

A DEHUMIDIFIER AND A METHOD OF DEHUMIDIFICATION

FIELD

This application relates to dehumidifiers, and particularly, to desiccant dehumidifiers.

5 BACKGROUND

In the last few decades, utilization of cooling and dehumidification in both buildings and industries has increased dramatically. Many researchers have focused on the improvement of cooling cycles utilizing renewable energy and waste heat sources. Alternatively, a rotary desiccant wheel has been introduced for dehumidification of supply air so as to remove partially the latent heat load. FIG. 1 (prior art) shows a typical example of a desiccant system designed for a commercial building. In the process side, DW adsorbs moisture from the process air resulting in dehumidification and heating of outdoor air. RR reduces the temperature of process air. The cool and dry process air leaving RR is passed through an evaporative cooler, EC 1, which adds moisture to the air, reducing its temperature further to provide indoor design state for the conditioned air. Hot air from the conditioned space passes through EC 2, RR, and electrical heater and DW in its return path resulting in the regeneration side of DCS operation. The temperature of the air from the conditioned space is reduced through EC 2 together with humidification. The heat transfer in RR, which operates the outcome of EC 2, produces hot and wet regeneration air. The hot air exiting RR is further heated in the heater to provide TR in a controlled manner. Hot and dry air is used for the regeneration of rotary DW with further moisture absorption, i.e. humidification resulting in wet and cooled air for the termination of the operation cycle. However, the rotary desiccant wheel is relatively costly to maintain.

SUMMARY

This application discloses a dehumidifier for dehumidification of atmospheric moist air using a low temperature waste heat driven process for the removal of moisture of outdoor air. Heat is supplied to the dehumidifier for regeneration of a desiccant which
5 can be used to perform the dehumidification in a batch-operated process. The energy savings from the dehumidifier can be as high as 25% of a conventional vapour compression dehumidification system.

The disclosed dehumidifier uses almost no moving parts. It comprises multiple beds of
10 desiccant which allow reduction of moisture content of the supplying air. This results in substantial electrical power savings provided that low grade thermal energy sources are available. The disclosed dehumidifier is particularly effective where the price of electrical energy is high, and where the latent heat percentage is high or where the needed air dew point is low desiccant dehumidification.

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According to a first exemplary aspect, there is provided a dehumidifier configured for alternately cycling between a first operating configuration and a second operating configuration, the dehumidifier comprising a first desiccant bed configured for performing adsorption in the first operating configuration and for performing desorption
20 in the second operating configuration; and a second desiccant bed configured for performing desorption in the first operating configuration and for performing adsorption in the second operating configuration.

The dehumidifier may further comprise an inflow channel and an outflow channel, wherein the first desiccant bed is disposed in a first flow channel between the inflow channel and the outflow channel and wherein the second desiccant bed is disposed in a second flow channel between the inflow channel and the outflow channel.

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The first desiccant bed and the second desiccant bed may each comprise a heat exchange coil configured for allowing passage of fluid therethrough.

The dehumidifier may further comprise a cooling water supply configured for providing
10 cooling fluid to the heat exchange coil of the first desiccant bed in the first operating configuration and for providing cooling fluid to the heat exchange coil of the second desiccant bed in the second operating configuration.

The dehumidifier may further comprise a hot fluid supply configured for providing hot
15 fluid to the heat exchange coil of the second desiccant bed in the first operating configuration and for providing hot fluid to the heat exchange coil of the first desiccant bed in the second operating configuration.

The first desiccant bed and the second desiccant bed may each comprise a plurality of
20 adsorbent cakes arranged in a zigzag configuration.

Each adsorbent cake may comprise a portion of heat exchange coil disposed between two sheets of wire mesh, and wherein interstitial space around the portion of heat exchange coil defined between the two sheets of wire mesh is filled with silica gel.

The dehumidifier may further comprise a first additional heat exchange coil provided between the first desiccant bed and the outflow channel, and further comprising a second additional heat exchange coil provided between the second desiccant bed and the outflow channel.

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The first additional heat exchange coil may be configured for passage of cooling fluid therethrough in the first operating configuration and for passage of hot fluid therethrough in the second operating configuration, and wherein the second additional heat exchange coil is configured for passage of hot fluid therethrough in the first
10 operating configuration and for passage of cooling fluid therethrough in the second operating configuration.

The dehumidifier may further comprise a further heat exchange coil provided in the outflow channel for cooling air channeled through the outflow channel to an air
15 handling unit.

The first flow channel and the second flow channel may be in open fluid communication at an upstream end of the outflow channel.

20 According to a second exemplary aspect, there is provided a method of dehumidification, the method comprising: (a) a first desiccant bed of the dehumidifier performing adsorption as an adsorption bed and a second desiccant bed of the dehumidifier performing desorption as a desorption bed; (b) the second desiccant bed

performing adsorption as the adsorption bed and the first desiccant bed performing desorption as the desorption bed; and (c) repeating the method from step (a).

5 The first desiccant bed performing adsorption may comprise channeling incoming air from an inflow channel into a first flow channel housing the first desiccant bed, and the second desiccant bed performing adsorption may comprise channeling incoming air from an inflow channel into a second flow channel housing the second desiccant bed.

10 The first desiccant bed performing adsorption may comprise passing cooling fluid through a heat exchange coil of the first desiccant bed, the second desiccant bed performing desorption may comprise passing hot fluid through a heat exchange coil of the second desiccant bed, the second desiccant bed performing adsorption may comprise passing cooling fluid through the heat exchange coil of the second desiccant bed, and the first desiccant bed performing desorption may comprise passing hot fluid through
15 the heat exchange coil of the first desiccant bed.

The method may further comprise additionally cooling air that has passed through the adsorption bed before channeling it to an air handling unit.

20 The method may further comprise additionally heating air that has passed through the adsorption bed before channeling it to the desorption bed.

BRIEF DESCRIPTION OF THE FIGURES

A preferred embodiment will now be described with reference to the accompanying figures in which:

FIG. 1 (prior art) is a schematic piping and instrumentation diagram of a desiccant wheel dehumidifier and its operational curve;

5 FIG. 2 is a schematic cross-sectional side view of an exemplary embodiment of the dehumidifier;

FIG. 3 is a schematic perspective view of the dehumidifier of FIG. 2;

FIG. 4 is a schematic piping and instrumentation diagram of the dehumidifier of FIG. 2;

10 FIGS. 5(a), 5(b) and 5(c) are respectively schematic side, top and perspective views of an adsorbent cake;

FIG. 6 is a schematic perspective view of an exemplary configuration of a desiccant bed of the dehumidifier of FIG. 2 comprising a plurality of the adsorbent cake of FIG. 5;

FIG. 7 is a graph of humidity ratio of streams in the dehumidifier of FIG. 2;

15 FIG. 8 is a graph of a process of dehumidification on a psychometric chart;

FIG. 9 is a graph of relative humidity profiles across the dehumidifier of FIG. 2;

FIG. 10 is a graph of temperature distribution of outflow air of the dehumidifier of FIG. 2;

FIG. 11 is a flow chart of an exemplary dehumidification method;

20 FIG. 12 is an alternative exemplary embodiment of the dehumidifier; and

FIG. 13 is a further alternative exemplary embodiment of the dehumidifier.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

An exemplary embodiment of a dehumidifier 10 and a method of dehumidification 100 will be described below with reference to FIGS. 2 to 13.

As shown in FIGS. 2 and 3, the dehumidifier 10 comprises an inflow channel 13, an outflow channel 15, and two desiccant beds 20, 30. The dehumidifier 10 is configured for alternately cycling between a first operating configuration 102 and a second operating configuration 104. At any one time, one of the two desiccant beds 20, 30 functions as an adsorption bed while the other of the two desiccant beds 20, 30 simultaneously functions as a desorption bed.

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At a downstream end of the inflow channel 13, the inflow channel 13 separates into two flow channels 22, 32. The first flow channel 22 houses the first desiccant bed 20 while the second flow channel 32 houses the second desiccant bed 30. In an exemplary embodiment, the two desiccant beds 20, 30 are arranged one 20 on top of the other 30 by positioning the first flow channel 22 above the second flow channel 32. Alternatively, the desiccant beds 20, 30 may be arranged side by side by positioning the two flow channels 22, 32 side by side. The two flow channels 22, 32 converge into an upstream end of the outflow channel 15, with the two flow channel 22, 32 being in open fluid communication with each other at the upstream end of the outflow channel 15. The inflow channel 13, outflow channel 15 and two flow channels 22, 32 are preferably constructed of zinc galvanized steel.

A first damper 24 is provided in the first flow channel 22 between the inflow channel 13 and first desiccant bed 20, such that opening the first damper 24 allows air to flow from

the inflow channel 13 directly into the first flow channel 22, while closing the first damper 24 prevents air from flowing from the inflow channel 13 directly into the first flow channel 22. Similarly, a second damper 34 is provided in the second flow channel 32 between the inflow channel 13 and second desiccant bed 30, such that opening the second damper 34 allows air to flow from the inflow channel 13 directly into the second flow channel 32, while closing the second damper 34 prevents air from flowing from the inflow channel 13 directly into the second flow channel 32.

A first auxiliary damper 26 is provided for the first desiccant bed 20. When open, the first auxiliary damper 26 allows air to leave the dehumidifier from the first flow channel 22. Similarly, a second auxiliary damper 36 is provided for the second desiccant bed 30. When open, the second auxiliary damper 36 allows air to leave the dehumidifier from the second flow channel 32.

The two desiccant beds 20, 30 are configured to alternate in performing the functions of adsorption and desorption. In the first operating configuration 102 of the dehumidifier 10, the first desiccant bed 20 performs adsorption by functioning as the adsorption bed while the second desiccant bed 30 performs desorption by functioning as the desorption bed. Generally, the dehumidifier 10 switches 103 to the second operating configuration 104 when the first desiccant bed 20 has been saturated with adsorbed water vapor. However, the switch 103 may occur sooner if the efficiency of adsorption is found to drop significantly after some time of operation in the first operating configuration 102. In the second operating configuration 104 of the dehumidifier 10, the second desiccant bed 30 performs adsorption by functioning as the adsorption bed while the first

desiccant bed 20 performs desorption by functioning as the desorption bed. The dehumidifier 10 switches 105 to the first operating configuration 102 when the second desiccant bed 30 has been saturated with adsorbed water vapor or when efficiency of adsorption is considered to have dropped significantly after some time of operation in the second operating configuration 104. During operation, the dehumidifier 10 thus alternately cycles between the first operating configuration 102 and the second operating configuration 104. The two desiccant beds 20, 30 each comprise a heat exchange coil configured for allowing passage of fluid therethrough.

10 In the first operating configuration 102, air is moved in the dehumidifier 10 in the directions indicated by the arrows as shown in FIGS. 2 and 4. To begin with, fresh air or outside air is drawn into the dehumidifier 10 through the inflow channel 13. This may be achieved by providing an appropriately configured blower 12 at an upstream end of the inflow channel 13. In-coming air is then passed through the first desiccant bed 20 which functions as the adsorption bed. This is achieved by opening the first damper 24 and closing the second damper 34, so that in-coming air from the inflow channel 13 is directed into only the first flow channel 22 and prevented from passing directly into the second flow channel 32. The first auxiliary damper 26 is also kept closed in the first operating configuration 102. Water vapor in the in-coming air is thus absorbed by the adsorbent in the first desiccant bed 20 in the first flow channel 22. During adsorption, cooling fluid 70 from a cooling fluid supply 40 at a temperature of about 20°C to 32°C is circulated through the adsorption bed 20 to remove heat of adsorption. Performance of adsorbent is controlled by the temperature of the adsorbent in the adsorption bed 20. Typically, air leaving the adsorption bed 20 may have a temperature of about 34°C and

relative humidity of 55%. After the air has been dried by passing through the adsorption bed 20, it is passed from the first flow channel 22 into the outflow channel 15 to an air handling unit or AHU (not shown) to be cooled down to a desired temperature. Heat of adsorption may be recovered either by redirection to a heat source or used for other applications such as indoor heating systems.

While operating the dehumidifier 10 in the first operating configuration 102, the second desiccant bed 30 undergoes desorption, being regenerated or prepared for performing adsorption in a next cycle of the dehumidifier 10. This is because the second desiccant bed 30 would have been saturated with water vapor from a previous dehumidification cycle of the dehumidifier 10 operated in the second operating configuration 104. For regeneration, hot fluid 80 at a temperature of about 65°C to 85°C from a hot fluid supply 50 is circulated through the second desiccant bed 30 to heat up the adsorbent in the second desiccant bed 30 so that water vapor is desorbed from the second desiccant bed 30. The circulating hot fluid 80 may be heated by any appropriate means, including microwaving or by using other sources of heat such as industrial waste heat, solar heat, geothermal heat or electricity or any combination of any two or more heat sources. By opening the second auxiliary damper 36, a small amount of air leaving the first flow channel 22 enters the second flow channel 32 and subsequently leaves the dehumidifier 10 after having been passed through the second desiccant bed 30. This facilitates the desorption process of the second desiccant bed 30 by purging out water vapor released by the heated adsorbent in the second desiccant bed 30. When the desorption process is complete, the second desiccant bed 30 is again ready to perform adsorption when the dehumidifier 10 switches to the second operating configuration 104.

In the second operating configuration 104, the first damper 24 is closed while the second damper 34 is opened. The first auxiliary damper 26 is opened while the second auxiliary damper 36 is closed. In this way, in-coming air from the inflow channel 13 is directed into the second flow channel 32 for adsorption of fluid vapour by the second desiccant bed 30. Also, a small amount of leaving the second flow channel 32 passes into the first flow channel 22, through the first desiccant bed 20 and leaves the dehumidifier 10 via the open first auxiliary damper 26. This facilitates desorption of the adsorbent in the first desiccant bed 20 so as to regenerate the first desiccant bed 20.

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The dehumidifier 10 is thus alternated between the first operating configuration 102 and the second operating configuration 104 by controlling the opening and closing of the first and second dampers 24, 34, by controlling the opening and closing of the first and second auxiliary dampers 26, 36, and also by controlling the circulation of cooling fluid 70 and hot fluid 80 for the adsorption and desorption beds respectively.

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Hot fluid 80 and cooling fluid 70 circulation to the two desiccant beds 20, 30 is preferably controlled by providing a number of valves 60 controlled using programmable logic control (PLC). The valves 60 are preferably three-way solenoid valves. Each desiccant bed 20, 30 only needs to be provided with a single fluid inlet 23, 33 and a single fluid outlet 25, 35 since only either cooling fluid 70 or hot fluid 80 is passed through the heat exchange coil of each desiccant bed 20, 30 at any one time. As shown in FIG. 4, when operating the dehumidifier 10 in the first operating configuration 102, cooling fluid 70 from a cooling tower 40 is circulated to the first desiccant bed 20

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functioning as the adsorption bed 20, using a cooling fluid pump 42. Hot fluid 80 from a hot fluid tank 50 is circulated to the second desiccant bed 30 functioning as the desorption bed 30, using a hot fluid pump 52. When the dehumidifier 10 is switched to operating in the second operating configuration 104, the valves 60 are switched so that cooling fluid 70 from the cooling tower 40 is circulated to the second desiccant bed 30 functioning as the adsorption bed 30, while hot fluid 80 from the hot fluid tank 50 is circulated to the first desiccant bed 20 functioning as the desorption bed 20. Preferably, water is used as the cooling fluid 70 and as well as the hot fluid 80, although air may also be used as an alternative or in addition to water.

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Each desiccant bed 20, 30 preferably comprises a plurality of adsorbent cakes 90. An exemplary adsorbent cake 90 is shown in FIG. 5. Each of the cakes 90 installed in the desiccant beds 20, 30 comprises a portion of a heat exchange coil comprising finned heat exchange tubes in which the cooling fluid 70 and the hot fluid 80 are alternately passed, depending on whether the dehumidifier is operating in the first operating configuration 102 or the second operating configuration 104 as described above. The fins are preferably made of aluminium while the tubes are preferably made of copper. As shown in FIG. 5, each adsorbent cake 90 comprises a portion of the heat exchange coil 94 disposed between two sheets of wire mesh 92. Interstitial space around the portion of the heat exchange coil 94 defined between the two sheets of wire mesh 92 is filled with the adsorbent.

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Any material used for the adsorbent in the adsorbent cake 90 should be a hydrophilic porous material having a high specific surface pore area. The surface pore area is

preferably greater than 500 m²/g. A preferred form of adsorbent for the cake 90 is silica gel. Silica gel is preferred because of its greater pore surface area, extreme affinity to fluid molecules and good moisture adsorption capacity. Silica gel generally performs better than other desiccant materials in the region of 50% ~97% of relative humidity.

- 5 Moreover, its regeneration temperature is also low in the range of 62~85°C. The silica gel used in the present dehumidifier is Type RD 2060 from Fuji Silysia of Japan. The specification of a preferred form of the silica gel is given in Table 1 below.

ITEMS		SPECIFICATION
Moisture Adsorption(%)	at 5% RH	4.0 (Min.)
	at 20% RH	13.5 (Min.)
Water Content (wt%)		15 (Max.)
pH (5% slurry)		3.0 – 5.0
Particle Size Distribution (wt%)		
Above 1.00 mm		5.0 (Max.)
0.25 – 1.00 mm		82.0 (Min.)
Below 0.25 mm		13.0 (Max.)

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Table 1. Specification of RD type silica gel

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To prevent beads of the silica gel from falling and undesirably accumulating at one side of the cake 90 due to gravity, the sheets of wire mesh 92 should be fully flattened or kept taut against the heat exchange coil 94, thereby ensuring no room for the beads of silica gel to fall away from their original placement around the heat exchange coil 94.

Pressure drop across the desiccant beds 20, 30 has a significant effect on performance of the dehumidifier 10. It has been found that the pressure drop for a desiccant bed fully packed with adsorbent is rather high. Accordingly, pressure drop in the dehumidifier 10 is minimized by installed the cakes 90 in each desiccant bed 20, 30 in a V-shaped or zigzag configuration as shown in FIG. 6, with an aim to achieving laminar flow of the in-coming air. This increases surface area in the desiccant beds 20, 30, thereby minimizing pressure drop across the dehumidifier 10 while enhancing dehumidification performance.

Installation of the dehumidifier 10 is simple. The inflow channel 13, outflow channel 15 and flow channels 22, 32 are preferably pre-fabricated so that on site, only installation of the desiccant beds 20, 30 comprising assembly of the desiccant cakes 90 is required. The dehumidifier 10 is also designed such that it facilitates easy maintenance if required. The flow channels 22, 32 are configured to be operable for ready replacement or repair of the cakes 90 forming the desiccant beds 20, 30. The cakes 30 of the two desiccant beds 20, 30 are preferably housed on top of each other to for easy access via single walkway. As for durability of the desiccant or adsorbent, replacement time is expected to be once every decade due to the extremely long life span of the RD type silica gel. On average, the RD type silica gel can undergo 20 million adsorption-regeneration cycles before it is deemed as inefficient.

Besides the heat exchange coils provided in the desiccant beds 20, 30 for alternately cooling and heating the desiccant beds 20, 30, additional heat exchange coils 14, 16 may further be provided in the flow channels 22, 32 respectively, as shown in FIG. 12.

The additional heat exchange coils 14, 16 are located in the first and second flow channels 22, 32 between the desiccant beds 20, 30 and the outflow channel 15. The additional heat exchange coils 14, 16 serve to further cool down air that leaves the adsorption bed before passing it to the AHU, and to heat up air that is passed through the desorption bed. In the first operating configuration 102, as shown in FIG. 12, cooling fluid is passed through the additional heat exchange coil 14 provided in the first flow channel 22 so as to cool down air that has been passed through the first desiccant bed 20 operating as the adsorption bed. In this way, cooling load on the AHU is reduced. At the same time, hot fluid is passed through the additional heat exchange coil 16 provided in the second flow channel 32. This heats up air that is passed through the second desiccant bed 30 operating as the desorption bed. In this way, desorption is more effectively achieved as more water vapor can be drawn out of the desiccant in the desiccant bed 30 by passing air of higher temperature through the desorption bed 30. In the second operating configuration 104 (not shown), flow of cooling and hot fluid is switched such that hot fluid is passed through the additional heat exchange coil 14 in the first flow channel 22 while cooling fluid is passed through the additional heat exchange coil 16 in the second flow channel 32.

FIG. 13 shows yet another exemplary embodiment of the dehumidifier 10 in which a further heat exchange coil 18 is provided in the outflow channel 15. Cooling fluid is always circulated through the further heat exchange coil 18 in order to further cool down dehumidified air that is passed to the AHU, so as to further reduce load on the AHU.

Performance of the dehumidifier 10 was investigated at different relative humidity and air flow rates for a range of hot fluid 80 inflow temperatures. In this experiment, outside air at a temperature of about 32°C with a relative humidity RH of about 95% was passed through the system. FIG. 7 represents the outflow humidity ratio of the outflow air. As shown in FIG. 7, removal of moisture from the ambient or in-coming air was about 0.013 kg of moisture per unit mass of supply air (kgDA). This amount of water vapor removal reduces latent load which is difficult to remove by the AHU. The process of dehumidification is shown in FIG. 8. As shown, almost 50% of latent load is removed by the dehumidifier 10, thereby obtaining energy saving in the chiller or AHU load.

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Experimental results of relative humidity and temperature of outflow dry air are plotted in FIGS. 9 and 10 respectively. Relative humidity of outflow air was found to be about 60%. Contrary to the prior art desiccant wheel system, it can be seen from FIG. 10 that sensible heat induced in the present dehumidifier 10 due to the adsorption process is very much less compared to latent heat removal. The temperature rise was found to be about 2°C.

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Experiments have also shown that the present dehumidifier 10 is able to perform dehumidification of air at a relative humidity of 75% and temperature of 28°C, which the prior art rotary desiccant wheel is unable to do.

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By providing static desiccant beds 20, 30 for performing the dehumidification process, the dehumidifier 10 has practically no major moving mechanical parts besides the valves 60 provided for controlling circulation of the cooling fluid 70 and the hot fluid

80. This results in minimal maintenance costs and greatly reduces likelihood of equipment damage. The dehumidifier 10 also takes advantage of waste heat from air that has been passed through the adsorbent bed to facilitate and enhance regeneration of the desiccant in the desorption bed, thereby further lowering operating cost.

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In addition, unlike conventional systems that risk mixing process and dry air together, the present dehumidifier 10 segregates both air flows into two separate chambers or channels 22, 32, thereby avoiding exchange of sensible heat. One major merit of the present dehumidifier 10 is that temperature of the desiccant or adsorbent in the
10 adsorption bed is controlled by the cooling of the adsorption bed by circulating the cooling fluid 70 from cooling tower 40. By contrast, the prior art rotary desiccant wheel design does not provide for wheel cooling. Cooling of the adsorption bed improves dehumidification performance of the dehumidifier 10. Furthermore, because of adsorption bed cooling during operation, outflow air temperature of the dehumidified air
15 is not very high, being at about 32°C. Further cooling of the outflow stream by the AHU can thus be performed more efficiently. In addition, regeneration of the desorption bed is performed by using either hot fluid or warm air from the outflow stream or both. The present dehumidifier 10 is also scalable for various capacities as may be required.

20 Whilst there has been described in the foregoing description preferred embodiments of the present invention, it will be understood by those skilled in the technology concerned that many variations or modifications in details of design or construction may be made without departing from the present invention. For example, while only one pair of desiccant beds 20, 30 alternately functioning as the adsorption and desorption beds has

been described in the exemplary embodiments, the dehumidifier 10 may further comprise one or more additional pairs of desiccant beds similarly alternately functioning as additional adsorption and desorption beds in the same first operating configuration 102 and the same second operating configuration 104, for increased efficiency. In addition to or alternatively to silica gel, the adsorbent may also comprise other materials such as zeolite or other hydrophilic adsorbents. The inflow channel 13 is also not strictly necessary since it is possible to directly draw incoming air into either one of the two flow channels 22, 32 by providing a blower for each of the two flow channels 22, 32.

Claims

1. A dehumidifier configured for alternately cycling between a first operating configuration and a second operating configuration, the dehumidifier comprising:
 - a first desiccant bed configured for performing adsorption in the first operating configuration and for performing desorption in the second operating configuration;
 - and
 - a second desiccant bed configured for performing desorption in the first operating configuration and for performing adsorption in the second operating configuration.
2. The dehumidifier of claim 1, further comprising an inflow channel and an outflow channel, wherein the first desiccant bed is disposed in a first flow channel between the inflow channel and the outflow channel, and wherein the second desiccant bed is disposed in a second flow channel between the inflow channel and the outflow channel.
3. The dehumidifier of claim 1 or claim 2, wherein the first desiccant bed and the second desiccant bed each comprise a heat exchange coil configured for allowing passage of fluid therethrough.
4. The dehumidifier of claim 3, further comprising a cooling water supply configured for providing cooling fluid to the heat exchange coil of the first desiccant bed in the first operating configuration and for providing cooling fluid to the heat exchange coil of the second desiccant bed in the second operating configuration.

5. The dehumidifier of claim 4, further comprising a hot fluid supply configured for providing hot fluid to the heat exchange coil of the second desiccant bed in the first operating configuration and for providing hot fluid to the heat exchange coil of the first desiccant bed in the second operating configuration.

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6. The dehumidifier of any preceding claim, wherein the first desiccant bed and the second desiccant bed each comprise a plurality of adsorbent cakes arranged in a zigzag configuration.

- 10 7. The dehumidifier of claim 6 when dependent on any one of claims 3 to 5, wherein each adsorbent cake comprises a portion of heat exchange coil disposed between two sheets of wire mesh, and wherein interstitial space around the portion of heat exchange coil defined between the two sheets of wire mesh is filled with silica gel.

- 15 8. The dehumidifier of claim 2 or any one of claims 3 to 7 when dependent on claim 2, further comprising a first additional heat exchange coil provided between the first desiccant bed and the outflow channel, and further comprising a second additional heat exchange coil provided between the second desiccant bed and the outflow channel.

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9. The dehumidifier of claim 8, wherein the first additional heat exchange coil is configured for passage of cooling fluid therethrough in the first operating configuration and for passage of hot fluid therethrough in the second operating configuration, and wherein the second additional heat exchange coil is configured

for passage of hot fluid therethrough in the first operating configuration and for passage of cooling fluid therethrough in the second operating configuration.

10. The dehumidifier of claim 2 or any one of claims 3 to 9 when dependent on claim 2,
5 further comprising a further heat exchange coil provided in the outflow channel for cooling air channeled through the outflow channel to an air handling unit.
11. The dehumidifier of claim 2 or any one of claims 3 to 10 when dependent on claim 2, wherein the first flow channel and the second flow channel are in open fluid
10 communication at an upstream end of the outflow channel.
12. A method of dehumidification, the method comprising:
- (a) a first desiccant bed of the dehumidifier performing adsorption as an adsorption bed and a second desiccant bed of the dehumidifier performing
15 desorption as a desorption bed;
 - (b) the second desiccant bed performing adsorption as the adsorption bed and the first desiccant bed performing desorption as the desorption bed; and
 - (c) repeating the method from step (a).
- 20 13. The method of claim 12, wherein the first desiccant bed performing adsorption comprises channeling incoming air from an inflow channel into a first flow channel housing the first desiccant bed, and wherein the second desiccant bed performing adsorption comprises channeling incoming air from an inflow channel into a second flow channel housing the second desiccant bed.

14. The method of claim 12 or 13, wherein the first desiccant bed performing adsorption comprises passing cooling fluid through a heat exchange coil of the first desiccant bed, wherein the second desiccant bed performing desorption comprises passing hot
5 fluid through a heat exchange coil of the second desiccant bed, wherein the second desiccant bed performing adsorption comprises passing cooling fluid through the heat exchange coil of the second desiccant bed, and wherein the first desiccant bed performing desorption comprises passing hot fluid through the heat exchange coil of the first desiccant bed.
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15. The method of any one of claims 12 to 14, further comprising additionally cooling air that has passed through the adsorption bed before channeling it to an air handling unit.
- 15 16. The method of any one of claims 12 to 15, further comprising additionally heating air that has passed through the adsorption bed before channeling it to the desorption bed.