widespread acceptance as an alternative to mechanical cooling, especially in light commercial and residential applications.

[0007] There remains a need for alternative cooling technologies for comfort conditioning applications, which can largely replace mechanical cooling. The growing awareness of environmental impacts, electricity consumption and increasing regulatory pressure on refrigerants are pressing challenges for current HVAC cooling equipment. There is a need for a commercially viable design which meets requirements for capital and installation costs, operating costs, performance, reliability, size/weight restrictions, etc., while avoiding the creation of any new resource utilization problems, such as excessive water or gas consumption. The design should have good cooling performance and compactness, make use of low cost materials, and avoid the use of any environmentally harmful or toxic substances. From a thermodynamic perspective, the system should operate near atmospheric pressures with low grade heat input, employ moderate temperature changes and exchange fluxes to minimize irreversibility in the system and improve second law efficiency. Comfort conditioning may only require low grade cooling, and an exergy analysis shows how wasteful it is to use precious high grade energy sources such as electricity to drive cooling equipment.

SUMMARY

[0007a] An aspect of the present disclosure provides a system for conditioning air for an enclosed space, the system comprising:

a process plenum having a plenum inlet and outlet, the process plenum configured to direct air in an air flow path from the plenum inlet to the plenum outlet;

a liquid-to-air membrane energy exchanger (LAMEE) arranged inside the process plenum, the LAMEE comprising a desiccant flow path separated from the air flow path by a membrane, the LAMEE configured to circulate a desiccant through the desiccant flow path and remove water from the air in the air flow path, a moisture content of the air at a LAMEE outlet being lower than a moisture content of the air at a LAMEE inlet; and

a direct evaporative cooler (DEC) arranged inside the process plenum downstream of the LAMEE, the DEC configured to evaporatively cool the air, a temperature of the air at a DEC outlet being lower than a temperature of the air at a DEC inlet.

[0007b] Another aspect of the present disclosure provides a system for conditioning air for an enclosed space, the system comprising:

a process plenum configured to direct air from a process inlet to a process outlet, the process inlet receiving air at a first temperature and the process outlet supplying air to the space at a second temperature that is lower than the first temperature;

a first liquid-to-air membrane energy exchanger (LAMEE1) arranged inside the process plenum, the LAMEE1 configured to use a liquid desiccant flowing through the LAMEE1 to reduce the humidity of the air, a first concentration of water in the liquid desiccant at a fluid inlet of the LAMEE1 being lower than a second concentration of water in the liquid desiccant at a fluid outlet of the LAMEE1; and

a second LAMEE (LAMEE2) arranged inside the process plenum downstream of the LAMEE1, the LAMEE2 configured to use water flowing there through to evaporatively cool the air, a temperature of the air at an air outlet of the LAMEE2 being lower than a temperature of the air at an air inlet of the LAMEE2.

[0007c] Another aspect of the present disclosure provides a method of conditioning air for an enclosed space, the method comprising:

directing air through a process plenum having a plenum inlet and outlet, the air entering the plenum inlet at a first temperature;

directing the air through a liquid-to-air energy exchanger (LAMEE) arranged inside the plenum, a first moisture content of the air being higher at a LAMEE inlet compared to a second moisture content of the air at a LAMEE outlet;

directing a desiccant through the LAMEE, the desiccant and air separated by a membrane of the LAMEE, the LAMEE configured to remove water from the air using the desiccant, a first concentration of water in the desiccant being lower at a LAMEE inlet compared to a second concentration of water in the desiccant at a LAMEE outlet, the desiccant at the LAMEE outlet being a dilute desiccant;

directing the air through a direct evaporative cooler (DEC) arranged inside the process plenum downstream of the LAMEE to cool the air; and

delivering the air to the enclosed space, the air exiting the plenum outlet at a second temperature lower than the first temperature.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] In the drawings, which are not necessarily drawn to scale, like numerals may describe similar components in different views. Like numerals having different letter suffixes may represent different instances of similar components, sub-components of a larger logical or

physical system, or the like. The drawings illustrate generally, by way of example, but not by way of limitation, various examples described in the present disclosure.

[0009] FIG. 1 schematically depicts an example conditioning system with a single working air stream, a desiccant dryer LAMEE and a direct evaporative cooler (DEC).

[0010] FIG. 2 is a psychometric chart for a modeled conditioning system similar to the conditioning system of FIG. 1.

[0011] FIG. 3 schematically depicts another example conditioning system that uses outdoor air in combination with process air and includes a desiccant dryer LAMEE, a DEC and a pre-cooler disposed between the desiccant dryer LAMEE and DEC.

[0012] FIG. 4 is a psychometric chart for a modeled conditioning system similar to the conditioning system of FIG. 2.

[0013] FIG. 5 schematically depicts an example regeneration system for use in a conditioning system.