

A COOLING SYSTEM

TECHNICAL FIELD

This invention relates generally to a cooling system and a cooling method for computing data
5 centers.

Background

Natural gas is a naturally occurring hydrocarbon gas mixture consisting primarily of methane,
but commonly including varying amounts of other higher alkanes, and sometimes a small
10 percentage of carbon dioxide, nitrogen, hydrogen sulfide, or helium. Natural gas is a fossil
fuel used as a source of energy for heating, cooking, and electricity generation. It is also used
as a fuel for vehicles and as a chemical feedstock in the manufacture of plastics and other
commercially important organic chemicals. Natural gas is often informally referred to
simply as "gas", especially when compared to other energy sources such as oil or coal.
15 However, it is not to be confused with gasoline, especially in North America, where the term
gasoline is often shortened in colloquial usage to gas.

Liquefied natural gas (LNG) is a composition of methane and some mixture of ethane used to
convert natural gas to liquid form for ease and safety of storage transport. It is cooled to
20 approximately -256 degrees Fahrenheit so that it can be transported from countries with a
large supply of natural gas to countries that demand more natural gas than they produce. In
its liquid state, natural gas takes up 1/600th of the space, making it much easier to ship and
store when pipeline transport is not feasible. Liquefied natural gas is primarily used to
transport natural gas from one source to another. The main method of transportation
25 is storage tanks ashore to vessel tanks. Once the cargo is delivered, the natural gas is allowed
to expand and convert back to its gaseous form. Regasification terminals are used to help
convert temperatures back to a natural gas state. The heat energy gain typically comes from
the environment.

However, the state change and the accompanying temperature increase can be better used for cooling of a heat generating systems prior to being provided for consumption by, for example, a combustion heat and power system. One such heat generating systems is a data center that contains a myriad of computing units such as a server. These data center generates a lot of heat and has to be cooled to have the computing units operate at an optimal state. Therefore, there exists a need for a cooling system that uses the state and temperature change of LNG for cooling heat generating systems such as data centers or multiple computing units.

10 Summary

In accordance with a first aspect of the invention, there is disclosed a cooling system comprising a first heat exchanger for receiving heat from a heat generating system, a second heat exchanger, a first closed-loop circuit for conveying heat from the first heat exchanger to the second heat exchanger, a storage system operable for providing natural gas to the second heat exchanger for receiving heat conveyed by the first closed-loop circuit to the second heat exchanger, and a gas engine for receiving the natural gas from and heated by the second heat exchanger and enabling generating of energy therefrom. The energy generated by the gas engine being at least one of heat energy and mechanical energy.

20 In accordance with a second aspect of the invention, there is disclosed a cooling method comprising receiving heat from a heat generating system by a first heat exchanger, conveying heat from the first heat exchanger to a second heat exchanger by a first closed-loop circuit, providing natural gas from a storage system to the second heat exchanger for receiving heat conveyed by the first closed-loop circuit to the second heat exchanger, and generating of
25 energy by a gas engine from natural gas received from and heated by the second heat exchanger. The energy generated by the gas engine being at least one of heat energy and mechanical energy.

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Brief Description of the Drawings

FIG. 1 shows an exemplary system diagram of a cooling system in accordance with an aspect of the invention;

- 5 FIG. 2 shows an exemplary system diagram of a cooling system in accordance with another aspect of the invention; and

FIG. 3 shows an exemplary process flow diagram for a cooling method utilizing the cooling system of FIG. 1 and FIG. 2.

Detailed Description

An exemplary embodiment of the present invention, a cooling system 20, is described hereinafter with reference to FIG. 1 to FIG. 3. The cooling system 20 may utilize a cooling method 100 as herein described. The cooling system 20 comprises a first heat exchanger 22 for receiving heat from a heat generating system 24, a second heat exchanger 26 and a first closed-loop circuit 28 for conveying heat from the first heat exchanger 24 to the second heat exchanger 26. Preferably, the first closed-loop circuit 28 is a circulatory conduit having water, refrigerant or the like fluids passaging therethrough for the conveyance of heat from one point to another point along the first closed-loop circuit 28.

The cooling system 20 further comprises a storage system 30 operable for providing natural gas to the second heat exchanger 26 for receiving heat conveyed by the first closed-loop circuit 28 to the second heat exchanger 26. The cooling system 20 further comprises a gas engine 32 for receiving the natural gas from and heated by the second heat exchanger 26 and enabling generating of energy therefrom. The energy generated by the gas engine 32 is at least one of heat energy and mechanical energy.

Preferably, the heat generating system 24 is a computer data center, a server farm, at least one processor, at least one computing unit and a heat-exhaust. The first heat exchanger 26 may be adapted to be mounted directly to one or more processors of multiple computing units of a computer data center or server farm, for example from heat sinks mounted directly to the processors or from stand-alone liquid-cooled systems mounted to the processors the multiple computing units. Alternative, the first heat exchanger 26 may be disposed or coupled to a manifold where heat from server racks or multiple server blades are directed by multiple blower or fan units.

The heat generating system 24 may be sited on one of a floating platform and a sea-going vessel in open water or may be sited on land. An example of the floating platform is a

pontoon-based platform structure while an example of the sea-going vessel is a boat, ship or tanker.

5 Preferably, the natural gas provided by the storage system 30 is liquefied natural gas for provision to the second heat exchanger 26 and the natural gas discharged by the second heat exchanger 26 is vaporized natural gas for provision to the gas engine 32.

10 Further preferably, the natural gas provided by the storage system 30 is methane (CH_4) with the gas engine 32 combusting the natural gas to generate the energy and flue gas. The cooling system further comprising a carbon capture system 34 for substantially capturing carbon dioxide (CO_2) from the flue gas. The carbon capture system 34 is further adapted for isolating the carbon dioxide for downstream usage, for storage as one of gaseous carbon dioxide and liquefied carbon dioxide and for conversion into liquid fuel.

15 Preferably, the gas engine 32 is a combined heat and power (CHP) system 36 for generating electricity and heat from the natural gas. The cooling system 20 comprises a second closed-loop circuit 37 and an adsorption chiller 38 for receiving heat generated by the CHP system 36 for cooling liquid transported along the second closed-loop circuit 37 from the first heat exchanger 24 and returning the cooled liquid to the first heat exchanger 24. Preferably, the
20 second closed-loop circuit 37 is a circulatory conduit having water, refrigerant or the like fluids passing therethrough for the conveyance of heat from one point to another point along the second closed-loop circuit 37.

The storage system 30 comprises a plurality of insulative vessels 40 for storing the natural
25 gas and inter coupled for selectively providing the natural gas to the second heat exchanger. The plurality of insulative vessels 40 can be a plurality of cryogenic dewars.

Preferably, the cooling system 20 further comprises at least one of a floating platform 42 for supporting the plurality of insulative vessels 40 out on open water, and a sea-going vessel 44
30 whereto the plurality of insulative vessels 40 are one of mounted and integrated. Similarly,

an example of the floating platform 42 is a pontoon-based platform structure while an example of the sea-going vessel 44 is a boat, ship or tanker

In another implementation of the cooling system 20, the cooling system 20 further comprises a generator 46, for example a turbo expander, for receiving the natural gas from the second heat exchanger 26 for generating mechanical energy therefrom to thereby reduce temperature of the natural gas, a third heat exchanger 48 for receiving the natural gas from the generator 46 and for heat exchange to receive heat from a third closed-loop circuit 50 to thereby increase the pressure and temperature of the natural gas for provision to the gas engine 32.

The third closed-loop circuit 50 is for transporting heat received from the heat generating system 24. Preferably, the third closed-loop circuit 50 is a circulatory conduit having water, refrigerant or the like fluids passing therethrough for the conveyance of heat from one point to another point along the third closed-loop circuit 50. When implemented, the third closed-loop circuit 50 may be for transporting heat away from and thereby cool the same or other portions of the heat generating system 24. For example, the first closed loop-system 28 may be used for cooling by transporting heat away from processors of the computing units or servers of the data center while the second closed loop-system 50 may be used for cooling by transporting heat away from the chip-sets, GPUs or the server racks supporting the computing units or servers of the data center.

In an implementation of the cooling system 20 with the cooling method 100, the cooling method comprises a step 102 of receiving heat from a heat generating system 24 by a first heat exchanger 22, a step 104 of conveying heat from the first heat exchanger 22 to a second heat exchanger 26 by a first closed-loop circuit 28, a step 106 of providing natural gas from a storage system 30 to the second heat exchanger 26 for receiving heat conveyed by the first closed-loop circuit 28 to the second heat exchanger 26, and a step 108 of generating of energy by a gas engine 32 from natural gas received from and heated by the second heat exchanger 26.

The cooling method 100 further comprises a step 110 of receiving heat generated by the CHP system 36 for cooling liquid transported along a second closed-loop circuit 37 from the first heat exchanger 22 and returning the cooled liquid to the first heat exchanger 22.

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The cooling method 100 further comprises a step 200 of providing the natural gas from the second heat exchanger 26 to a generator 46 for generating mechanical energy therefrom to thereby reduce temperature of the natural gas, and a step 202 of providing the natural gas from the generator 46 to a third heat exchanger 48 for heat exchange to receive heat from a
10 third closed-loop circuit 50 to thereby increase the pressure and temperature of the natural gas for provision to the gas engine 32.

Aspects of particular embodiments of the present disclosure address at least one aspect, problem, limitation, and/or disadvantage associated with existing cooling systems. While
15 features, aspects, and/or advantages associated with certain embodiments have been described in the disclosure, other embodiments may also exhibit such features, aspects, and/or advantages, and not all embodiments need necessarily exhibit such features, aspects, and/or advantages to fall within the scope of the disclosure. It will be appreciated by a person of ordinary skill in the art that several of the above-disclosed structures, components,
20 or alternatives thereof, can be desirably combined into alternative structures, components, and/or applications. In addition, various modifications, alterations, and/or improvements may be made to various embodiments that are disclosed by a person of ordinary skill in the art within the scope of the present disclosure, which is limited only by the following claims.

Claims

1. A cooling system comprising:

a first heat exchanger for receiving heat from a heat generating system;

5 a second heat exchanger;

a first closed-loop circuit for conveying heat from the first heat exchanger to the second heat exchanger;

10 a storage system operable for providing natural gas to the second heat exchanger for receiving heat conveyed by the first closed-loop circuit to the second heat exchanger;

a generator for receiving the natural gas from the second heat exchanger for generating mechanical energy therefrom to thereby reduce temperature of the natural gas, the generator being a turbo expander;

a second closed-loop circuit;

15 a third heat exchanger for receiving the natural gas from the generator and for heat exchange to receive heat from a third closed-loop circuit to thereby increase the pressure and temperature of the natural gas for provision to a gas engine for generating of energy therefrom, the gas engine being a combined heat and power (CHP) system for generating electricity and heat from the natural gas; and

20 an adsorption chiller for receiving heat generated by the CHP system for cooling liquid transported along the second closed-loop circuit from the first heat exchanger and returning the cooled liquid to the first heat exchanger;

wherein the third closed-loop circuit is for transporting heat received from the heat generating system.

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2. The cooling system as in claim 1, the heat generating system being a computer data center, a server farm, at least one processor, at least one computing unit and a heat-exhaust, the heat generating system being sited on one of a floating platform and a sea-going vessel in open water.

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3. The cooling system as in claim 2, the natural gas provided by the storage cooling system being liquefied natural gas for provision to the second heat exchanger and the natural gas discharged by the second heat exchanger being vaporized natural gas for provision to the gas engine, the natural gas being methane (CH₄) with the gas engine
5 combusting the natural gas to generate the energy and flue gas, carbon dioxide (CO₂) is captured from the flue gas by a carbon capture system, the carbon dioxide being further isolated by the carbon capture system for at least one of provided for downstream usage, for storage as one of gaseous carbon dioxide and liquefied carbon dioxide and for conversion into liquid fuel.

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4. The cooling system as in claim 1, further comprising at least one of:
a floating platform for supporting the plurality of insulative vessels out on open water; and
a sea-going vessel whereto the plurality of insulative vessels are one of
15 mounted and integrated,
wherein the storage cooling system comprising a plurality of cryogenic dewars for storing the natural gas and inter coupled for selectively providing the natural gas to the second heat exchanger.

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5. A cooling method comprising:
receiving heat from a heat generating system by a first heat exchanger;
conveying heat from the first heat exchanger to a second heat exchanger by a first closed-loop circuit;
providing natural gas from a storage system to the second heat exchanger for
25 receiving heat conveyed by the first closed-loop circuit to the second heat exchanger;
providing the natural gas from the second heat exchanger to a generator for generating mechanical energy therefrom to thereby reduce temperature of the natural gas, the generator being a turbo expander;
providing the natural gas from the generator to a third heat exchanger for heat
30 exchange to receive heat from a third closed-loop circuit to thereby increase the

pressure and temperature of the natural gas for provision to a gas engine for generating energy therefrom, the gas engine being a combined heat and power (CHP) system for generating electricity and heat from the natural gas; and

receiving heat generated by the CHP system for cooling liquid transported along a second closed-loop circuit from the first heat exchanger and returning the cooled liquid to the first heat exchanger,

wherein the third closed-loop circuit is for transporting heat received from the heat generating system.

6. The cooling method as in claim 5, the heat generating system being a computer data center, a server farm, at least one processor, at least one computing unit and a heat-exhaust, and the heat generating system being one of mounted on and integrated with one of a floating platform and a sea-going vessel in open water.

7. The cooling method as in claim 6, the natural gas provided by the storage system being liquefied natural gas for provision to the second heat exchanger and the natural gas discharged by the second heat exchanger being vaporized natural gas for provision to the gas engine,

wherein the natural gas being methane (CH₄) with the gas engine combusting the natural gas to generate the energy and carbon dioxide (CO₂) is captured from the flue gas by a carbon capture system, the carbon dioxide being further isolated by the carbon capture system for at least one of provided for downstream usage, for storage as one of gaseous carbon dioxide and liquefied carbon dioxide and for conversion into liquid fuel.

8. The cooling method as in claim 5, the storage system comprising:
a plurality of cryogenic dewars for storing the natural gas and inter coupled for selectively providing the natural gas to the second heat exchanger,

wherein the plurality of cryogenic dewars being one of supported on a floating platform and one of mounted on and integrated with a sea-going vessel.