can be turned off and, by operating valves, compressors and expansion valves can be integrated into the system refrigerant flow to allow the system to act as a direct expansion cooling system.

[0005] System design constraints in direct expansion systems generally call for modest pressure drops in the evaporator and condenser section of the system to provide even refrigerant flow through the multiple parallel evaporator and condenser circuits of the system. It is because of these pressure drops that the system requires a pump to circulate the refrigerant fluid when running in the near passive mode. As the refrigerant circuit includes a compressor system, the refrigerant volume also needs to include oil for lubrication. There are various design and operational constraints, such as best practices for refrigerant velocity, (so called "oil management") for the pumped refrigerant systems that ensure oil does not get trapped in the various piping lengths of the system and returns reliably to the compressor where it is needed. These oil management constraints become problematic when operating in the pumped (near passive mode) because the flow paths and flow rates for the pumped mode may not coincide with the rules required for the DX mode. Refrigerant volume for proper operation within the system may also be quite different during the pumped mode and the DX mode due to differing available superheat and sub-cool levels, and coil flooding levels, for example.

[0006] Cooling systems with further reductions in energy use are thus desired, as are cooling systems that do not require oil management in a passive or near passive mode.

Summary

[0006a] In an aspect, the present disclosure refers to a cooling system comprising: an evaporator containing a primary cooling medium, the evaporator being configured to receive a process fluid and, when receiving the process fluid, to change the phase of the primary cooling medium from liquid to gas; a passive condenser having an outer surface and being fluidly coupled to the evaporator, the passive condenser being configured to have an airstream directed over the outer surface thereof, wherein, when the airstream is directed over the outer surface of the passive condenser, the passive condenser is configured (i) to receive the primary cooling medium in the gas phase from the evaporator, (ii) to transfer heat from the primary cooling medium, (iii) to change the phase of the primary cooling medium from

gas to liquid, and (iv) to supply the primary cooling medium in the liquid phase to the evaporator; a heat exchanger fluidly coupled to the evaporator and configured to have a secondary cooling medium selectively provided thereto such that: (a) when the secondary cooling medium is provided to the heat exchanger, at least some of the primary cooling medium in the gas phase switches from being received by the passive condenser to the heat exchanger without operating any valves located between the evaporator and the passive condenser and between the evaporator and the heat exchanger and the heat exchanger is configured (i) to receive the primary cooling medium in the gas phase from the evaporator, (ii) to transfer heat from the primary cooling medium, (iii) to change the phase of the primary cooling medium from gas to liquid, and (iv) to supply the primary cooling medium in the liquid phase to the evaporator; and (b) when the secondary cooling medium is not provided to the heat exchanger, the heat exchanger does not supply the primary cooling medium in the liquid phase to the evaporator; and a flow control valve positioned in the flow path between the heat exchanger and the evaporator and in the flow path between the passive condenser and the evaporator, the flow control valve having a plurality of open positions and configured to control the flow of the primary cooling medium in the liquid phase into the evaporator, wherein the primary cooling medium circulates between the evaporator and the passive condenser and between the evaporator and the heat exchanger by natural circulation and gravity without a pump in the flow path of the primary cooling medium between the heat exchanger and the evaporator and between the passive condenser and the evaporator to circulate the primary cooling medium.

[0006b] In an aspect, the present disclosure refers to an electronics system comprising: at least one electronics component cooled by a dielectric; and the cooling system according to the above aspect, wherein the cooling system cools the dielectric.

[0006c] In an aspect, the present disclosure refers to a method of cooling a process fluid, the method comprising: directing a process fluid through an evaporator to transfer heat from the process fluid to a primary cooling medium contained in the evaporator and change the primary cooling medium from a liquid phase to a gas phase; selectively utilizing at least one of a heat exchanger and a passive condenser to change the primary cooling medium from the gas phase to the liquid phase by cooling the at least one of the heat exchanger and the passive condenser, each of the heat exchanger and the passive condenser being coupled to the evaporator to receive the primary cooling medium in the gas phase from the evaporator and supply the primary cooling medium in the liquid phase to the evaporator; controlling the

liquid level in the evaporator; and circulating the primary cooling medium between the evaporator and the at least one of the heat exchanger and the passive condenser by natural circulation, wherein the heat exchanger is selected by initiating cooling of the heat exchanger and without operating any valves in the coupling between the evaporator and the passive condenser and in the coupling between the evaporator and the heat exchanger.

[0007] In one example, the present disclosure relates to a cooling system including an evaporator containing a primary cooling medium, a passive condenser, and a heat exchanger. The evaporator is configured to receive a process fluid and, when receiving the process fluid, to change the phase of the primary cooling medium from liquid to gas. The passive condenser has an outer surface and is fluidly coupled to the evaporator. The passive condenser is configured to have an airstream directed over the outer surface thereof. When the airstream is directed over the outer surface of the passive condenser, the passive condenser is configured (i) to receive the primary cooling medium in the gas phase from the evaporator, (ii) to transfer heat from the primary cooling medium, (iii) to change the phase of the primary cooling medium from gas to liquid, and (iv) to supply the primary cooling medium in the liquid phase to the evaporator. The heat exchanger is fluidly coupled to the evaporator and configured to have a secondary cooling medium selectively provided thereto.

When the secondary cooling medium is provided to the heat exchanger, the primary cooling medium in the gas phase switches from being received by the passive condenser to the heat exchanger without operating any valves located between the evaporator and the passive condenser and between the evaporator and the heat exchanger. The heat exchanger is configured (i) to receive the primary cooling medium in the gas phase from the evaporator, (ii) to transfer heat from the primary cooling medium, (iii) to change the phase of the primary cooling medium from gas to liquid, and (iv) to supply the primary cooling medium in the liquid phase to the evaporator. When the heat exchanger is not accepting the secondary cooling medium, the heat exchanger does not supply the primary cooling medium in the liquid phase to the evaporator. The primary cooling medium circulates between the evaporator and the passive condenser and between the evaporator and the heat exchanger by natural circulation and gravity without a pump in the flow path of the primary cooling medium between the heat exchanger and the evaporator and between the passive condenser and the evaporator to circulate the primary cooling medium.

[0008] In another example, the disclosure relates to a method of cooling a process fluid. The method includes directing a process fluid through an evaporator to transfer heat from the process fluid to a primary cooling medium contained in the evaporator and change the primary cooling medium from a liquid phase to a gas phase and selectively utilizing one of a heat exchanger and a passive condenser to change the primary cooling medium from the gas phase to the liquid phase. Each of the heat exchanger and the passive condenser are coupled to the evaporator to receive the primary cooling medium in the gas phase from the evaporator and supply the primary cooling medium in the liquid phase to the evaporator. The method also includes circulating the primary cooling medium between the evaporator and at least one of the heat exchanger and the passive condenser by natural circulation. The one of the heat exchanger and the passive condenser is selected without operating any valves in the coupling between the evaporator and the passive condenser and in the coupling between the evaporator and the heat exchanger.

[0009] These and other aspects, objects, features, and advantages of the invention will become apparent from the following detailed description of illustrative embodiments thereof, which is to be read in connection with the accompanying drawings.

Brief Description of the Drawings

[0010] Figure 1 is an elevation view of a data center using a cooling system according to a preferred embodiment of the invention.