

CLAIMS

1. A device (1) for absorbing water comprising:

at least one water absorption section (α) for absorbing water from a gas flow using a liquid desiccant, wherein the water absorption section is operatively connected to at least one liquid desiccant container (β) for delivery of liquid desiccant to and from the water absorption section (α), wherein the at least one liquid desiccant container (β) is further operatively connected to a liquid desiccant regenerating section (γ) for delivery of liquid desiccant to and from the at least one liquid desiccant container (β),

10 wherein the liquid desiccant regenerating section (γ) comprises

- at least one boiler (2) comprising a container (3),

a vacuum system (18) operatively connected to the boiler (2) for reducing the pressure in the container (3) and wherein the regenerating section (γ) preferably further comprises a heating unit (5) operatively connected to the container (3) configured to heat the liquid desiccant in the container (3), and

wherein the device further comprises a control unit (19) configured to obtain or determine a concentration value of liquid desiccant and to be operatively connected to the vacuum system (18) for controlling the vacuum system (18) to reduce the pressure in the container (3) to a first pressure during regeneration of liquid desiccant; wherein the control unit (19) also communicates with the liquid desiccant container (β) to determine or detect or measure the temperature and/or concentration of the collected liquid desiccant in the liquid desiccant container (β).

2. The device according to claim 1 wherein the control unit (19) also communicates with the water absorption section (α) to determine or detect or measure the concentration of the liquid desiccant to be dispensed (S1) and wherein the control unit (19) is preferably configured to determine the difference in concentration (ΔC) between the liquid desiccant to be dispensed (S1) and the concentration of the collected liquid desiccant in the liquid desiccant container (β).

3. The device according to claim 1 or 2, wherein the control unit (19) is further configured to determine an energy amount required for regeneration of the liquid

desiccant based at least on the concentration of liquid desiccant to be regenerated (S3) or the concentration of the collected liquid desiccant (S2) in the liquid desiccant container (β) and a predetermined desired concentration of the regenerated liquid desiccant (S4) after regeneration, and wherein the control unit is further configured
5 to select the first pressure so that the energy amount for operating the vacuum system to achieve and maintain the first pressure is less than or equal to a predetermined maximum energy.

4. The device according to any one of claims 1 to 3 wherein the control unit (19) is further configured to determine or predetermine the desired concentration of a
10 regenerated liquid desiccant (S4) based on at least one of an ambient temperature and an ambient humidity and/or wherein the control unit is further configured to determine or predetermine the threshold value of the collected dispensed liquid desiccant in the liquid desiccant container (β).

5. The device according to any one of claim 1 to 4 wherein the control unit (19) is
15 configured to select the first pressure to minimize a temperature difference between a third temperature of a regenerated liquid desiccant (S4) and a first temperature of a liquid desiccant to be regenerated (S3).

6. The device according to any one of claim 1 to 5 wherein the regenerating section (γ) further comprises a heating unit (5) comprising a compressor (7), a first
20 desiccant heat exchanger (9), a second desiccant heat exchanger (11), a regulator (17) and wherein the regenerating section (γ) further comprises an optional heating device (28);

wherein the first desiccant heat exchanger (9) is operatively connected to the at least one liquid desiccant container (β) for delivery and receiving of liquid desiccant
25 and further operatively connected to the container (3) for delivery and receiving of liquid desiccant;

wherein the container (3) is operatively connected to the regulator (17) for delivery of liquid desiccant to the regulator and where the regulator (17) is further
operatively connected to the second desiccant heat exchanger (11) for delivery of
30 liquid desiccant;

wherein the second desiccant heat exchanger (11) is further operatively connected to the container (3) for delivery of liquid desiccant; and

wherein the container (3) is also operatively connected to the compressor (7) for delivery of vapor formed in the container (3) to the compressor and wherein the
5 compressor (7) is further operatively connected to the second desiccant heat exchanger (11) for delivery of compressed vapor.

7. The device according to any one of claim 1 to 5 wherein the liquid desiccant regenerating section (γ) comprises

- 10 - at least one boiler (2) comprising a container (3) having a heating chamber (4) and a condensing chamber (6), wherein the heating chamber (4) is connected to the condensing chamber (6) allowing vapor formed in the heating chamber to enter the condensing chamber,
 - a vacuum system (18) operatively connected to the boiler (2) for reducing the pressure in the container (3), and
- 15 a heat pump system (8), wherein the heat pump system has a first heat exchanger (10) arranged in the heating chamber (4) in thermal contact with liquid desiccant in the heating chamber, a second heat exchanger (12) arranged in the condensing chamber (6) in thermal contact with vapor in the condensing chamber (6), wherein the first heat exchanger is further connected to a cooling device (14), wherein the
20 cooling device (14) is also connected to the second heat exchanger (12) and wherein the second heat exchanger is connected to a compressor (16), said compressor (16) also being connected to the first heat exchanger (10).

8. The device according to claim 7 wherein the liquid desiccant container (β) comprises a heater (50) wherein said heater is a heat exchanger in which the liquid
25 desiccant in the liquid desiccant container (β) is heat exchanged with the cooling media of the heat pump (8).

9. The device according to any one of claims 1 to 8 wherein the device comprises two or more water absorption sections (α) per each liquid desiccant regenerating section (γ).

10. The device according to any one of the preceding claims wherein the device comprises two or more water absorption sections (α) per each liquid desiccant container (β).
11. The device according to any one of the preceding claims wherein the liquid desiccant container (β) comprises a liquid desiccant collecting part (46) operatively connected to the water absorption section (α) and wherein the liquid desiccant collecting part is further operatively connected to a liquid desiccant storage tank (48), for delivery of liquid desiccant to and from the water absorption section (α) and for delivery of liquid desiccant to the liquid desiccant storage tank (48).
12. The device according to any one of the preceding claims wherein the temperature of the liquid desiccant in the boiler or in the heating chamber is 40 to 125°C preferably 70-115°C, more preferably 75-110°C.
13. The device according to any one of the preceding claims wherein the water absorption section (α) comprises at least one means for dispensing the liquid desiccant (66) and wherein said means is a cooling pad or evaporator pad or pads, and wherein the water absorption section (α) further preferably comprises a fan or a pump (72) in order to provide a gas flow through the first housing (60).
14. The device according to any one of the preceding claims wherein the concentration of the regenerated liquid desiccant (S4) is 1-30 % higher than before regeneration, preferably 3-25%.
15. The device according to any one of the preceding claims wherein the water absorption section (α), the liquid desiccant container (β) and the liquid desiccant regenerating section (γ) are connected via insulated tubing for minimizing precipitation of desiccant.
16. The device according to claim 13 wherein the cooling pad or evaporator pad is arranged at an angle X° with respect to an axis (a) extending essentially in the direction of the gas flow and wherein the pad extends across the direction of the gas flow from one side of the first housing (60) and wherein preferably the pad comprises protruding elements (67) which are arranged essentially non-perpendicular to the pads.

17. The device according to claim 16 wherein the angle X° is 10-40°.
18. The device according to any one of the preceding claims wherein the liquid desiccant is an aqueous solution of magnesium chloride (MgCl_2) or an alkali acetate preferably potassium acetate.
- 5 19. The device according to claim 18 wherein the concentration of magnesium chloride in the liquid desiccant to be dispensed (S1) using the means for dispensing a liquid desiccant (66) is at least 30 weight%, preferably 34 to 36 weight%, or wherein the concentration of alkali acetate in the liquid desiccant to be dispensed (S1) using the means for dispensing a liquid desiccant (66) is at least 65 weight%,
10 preferably 67-70weight%.
20. The device according to any one of claims 1 to 19 wherein the control unit (19) communicates with the vacuum system (18) and the heating unit (5) and wherein the vacuum system and the heating unit (5) are configured to generate a regenerated liquid desiccant with an optimum temperature range.
- 15 21. The device according to any one of claims 1 to 3 wherein the device further comprises a control unit (19), wherein the control unit (19) communicates with the heating unit (5) and the vacuum system (18).
22. A dehumidifier comprising the device according to any one of claims 1 to 21.
23. An air cooler comprising the device (1) according to any one of claims 1 to 21
20 further comprising a humidifier (λ) comprising a second housing (80) operatively connected to the water absorption section (α) for receiving air having means for dispensing water (86) and optionally means (88) for increasing the contact time and contact area between the gas and the water.
24. The air cooler according to claim 23 wherein the means for dispensing water
25 (86) is arranged so that the dispensing of water is done approximately in the direction of the gas flow.
25. Method for controlling a device for absorbing water, the device comprising a liquid desiccant regenerating section (γ), wherein the method comprises

- detecting or determining a concentration of a water absorbing material in a liquid desiccant,
 - transporting liquid desiccant (S3) to a liquid desiccant regenerating section (γ) when the detected concentration is at a predetermined value or below a predetermined value, said liquid desiccant having a first temperature (T1),
 - performing a regeneration for removing water from the liquid desiccant, the regeneration taking place in the liquid desiccant regenerating section (γ) at a second temperature (T2) and at a first pressure (P1), wherein a first energy amount is used for setting and maintaining the first pressure during regeneration,
 - transporting regenerated liquid desiccant (S4) from the liquid desiccant regenerating section (γ) for use in absorbing water, the regenerated liquid desiccant (S4) having a third temperature (T3),
- wherein the first pressure (P1) is selected so that a first energy amount is at or below a predetermined maximum energy and so that a concentration of the regenerated liquid desiccant is at a predetermined desired concentration and/or a difference between the third temperature (T3) and the first temperature (T1) is minimized.
26. Method according to claim 25, wherein the regeneration is performed by bringing the liquid desiccant to a boiling temperature for releasing water from the liquid desiccant in the form of steam, and wherein the second temperature (T2) is the boiling temperature.
27. Method according to claim 25 or 26, wherein the boiling temperature is controlled by adjusting the first pressure (P1) in the liquid desiccant regenerating section (γ).
28. Method according to any of claims 25-27, wherein the predetermined value for the concentration of liquid desiccant is at least 33wt%, or at least 34wt%, or at least 35wt%, preferably 34-36wt%.
29. Method according to any of claims 25-28, further comprising

- cooling the regenerated liquid desiccant (S4) to the first temperature (T1).

30. Method according to any of claims 25-29, further comprising

- detecting an ambient temperature and cooling the regenerated liquid desiccant (S4) to the ambient temperature or lower.

31. Method according to any of claims 25-30, wherein the liquid desiccant (S3) transported to the liquid desiccant regenerating section (γ) for regeneration is less than 0.25 of a total amount of liquid desiccant in the device (1) for absorbing water, preferably less than 0.1 of the total amount and more preferably less than 0.05 of the total amount.

32. Method according to any of claims 25-31, wherein the regenerated liquid desiccant (S4) is mixed with further liquid desiccant that is not regenerated and used for absorbing water from a gas in a water absorption section of the device.

33. Method according to any of claims 25-32, wherein the concentration is determined at predetermined intervals and wherein further liquid desiccant is transported to the regeneration section (γ) for regeneration as long as the concentration is below the predetermined value.

34. Method according to any of claims 25-33, wherein the transporting of liquid desiccant to and from the regeneration section (γ) is performed at least one condition for minimizing precipitation of the salt, said condition preferably being a pressure above a second pressure (P2) or a temperature above a fourth temperature (T4).

35. Method according to any of claims 25-34, wherein the desired concentration of the regenerated liquid desiccant is an optimal concentration at which a concentration of the regenerated liquid desiccant mixed with liquid desiccant in a liquid desiccant collecting container (β) is at or above the predetermined value of concentration.

36. Method according to any of claims 25-35, wherein said desired concentration is determined based on at least one of an ambient temperature and an ambient humidity.

37. A data processing device comprising means for carrying out the method of any of claims 25-36, said data processing device preferably being a control unit of the device for absorbing water.

38. A computer program product comprising instructions which, when the program is executed by a computer, cause the computer to carry out the method of any of claims 25-36.

39. A computer-readable storage medium comprising instructions which, when executed by a computer, cause the computer to carry out the method of any of claims 25-36.