Abstract: A method and apparatus for recovering cold energy for use in cooling applications from a fluid such as liquefied gas or cold gas. The fluid is fed to a first heat exchanger where it will contact with a cryogenic fluid transferring cold energy into the heat transfer fluid. The heat transfer fluid is fed to a second heat exchanger where it will contact a cooling medium which receives the cold energy from the heat transfer fluid. The cooling medium is recovered and cold energy from the cooling medium is used for the cooling applications.
METHODS AND APPARATUS FOR COLD ENERGY RECOVERY

BACKGROUND OF THE INVENTION

[0001] The invention relates to methods for recovering cold energy normally lost during vaporization of liquefied gases, and an apparatus relating thereto. These liquefied gases are typically nitrogen, oxygen, argon, carbon dioxide, natural gas and ethylene.

[0002] Industrial gases such as nitrogen, oxygen, carbon dioxide, natural gas and ethylene are widely used in many and diverse industrial fields. They may be used as inerting agents, purge gases, reactants, cooling mediums and so forth. Depending upon the application and amount consumed, these gases are stored and supplied in either the gaseous or liquid phase. When gas demand is more than 1000 Nm³/hr, the gas is normally supplied on site for economy sake while the liquefied gases are supplied/transported and stored in vacuum-jacketed vessels for the liquid gas users and smaller volume gas users.

[0003] Besides being supplied onsite, gas can also be supplied by vaporizing a liquefied gas. The boiling points of nitrogen, oxygen and carbon dioxide under atmospheric pressure are -196°C, -183°C and -78.5°C respectively. It is well known, however that liquefying these gas is an energy intensive procedure. This cold energy is completely lost during vaporization of these liquefied gases in an ambient air vaporizer. To supply gas at ambient temperature and to minimize ice formation, very large, free-standing vaporizer modules are required. In some circumstances, such as in winter, an extra heating device is needed. The cold energy loss also occurs when liquid gas such as liquid nitrogen and liquid carbon dioxide are used for cooling purposes. The cold energy, especially sensible heat of the liquid cannot be sufficiently utilized because of either poor heat exchange efficiency or other process limitations.
[0004] The cold energy lost during evaporation is recovered by some gas users by using extra mechanical refrigeration systems to generate cold energy for freezing and cooling. However it is dangerous to recover the cold energy by directly heat-exchanging between liquid gases and water because of the possible icing of the water in the heat exchangers which can cause damage.

[0005] The invention addresses these concerns by the use of a reliable, cold energy recovery unit which can be used to replace a conventional ambient air vaporizer and to directly recover the cold energy during the evaporation of the liquefied gases or from cold spent gases.

**SUMMARY OF THE INVENTION**

[0006] In one embodiment of the invention, there is disclosed a method for recovering cold energy from a fluid comprising the steps:

a) feeding the fluid to a first heat exchanger and contacting with a heat transfer fluid;

b) feeding the heat transfer fluid to a second heat exchanger and contacting the heat transfer fluid with a cooling medium; and

c) recovering cold from the cooling medium.

[0007] The fluid or cold energy source is selected from the group consisting of liquefied gas and cold gas such as liquid nitrogen or liquid carbon dioxide.

[0008] The first heat exchanger may be two heat exchangers in series and both the first and second heat exchangers may be cryogenic heat exchangers such as finned-tube heat exchangers. The fluid is heated in the first heat
exchanger and transfers its cold energy into a heat transfer fluid. The heat transfer fluid is selected from the group consisting of anhydrous alcohol having 1 to 2 carbon atoms such as methanol or ethanol; hydrocarbons with about six carbon atoms such as iso-hexane and methylcyclopentane; and halohydrocarbons such as dichloromethane.

[0009] The cooling medium or cold energy carrier is selected from the group consisting of normal water, glycol solution and brine and is withdrawn from the second heat exchanger for use in cooling applications such as reaction temperature control, air conditioning and process cooling.

[0010] The flow of the heat transfer fluid is regulated to maintain its temperature above the freezing point of the cooling medium to avoid the difficulties in freezing cooling medium in the second heat exchanger. The flow is regulated through the use of an expansion vessel and control valve.

[0011] In another embodiment of the invention, there is disclosed an apparatus comprising first heat exchange means in fluid communication with second heat exchange means. The apparatus further comprises an expansion vessel in fluid communication with the first heat exchange means and a recycle pump in fluid communication with the first and second heat exchange means. The first heat exchange means may comprises two heat exchangers in series and both the first and second heat exchange means may be cryogenic heat exchangers.

[0012] The first and the second heat exchange means are fluidly connected by lines or tubing and a heat transfer fluid which is used to capture cold from said first heat exchange means and transfer it to the second heat exchange means. The heat transfer fluid will contact a cooling medium in the second heat exchange means which will recover the cold energy from the heat transfer fluid and this cold energy is recovered and used for cooling purposes.
BRIEF DESCRIPTION OF THE DRAWINGS

[0013] Figure 1 is a schematic process flow diagram of a cold energy recovery unit of the invention.

DETAILED DESCRIPTION OF THE INVENTION

[0014] The invention is a method for recovering cold energy during evaporation of liquefied gas or from very cold gases. The recovered cold energy can be used for cooling such as process and equipment cooling and for air conditioning.

[0015] Turning to Fig. 1, the cold energy recovery unit comprises two heat exchangers, E101A/B and E102, a recycle pump, P101, an expansion vessel, V101 and a control valve, A10. Liquefied gas or cold gas is introduced into cryogenic heat exchanger E101A/B through line 30. In cryogenic heat exchanger E101A/B, the liquefied gas is vaporized and/or cold gas is heated up and vents from the heat exchanger through line 40.

[0016] In heat exchanger E101A/B, the cold energy from the liquefied gas or cold gas is transferred to an internal heat transfer fluid (HTF), which enters E101A/B through line 50 and vents through line 60. A special HTF is applied to minimize the possibility of icing in heat exchanger E101A/B. The HTF should have a relatively low viscosity at low temperatures for ensuring good pumpability and a low melting point to prevent any freezing of the HTF in the cryogenic heat exchanger. Examples of an appropriate HTF for use in the invention are selected from the group consisting of anhydrous alcohol having 1 to 2 carbon atoms such as methanol and ethanol; hydrocarbons with about six carbon atoms such as iso-hexane, methylcyclopentane; halohydrocarbons such as dichloromethane; and other organic compounds having suitable viscosity and melting point to be used as an internal HTF for the cold energy
recovery unit.

[0017] Cold HTF from heat exchanger E101A/B is pumped into heat exchanger E102, in which the HTF thermally contacts and is heat exchanged with another cooling medium such as normal water, glycol solution or brine. The cooling medium is introduced into heat exchanger E102 through line 10. The chilled cooling medium vents in line 20 which can be used for any cooling purposes such as reaction temperature control, air-conditioning and process cooling.

[0018] The flow rate of the recycled HTF is adjusted with control valve A10 to ensure that the temperature T01 of the cold HTF in line 70 is not lower than the freezing point of the cooling medium in line 10. By varying the flow rate of the HTF through line 70, icing in heat exchanger E102 can be minimized.

[0019] When it is desired to recover cold energy from liquefied gases such as liquid nitrogen or liquid carbon dioxide, two heat exchangers may be employed in the first step. Heat exchanger E101A/B may be divided into two heat exchangers, cryogenic heat exchanger E101A may be used with the cryogenic heat exchanger E101B in series. The liquefied gas is vaporized in heat exchanger E101A and further heated up in heat exchanger E101B. In the case of cold gases, one or two heat exchangers are used depending upon the temperature and flow rate of the cold gas stream. The two heat exchangers E101A and E101B can be integrated into a single heat exchanger whereby vaporization and the warming of the liquefied gas occur in a single cryogenic heat exchanger.

[0020] An expansion vessel V101 is also necessary for balancing out temperature-related volume changes of the HTF.

[0021] While this invention has been described with respect to particular embodiments thereof, it is apparent that numerous other forms and
modifications of the invention will be obvious to those skilled in the art. The appended claims in this invention generally should be construed to cover all such obvious forms and modifications which are within the true spirit and scope of the invention.
Having thus described the invention, what I claim is:

1. A method for recovering cold energy from a fluid comprising the steps:
   a) feeding said fluid to a first heat exchanger and contacting with a heat transfer fluid;
   b) feeding said heat transfer fluid to a second heat exchanger and contacting said heat transfer fluid with a cooling medium; and
   c) recovering cold from said cooling medium.

2. The method as claimed in claim 1 wherein said fluid is selected from the group consisting of a liquefied gas and cold gas.

3. The method as claimed in claim 1 wherein said first heat exchanger is a cryogenic heat exchanger.

4. The method as claimed in claim 1 wherein said first heat exchanger is two heat exchangers in series.

5. The method as claimed in claim 1 wherein said fluid is heated in said first heat exchanger.

6. The method as claimed in claim 1 wherein cold energy is transferred to said heat transfer fluid in said first heat exchanger.

7. The method as claimed in claim 1 wherein said heat transfer fluid is selected from the group consisting of anhydrous alcohol having 1 to 2 carbon atoms; hydrocarbons with about six carbon atoms; and halohydorcarbons.

8. The method as claimed in claim 7 wherein said anhydrous alcohol
having 1 to 2 carbon atoms is selected from the group consisting of methanol and ethanol.

9. The method as claimed in claim 8 wherein said hydrocarbons with about six carbon atoms is selected from the group consisting of iso-hexane and methylcyclopentane.

10. The method as claimed in claim 7 wherein said halohydrocarbon is dichloromethane.

11. The method as claimed in claim 1 wherein said second heat exchanger is a cryogenic heat exchanger.

12. The method as claimed in claim 1 wherein said cooling medium is selected from the group consisting of normal water, glycol solution and brine.

13. The method as claimed in claim 1 wherein said cooling medium is withdrawn from said second heat exchanger and is used for cooling applications.

14. The method as claimed in claim 13 wherein said cooling applications are selected from the group consisting of reaction temperature control, air conditioning and process cooling.

15. The method as claimed in claim 1 wherein flow of said transfer fluid is regulated to maintain its temperature above the freezing point of said cooling medium.

16. The method as claimed in claim 15 wherein said regulated flow is through the use of an expansion vessel and a control valve.

17. An apparatus comprising first heat exchange means in fluid
communication with second heat exchange means.

18. The apparatus as claimed in claim 17 further comprising an expansion vessel in fluid communication with said first heat exchange means.

19. The apparatus as claimed in claim 17 further comprising a recycle pump in fluid communication with said first and said second heat exchange means.

20. The apparatus as claimed in claim 17 wherein said first heat exchange means comprises two heat exchangers in series.

21. The apparatus as claimed in claim 17 wherein said first and said second heat exchange means are cryogenic heat exchangers.

22. The apparatus as claimed in claim 17 wherein said first and said second heat exchange means are fluidly connected by a heat transfer fluid.

23. The apparatus as claimed in claim 17 wherein cold energy is recovered from said second heat exchange means.
**INTERNATIONAL SEARCH REPORT**

**International application No.**
PCT/CN2011/075921

**A. CLASSIFICATION OF SUBJECT MATTER**

F25J5/00 (2006.01) i

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

IPC: F25J

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CNPAT, WPI, EPODOC, cold energy, recovery+, heat exchanger, low temperature, cryogenic

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

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<td>CN201532078U (CHINA NATIONAL OFFSHORE OIL CORP., et al.) 21 Jul. 2010 (21.07.2010) paragraph 30 of description, fig. 1</td>
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<td>CN1407303A (CHINESE SCIENCE &amp; TECHNOLOGY UNIVERSITY) 02 Apr. 2003 (02.04.2003) paragraph 4, page 6-paragraph 1, page 7, fig. 1</td>
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Further documents are listed in the continuation of Box C.

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**Date of the actual completion of the international search**
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