Claims

1. Heat pump apparatus comprising:

- an evaporator, such as an evaporation tank (21), configured to evaporate by direct evaporation, i.e., evaporation provided by vacuum or partly vacuum, water received from an external water source through a water inlet line (5) and an evaporator inlet (22) to an evaporation chamber, the pressure in the evaporation chamber being lower than the pressure in the water inlet line (5) and sufficient low for evaporating the water entering the evaporation chamber, i.e., the pressure in the evaporation chamber is so that the evaporation temperature of the water associated with the pressure is lower than the temperature of the water entering the evaporation chamber through the evaporator inlet (22) and allowing for generating a pressurized vapor leaving the evaporator through an evaporator vapor outlet (24), the evaporator additionally comprising an evaporator water outlet (23),

- an expander (7) having an expander inlet (25) and an expander outlet (26), the expander inlet (25) having a fluid connection to the evaporator vapor outlet (24) and is being configured to receive pressurized vapor from the evaporation to drive the expander (7),

- a compressor (9) having a compressor inlet (64) and a compressor outlet (65), the compressor (9) being operatively driven by the expander (7) and is being configured to compress a gas from a low pressure, low temperature inlet gas at the compressor inlet (64) to a high pressure, high temperature outlet gas at the compressor outlet (65),

- a first condenser (13a, 51) having a first condenser inlet (31) and a first condenser outlet (32) , the first condenser inlet (31) having a fluid connection to the expander outlet (26) and is being configured to condense the fluid received from the expander (7) and the first condenser outlet (32) being connected to a first liquid outlet line (16a, 33).

2. The heat pump apparatus according to claim 1, comprising a second condenser (13b, 52) having a second condenser gas inlet (70) and a second condenser liquid outlet (71), the second condenser gas inlet (70) having a fluid connection to the compressor outlet (65) through which the high pressure, high temperature outlet gas leaves the compressor (9).

3. The heat pump apparatus according to claim 2, wherein the second condenser outlet (71) has a fluid connection to an evaporation system.

4. The heat pump apparatus according to claim 3 wherein the evaporation system comprises an absorber (18) having an absorber inlet (78) and an absorber outlet (79), the absorber inlet (78) having

a fluid connection to the second condenser outlet (71), the absorber outlet (79) being connected to the compressor inlet (64), through which low pressure, low temperature gas enters the compressor.

5. The heat pump apparatus according to claim 3 wherein the evaporation system comprises a liquid-gas separator (98) separating liquid from gas and having a first inlet (73) and a second inlet (75), a separator gas outlet (76) and a separator liquid outlet (77),

the separator gas outlet (76) having a fluid connection to the compressor inlet (64) through which low pressure, low temperature enters the compressor (9),

the separator liquid outlet (77) having a fluid connection to an absorber inlet (78) of an absorber (18) having an absorber outlet (79)

the first inlet (73) of the separator (98) has a fluid connection to the outlet (71) of the second condenser (13b, 52), and

the second inlet (75) of the separator (98) has a fluid connection to the outlet of the absorber (18).

6. The heat pump apparatus according to any of the preceding claims 2 to 5, wherein the second condenser is a spray condenser (52) having additionally a second inlet (74) for liquid supply of a liquid having a first temperature, and where spray condensation of the high pressure, high temperature outlet gas with the liquid having the first temperature provides for a temperature increase so that liquid leaving the second condenser (52) through a second liquid outlet (69) thereof has a second temperature being higher than the first temperature.

7. The heat pump apparatus according to the preceding claims, wherein the external water source is a water cycle system comprising a first external source supply line (53) and a first external source return line (54).

8. The heat pump apparatus according to any of the preceding claim 5 or 6, wherein the gas-liquid separator (98) has a fluid connection to the second condenser (52) and the second condenser second liquid outlet (69) is connected to the first liquid outlet line (33) being in fluid connection to the external liquid source.

9. The heat pump apparatus according to any of the preceding claims 2 to 8, wherein the compressor outlet (65) is fluidly connected to the second condenser (13b, 52) optionally being a spray condenser (52) via a heat exchanger (55; 57-58) arranged on a wall of the evaporator (21) or in the evaporator chamber of the evaporator (21).

10. The heat pump apparatus according to any of the preceding claims, wherein two or more expanders (7', 7") are arranged in series, the first expander (7') being driven by the exhaust flow from the evaporator (21) and the second expander (7") being driven by the exhaust flow from the first expander.

11. The heat pump apparatus according to claim 10, wherein the first expander (7') is drivingly connected to a compressor (9') and the second expander (7") is drivingly connected to a generator (99).

12. The heat pump apparatus according to claim 11, wherein a heat exchanger (59) is arranged between the fluid outlet line from the compressor (9) and the exhaust line from the first to the second expander (7', 7").

13. The heat pump apparatus according to any of the preceding claims wherein two or more expanders (7', 7") are arranged in parallel, both being driven by respective exhaust flows from the evaporator (21) and being drivingly connected to respective compressors (9', 9") arranged in series, exhaust gas from the first compressor being delivered to the second compressor.

14. The heat pump apparatus according to any of the preceding claims, wherein an auxiliary motor (99) is connected to the expander or compressor for assisting in start-up procedures or during continuous operation procedures.

15. District heating network comprising:

a first external liquid source being a first grid and a second external liquid source being a second grid, the first grid comprising a first grid supply line (53') and a first grid return line (54'), and the second grid comprising a second grid supply line (53") and a second grid return line (54"),

the first grid supply line (53’) being colder than the second grid supply line (53”) and the first grid return line (54’) being colder than the second grid return line (54”),

the lines of the first and the second grid being connected to a heat pump apparatus according to claims 1 and 2, the heat pump apparatus additionally comprising:

a gas-liquid separator (98), separating gas from liquid and having a liquid inlet (93) and a liquid outlet (95) and a gas outlet (76) having a fluid connection to the compressor inlet (64).

16. The district heating network according to claim 15, wherein

the first liquid inlet line (5) to the evaporator (21) has a liquid connection to the return line (54") of the second grid,

the liquid inlet (93) of the separator (98) has a fluid connection to the supply line (53’) of the first grid,

a liquid inlet (94) of the second condenser (52) has a fluid connection to the liquid outlet (92) of the separator (98),

the liquid outlet (23) of the evaporator (21) has a fluid connection to the return line (54’)’ of the second grid,

the second liquid outlet (69) of the second condenser (52) has a fluid connection to the supply line (53”) of the second grid, and

the liquid outlet line (33) from the first condenser (51) has a fluid connection to the return line (54’) of the first grid.

17. The district heating network according to claim 15, wherein

the liquid inlet line (5) to the evaporator (21) has a fluid connection to the supply line (53’) of the first grid,

the liquid inlet (93) to the separator (98) has a fluid connection to the return line (54") of the second grid,

the liquid outlet (95) from the separator (98) has a fluid connection to the return line (54") of the second grid,

the evaporator liquid outlet (23) has a fluid connection to the second condenser (52),

the second condenser (52) has a fluid outlet to the supply line (53") of the second grid and

the liquid outlet line (33) from the first condenser (51) has a fluid connection to the return line (54') of the first grid.