**, a refrigeration system **40** and a refrigerant **50**.

[0029] A cold pack **10** may be placed within tray **20** and tray **20** with cold pack **10** may be placed between two or more plates **30**. Tray **20** may be thermally conductive and may convey cold packs **10** onto plates **30** for freezing and off of plates **30** once frozen. Tray **20** may be made of any thermally conductive material such as aluminum, aluminum alloys, steel, stainless steel, copper, copper alloys, and combinations thereof, and may have a thickness of about 1-5 millimeters. A freeze gradient may emanate from a plate **30** below tray **20** and the freeze gradient may translate through tray **20** to cold pack **10** within tray **20**.

[0030] Cold pack **10** may be in direct or indirect (via a thermally conductive layer) contact with plates **30**. Plates **30** may be constructed from aluminum, aluminum alloys, steel, stainless steel, steel alloys, copper, copper alloys, or other types of thermally conductive materials, and combinations thereof. Plates **30** may have one or more openings to allow for refrigerant **50** to enter plates **30** and one or more openings to allow refrigerant **50** to exit plates **30**.

[0031] Plates **30** may be hollow and may contain low temperature refrigerant **50** which may act to remove heat from cold pack **10**, and thus freeze cold pack **10**. Refrigerant **50** may be low temperature refrigerant and may be ammonia, carbon dioxide, various types of freon or other types of chlorofluorocarbons, hydrochlorofluorocarbons (HCFCs), hydrofluorocarbons (HFCs), or hydrocarbons (HCs), and combinations thereof.

[0032] Refrigeration system **40** may compress refrigerant **50** when refrigerant **50** is a gas, and then cool gas refrigerant **50** and allow it to condense into a liquid refrigerant **50**, then allow liquid refrigerant **50** to expand as it enters plates **30**, thereby converting back to a gas refrigerant **50** and absorbing heat in the process. Refrigerant **50** may undergo a vaporization phase change within plates **30**, creating an endothermic process. System **40** may include compressors, including screw compressors, condensing units, and various valves to control flow and pressures of refrigerant **50**. System **40** may further include a sub system to keep lubrication oil of a compressor at optimal temperatures.

[0033] System **40** may have an evaporator temperature setting below 0° C., with certain embodiments having an evaporator temperature setting range of −60° C. to −20° C.

[0034] System **100** may further comprise hydraulic, pneumatic, mechanical, or servo actuated systems **60** that press plates **30** together against two or more sides of cold pack **10**.

[0035] FIG. **2** is side cross section views of a frozen cold pack, arranged in accordance with at least some embodiments presented herein. Those components in FIG. **2** that are labeled identically to components of FIG. **1** will not be described again for the purposes of brevity. As shown in FIG. **2**, cold pack **10** may be frozen with a freeze gradient moving from each plate **30** on opposite sides of cold pack **10** so that cold pack **10** is simultaneously frozen flat on two major faces. Freeze gradients may move through each side of cold pack **10** toward the middle of cold pack **10**. Freeze gradients from top plate **30** and bottom plate **30** may meet towards a middle of cold pack **10** along a horizontal plane and may create two distinct layers (**210**, **220**) in cold pack **10** when cold pack **10** is fully frozen. The two layers may be separated by an ice grain boundary **230** which may be along a bisecting horizontal line and may be visible when examining a cross section of frozen cold pack **10**.

[0036] Ice grain boundary **230** may operate as a mid-structure separation which may relieve stress on cold pack **10** caused by an impact, static or live load deflection, or thermal expansion and contraction caused by temperature changes. Ice grain boundary **230** may provide structural integrity to cold pack **10** and reduce damage to cold pack **10** during an impact or other stress. Ice grain boundary **230** may provide cold pack **10** with improved deflection in axial (compressive), lateral (shear), or angular (bending) directions before cold pack **10** is damaged. Ice grain boundary **230** may provide structural protection to cold pack **10**.

[0037] FIG. **3** includes a top perspective view, side view and top view of a cold pack, arranged in accordance with at least some embodiments presented herein. Those components in FIG. **3** that are labeled identically to components of FIGS. **1**-**2** will not be described again for the purposes of brevity. As shown in FIG. **3**, cold pack **10** may be comprised of a water-based coolant such as a viscous gel consisting of >50% water that may be encapsulated with a flexible material **310** such as a plastic or paper material. Cold pack **10** may have an essentially rectangular shape and may be flat along a horizontal axis. In other embodiments, the cold pack may be comprised of a semi-solid gel coolant encapsulated with a flexible material such as a plastic or paper. In other embodiments, the semi-solid gel may not be encapsulated. The cold pack may have a freeze/thaw point between −25° C. and 8° C.

[0038] Another embodiment of the present disclosure includes a thin layer in lieu of thermally conductive tray **20**, which may convey cold packs **10** onto and off of plates **30** but may not be thermally conductive when the thin layer does not prevent thermal conduction.

[0039] In another embodiment, tray **20** is not required and cold packs **10** are directly placed onto plates **30**.

[0040] Cold pack **10** may be frozen rapidly due to a high efficiency of heat transfer in a conduction-based process. A thickness of cold pack **10**, in the z-dimension, may be a major determinant of an amount of time required to fully freeze cold pack **10**. As a representative example, in embodiments, water-based cold packs **10** were placed between two or more plates **30**. Plates **30** were in contact with Freon R-507A, which was used as refrigerant **50** and an Evaporator Temperature Setting of −40° C. and a Condensing Temperature Setting of +40° C.

TABLE 1

Example Freeze Times for Different Thicknesses of Cold Packs

Cold Pack Thickness (inches)	Approximate Freeze Time (minutes)
0.75	33
1.00	42
1.25	53
1.50	66
1.75	80
2.00	97
2.25	117

[0041] A system in accordance with the present disclosure may provide high efficiency of heat transfer and also allow for an energy efficient process with the majority of the refrigeration duty focused on the cold pack target.

[0042] A system in accordance with the present disclosure may provide frozen cold packs which are flat on two major faces, producing a block like shape that is dimensionally appealing for packaging applications.

[0043] A system in accordance with the present disclosure may provide frozen cold packs which have a high consistency of shape given the constraints of the plate on the cold pack's two major faces.

[0044] It should be understood that the foregoing description is only illustrative of the present disclosure. Various alternatives and modifications can be devised by those skilled in the art without departing from the disclosure. Accordingly, the present disclosure is intended to embrace all such alternatives, modifications and variances. The embodiments described with reference to the attached drawing figures are presented only to demonstrate certain examples of the disclosure. Other elements, steps, methods, and techniques that are insubstantially different from those described above and/or in the appended claims are also intended to be within the scope of the disclosure.

1. A system for freezing a cold pack comprising:

two or more plates containing a low-temperature refrigerant; and

a mechanical refrigeration system, wherein the system is configured to receive a cold pack between two of the plates and simultaneously freeze the cold pack on two faces of the cold pack.

2. The system of claim **1**, wherein the simultaneous freezing of the cold pack produces at least two major flat surfaces and an ice grain boundary along a bisecting horizontal plane.

3. The system according to claim **1**, further comprising

a system to press the plates together.

4. The system according to claim **1**, wherein the low temperature refrigerant is selected from the group consisting of ammonia, carbon dioxide, freon, chlorofluorocarbons, and combinations thereof.

5. The system according to claim **1**, wherein the plates are made from a material selected from the group consisting of aluminum or aluminum alloys, stainless steel or steel alloys, copper or copper alloys, and combinations thereof.

6. The system according to claim **3**, wherein the system to press the plates together is selected from the group consisting of a hydraulic system, a pneumatic system, and a servo actuated system.

7. The system according to claim **1**, wherein a thermally conductive tray is used to convey the cold pack onto and off the plates.

8. The system according to claim **14**, wherein the thermally conductive tray is made from a material selected from the group consisting of aluminum, copper, stainless steel, and combinations thereof.

9. The system according to claim **1**, wherein an evaporator temperature setting for the refrigeration system is less than 0° C.

10. The system according to claim **1**, wherein the cold pack is a water-based cold pack, comprising >50% water.

11. The system according to claim **1**, wherein the cold pack is encapsulated in a flexible plastic material or flexible paper material.

12. A method for freezing a cold pack, the method comprising:

placing a cold pack between two or more plates, wherein the plates contain a low-temperature refrigerant; and

simultaneously freezing the cold pack on two faces by the two or more plates.

13. The method of claim **12**, wherein the simultaneous freezing of the cold pack produces at least two major flat surfaces and an ice grain boundary along a bisecting horizontal plane.

14. The method of claim **12**, further comprising pressing the two or more plates together around the cold pack.

15. The method of claim **12**, further comprising placing the cold pack within a tray prior to placing the cold pack between the two or more plates.

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