SUMMARY

[**0008a]** In an aspect of the present disclosure, there is provided an absorber-evaporator comprising:

a cooling liquid channel through which a cooling liquid is configured to flow;

a liquid desiccant channel through which a liquid desiccant is configured to flow;

an air-gap cell disposed between the cooling liquid channel and the liquid desiccant channel;

a first permeable membrane disposed between the liquid desiccant channel and the air-gap cell; and

a second permeable membrane disposed between the second liquid channel and the air-gap cell.

[0008b] In another aspect of the present disclosure, there is provided a liquid desiccant absorption chiller (LDAC) comprising:

an absorber-evaporator comprising:

a cooling liquid channel through which a cooling liquid is configured to flow;

a liquid desiccant channel through which a liquid desiccant is configured to flow;

an air-gap cell disposed between the cooling liquid channel and the liquid desiccant channel;

a first permeable membrane disposed between the liquid desiccant channel and the air-gap cell; and

a second permeable membrane disposed between the second liquid channel and the air-gap cell; and

a regenerator configured to receive and regenerate dilute liquid desiccant from and return concentrated liquid desiccant to the absorber-evaporator.

[0009] The present inventors recognize, among other things, an opportunity for improved performance in providing cooling to a heat load using a conditioning system including a liquid desiccant absorption chiller (LDAC) system in accordance with examples of this application. For example, LDAC systems (also referred to as LDAC units) in accordance with this

disclosure can be employed in combination with an evaporative cooler system to cool a heat load from, e.g., an enclosed space or one or more heat-generating devices. In an example, the conditioning system including an example LDAC unit cools water (or other type of cooling liquid). The cooled water is conveyed from the conditioning system to a separate liquid or air cooling system that cools the heat load. The LDAC unit of the present disclosure can supplement or replace other trim chilling components of such a conditioning system to, e.g., improve thermal performance and/or functionality of the system at or near peak conditions (i.e., hot and/or humid outdoor air conditions).

[0010] Several conditioning systems can incorporate the LDAC unit of the present disclosure. In an example, the conditioning system can include an evaporative cooler to evaporatively cool a cooling liquid using scavenger air and the LDAC unit can provide additional liquid cooling under certain operating and/or environmental conditions. The evaporative cooler may be combined with a dry coil disposed downstream of the evaporative cooler. The dry coil (a type of liquid-to-air heat exchanger or LAHX) can also be configured to condition the cooling liquid using the scavenger air. In an evaporation mode, the evaporative cooler and the dry coil are both operating. The cooling liquid is evaporatively cooled in the evaporative cooler and delivered to the heat load. The cooling liquid that is delivered to and heated by the heat load is returned to a liquid inlet of the dry coil, which sensibly cools the liquid using the scavenger air exiting the evaporative cooler and delivers this pre-cooled cooling liquid to the liquid inlet of the evaporative cooler. In this evaporation mode, the cooling liquid can be delivered to the heat load directly from the evaporative cooler or from the evaporative cooler to the LDAC unit, and then from the LDAC unit to the heat load.

configured to be permeable to water, but not to other constituents that may be present in the liquids. Thus, generally anything in the liquid desiccant and cooling liquid in a gas phase can pass through the membranes and generally anything in a liquid or solid phase cannot pass through the membranes. As the cooling liquid flows through the evaporator portion of the AE device, water vapor can evaporate from the cooling liquid and migrate across the membranes and air-gap cell/chamber and into the liquid desiccant, thereby providing evaporative cooling to the cooling liquid.

[0014] An example absorber-evaporator according to this disclosure includes a cooling liquid channel through which a cooling liquid is configured to flow, a liquid desiccant channel through which a liquid desiccant is configured to flow, an air-gap cell, a first permeable membrane, and a second permeable membrane. The air-gap cell is disposed between the cooling liquid channel and the liquid desiccant channel. The first permeable membrane is disposed between the liquid desiccant channel and the air-gap cell. And the second permeable membrane is disposed between the second liquid channel and the air-gap cell.

[0015] Example conditioning systems according to the present application can employ, *inter alia*, a Liquid-to-Air Membrane Energy Exchanger (LAMEE) as an evaporative cooler. Such systems employing a LAMEE may reduce cooling energy consumption compared to conventional air cooling data centers techniques. Additionally, such cooling systems including a LAMEE may be significantly smaller in size and lighter compared to other direct evaporative coolers (DEC), including air-cooling DECs. Such systems may also reduce the water consumption in comparison with other systems including different types of evaporative coolers and may reduce the operating cost of the data center (or other heat load).

[0016] This overview is intended to provide an overview of subject matter in the present application. It is not intended to provide an exclusive or exhaustive explanation of the disclosure. The detailed description is included to provide further information about the present application.

What is claimed is:

1. An absorber-evaporator comprising:

a cooling liquid channel through which a cooling liquid is configured to flow;

a liquid desiccant channel through which a liquid desiccant is configured to flow;

an air-gap cell disposed between the cooling liquid channel and the liquid desiccant channel;

a first permeable membrane disposed between the liquid desiccant channel and the air-gap cell; and

a second permeable membrane disposed between the second liquid channel and the air-gap cell.

2. The absorber-evaporator of claim 1, wherein:

the first and second permeable membranes are configured to permeate gas and vapor and to prevent permeation of liquids and solids.

3. The absorber-evaporator of claim 1, wherein:

the cooling liquid channel comprises a plurality of evaporation chambers fluidically connected to one another in series and defining a cooling liquid channel flow path along which the cooling liquid flows through the cooling liquid channel.

4. The absorber-evaporator of claim 3, wherein:

the cooling liquid channel flow path is a serpentine flow path.

5. The absorber-evaporator of claim 4, wherein:

the liquid desiccant channel comprises a plurality of absorption chambers fluidically connected to one another in series and defining a liquid desiccant channel flow path along which the liquid desiccant flows through the liquid dessicant channel.

6. The absorber-evaporator of claim 5, wherein:

the liquid desiccant channel flow path is a serpentine flow path.

7. The absorber-evaporator of claim 6, wherein:

the cooling liquid flows through the serpentine flow path of the cooling liquid channel in a direction opposite a direction of flow of the liquid desiccant flowing through the serpentine flow path of the liquid desiccant channel.

8. The absorber-evaporator of claim 5, wherein:

the serpentine flow path of the liquid desiccant channel directs the liquid desiccant in first and second opposite directions through adjacent absorption chambers of the plurality of absorption chambers and in a third direction between adjacent absorption chambers of the plurality of absorption chambers; and

the third direction is perpendicular to the first and second opposing directions.

9. The absorber-evaporator of claim 4, wherein:

the serpentine flow path of the cooling liquid channel directs the cooling liquid in first and second opposite directions through adjacent evaporation chambers of the plurality of evaporation chambers and in a third direction between adjacent evaporation chambers of the plurality of evaporation chambers; and

the third direction is perpendicular to the first and second opposing directions.

10. The absorber-evaporator of claim 3, wherein:

the air-gap cell comprises a plurality of air-gap chambers each of which corresponds with one of the plurality of evaporation chambers and on of the plurality of absorption chambers to define an evaporation stage in which vapor separated from the cooling liquid passes from the evaporation chamber through the first membrane and the second

membrane via the air-gap chamber to be absorbed by the liquid desiccant.

11. The absorber-evaporator of claim 10, wherein:
the plurality of air-gap chambers of the air-gap cell are configured such that one or more parameters in each of the plurality of air-gap chambers are independently controllable.

12. The absorber-evaporator of claim 10, wherein:
the one or more parameters comprises air pressure.

13. The absorber-evaporator of claim 10, wherein:
the plurality of evaporation chambers of the cooling liquid channel are configured such that one or more parameters in each of the plurality of evaporation chambers are independently controllable.

14. The absorber-evaporator of claim 10, wherein:
the plurality of absorption chambers of the liquid desiccant channel are configured such that one or more parameters in each of the plurality of absorption chambers are independently controllable.

15. The absorber-evaporator of claim 1, wherein:
a vapor pressure of the cooling liquid in the cooling liquid channel is greater than a vapor pressure of the liquid desiccant in the liquid desiccant channel.

16. The absorber-evaporator of claim 1, wherein:
the cooling liquid is water.

17. The absorber-evaporator of claim 1, wherein:
pressure in the air-gap cell is negative.

18. A liquid desiccant absorption chiller (LDAC) comprising:

an absorber-evaporator comprising:

a cooling liquid channel through which a cooling liquid is configured to flow;

a liquid desiccant channel through which a liquid desiccant is configured to flow;

an air-gap cell disposed between the cooling liquid channel and the liquid desiccant channel;

a first permeable membrane disposed between the liquid desiccant channel and the air-gap cell; and

a second permeable membrane disposed between the second liquid channel and the air-gap cell; and

a regenerator configured to receive and regenerate dilute liquid desiccant from and return concentrated liquid desiccant to the absorber-evaporator.

19. The LDAC of claim 18, wherein:

the first and second permeable membranes are configured to permeate gas and vapor and to prevent permeation of liquids and solids.

20. The LDAC of claim 18, wherein:

the cooling liquid channel comprises a plurality of evaporation chambers fluidically connected to one another in series and defining a cooling liquid channel flow path along which the cooling liquid flows through the cooling liquid channel.

21. The LDAC of claim 20, wherein:

the liquid desiccant channel comprises a plurality of absorption chambers fluidically connected to one another in series and defining a liquid desiccant channel flow path along which the liquid desiccant flows through the liquid dessicant channel.