Disclosed are a hybrid desiccant dehumidifying apparatus and a control method thereof which are employed under poor environment, such as a ship painting field. External air cooled by an evaporator is dehumidified and heated while passing through a desiccant dehumidifier and external air heated by condensation heat of a condenser is supplied to the desiccant dehumidifier as a regeneration air source such that high-temperature and high-humidity regeneration. A cooler is integrally formed with the desiccant dehumidifier so that the hybrid desiccant dehumidifying apparatus is manufactured in a compact size and the operating cost thereof is significantly reduced.
FIG. 3

O.A → evaporator → compressor → condenser → capillary tube

cooling → desiccant rotor

processed air (dehumidified air)

S.A → dehumidifying space → T

E.A → heated air (regeneration)
FIG. 7

- evaporator
- compressor
- condenser
- capillary tube
- blower
- dehumidifying space
FIG. 9

O.A

Y

P

C

evaporator

compressor

condenser

capillary tube

cooling

E

E.A

heater

heated air

S.A

dehumidifying space
HYBRID DESICCANT DEHUMIDIFYING APPARATUS AND CONTROL METHOD THEREOF

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] The present invention relates to a hybrid desiccant dehumidifying apparatus and a control method thereof. More particularly, the present invention relates to a hybrid desiccant dehumidifying apparatus and a control method thereof which can be employed under poor environment, such as a ship painting field, in which external air pre-cooled by an evaporator is dehumidified and heated while passing through a desiccant dehumidifier and external air heated by condensation heat of a condenser is supplied to the desiccant dehumidifier as a regeneration air source such that high-temperature and high-humidity regeneration air can be exhausted to the outside through the heat exchange reaction, and in which a cooler is integrally formed with the desiccant dehumidifier so that the hybrid desiccant dehumidifying apparatus can be manufactured in a compact size and the operating cost thereof can be significantly reduced.

[0003] 2. Description of the Related Art

[0004] In general, an air conditioner is employed to perform the air conditioning operation (cooling and dehumidifying operation). The air conditioner includes an indoor unit and an outdoor unit and a refrigerant is circulated between the indoor unit and the outdoor unit while being subject to the phase change reaction.

[0005] The refrigerant having the liquid phase is evaporated through an evaporator of the indoor unit by absorbing heat from ambient air so that cooled air can be exhausted to the interior of a room. Then, the refrigerant having the vapor phase is transferred to a compressor of the outdoor unit.

[0006] The compressor compresses the refrigerant such that the refrigerant may have the high-temperature and high-pressure. Then, the refrigerant having the high-temperature and high-pressure is transferred to a condenser of the outdoor unit such that the refrigerant can be condensed into the liquid phase by the condenser. At this time, ambient air absorbs heat from the refrigerant so that the refrigerant having the vapor phase is changed into the refrigerant having the liquid phase. In addition, the heated ambient air is exhausted to the outside by means of a blowing fan.

[0007] In the case of the dehumidifying operation, the ambient air is cooled to the temperature sufficient for condensing humidity contained in the ambient air such that the humidity can be separated from the ambient air.

[0008] In general, the temperature for condensing the humidity is lower than the temperature available during the air conditioning operation, so over-cooled air may be exhausted to the interior of the room, causing unpleasant to the users.

[0009] Therefore, the temperature of the air must be properly adjusted by reheating the air before the air is exhausted to the interior of the room.

[0010] Since the air conditioning system must be equipped with the humidity control function as well as the temperature control function, the cooling and reheating operation is necessary in the air conditioning system.

[0011] There has been suggested a method of utilizing some of condensation heat in an indoor unit of a currently available household air conditioner. However, in the case of a duct type air conditioning system, a separate heat source is required.

[0012] Meanwhile, the conventional air conditioning system is unsuitable for poor environment, such as a ship painting field or a working place where dangerous materials are treated and circulated air cannot be reused.

[0013] In addition, since the circulated air cannot be reused, the cooling and dehumidifying apparatus must be operated for a long period of time to properly set the temperature and humidity, so that energy consumption is increased.

SUMMARY OF THE INVENTION

[0014] Accordingly, the present invention has been made to solve the above-mentioned problems occurring in the prior art, and an object of the present invention is to provide a hybrid desiccant dehumidifying apparatus and a control method thereof which can be employed under poor environment, such as a ship painting field, in which external air pre-cooled by an evaporator of a pneumatic cooler is dehumidified and heated while passing through a desiccant dehumidifier and the external air heated by condensation heat of a condenser is supplied to the desiccant dehumidifier as a regeneration air source such that the external air can be dehumidified and heated through the heat exchange reaction, and in which a cooler is integrally formed with the desiccant dehumidifier so that the hybrid desiccant dehumidifying apparatus can be manufactured in a compact size and the operating cost thereof can be significantly reduced.

[0015] In order to accomplish the object of the present invention, there is provided a hybrid desiccant dehumidifying apparatus comprising: a first external air receiving line into which external air is introduced; an evaporator installed in the first external air receiving line to cool the external air through a heat exchange reaction; a compressor for compressing a refrigerant that has passed through the evaporator; a condenser for condensing the refrigerant that has passed through the compressor; a capillary tube for expanding the refrigerant that has passed through the condenser; a desiccant rotor for dehumidifying and heating the external air cooled by the evaporator; a heated air supply line for supplying the external air, which is introduced through a second external air receiving line connected to the condenser, to the desiccant rotor after the external air is heated by condensation heat of the condenser; a regeneration air exhaust line which exhausts regeneration air having high-temperature and high-humidity by receiving the regeneration air from the desiccant rotor; an air feeding line for feeding processed air, which is dehumidified and heated while passing through the desiccant rotor, to a dehumidifying space such that the dehumidifying space keeps predetermined internal temperature and internal humidity; and a controller selectively cooling, dehumidifying or heating the external air according to external temperature and humidity conditions.

[0016] A filter is installed at an inlet side of the evaporator and an eliminator is installed at an outlet side of the evaporator so that condensing water contained in the external air can be easily removed without being scattered.

[0017] A first bypass is further provided to connect the outlet side of the evaporator to the regeneration air exhaust line, and a second bypass is further provided to connect the heated air supply line to the air feeding line.

[0018] According to another aspect, there is provided a method of controlling the hybrid desiccant dehumidifying...
apparatus including a first external air receiving line into which external air is introduced, an evaporator installed in the first external air receiving line to cool the external air through a heat exchange reaction, a compressor for compressing a refrigerant that has passed through the evaporator, a condenser for condensing the refrigerant that has passed through the compressor, a capillary tube for expanding the refrigerant that has passed through the condenser, a desiccant rotor for dehumidifying and heating the external air cooled by the evaporator, a heated air supply line for supplying the external air, which is introduced through a second external air receiving line connected to the condenser, to the desiccant rotor after the external air is heated by condensation heat of the condenser, a regeneration air exhaust line through which exhausts regeneration air by receiving the regeneration air from the desiccant rotor, an air feeding line for feeding processed air, which is dehumidified and heated while passing through the desiccant rotor, to a dehumidifying space such that the dehumidifying space keeps predetermined internal temperature and internal humidity, and a controller.

[0019] The controller selectively cools, dehumidifies, heats or blow the external air according to external air temperature and humidity conditions to generate the processed air which is supplied to the dehumidifying space such that the temperature and the humidity in the dehumidifying space can be maintained in a target level.

[0020] As mentioned above, the present invention can provide the hybrid desiccant dehumidifying apparatus and the control method thereof which can be employed under poor environment, such as a ship painting field or a working field where dangerous materials are treated and circuited air cannot be reused, in which external air can be pre-cooled by the evaporator or dehumidified and heated by condensation heat of the condenser. Thus, even if the circulated air cannot be reused, the condensation heat of the condenser can be used as the heat source of the desiccant dehumidifying apparatus so that energy consumption can be reduced and the temperature and the humidity can be properly maintained.

BRIEF DESCRIPTION OF THE DRAWINGS

[0021] FIG. 1 is a schematic view showing the structure of a hybrid desiccant dehumidifying apparatus according to the present invention;

[0022] FIG. 2 is a schematic view showing the structure of a hybrid desiccant dehumidifying apparatus according to the first embodiment of the present invention;

[0023] FIG. 3 is a block view showing the structure of a hybrid desiccant dehumidifying apparatus according to the first embodiment of the present invention;

[0024] FIG. 4 is a schematic view showing the structure of a hybrid desiccant dehumidifying apparatus according to the second embodiment of the present invention;

[0025] FIG. 5 is a block view showing the structure of a hybrid desiccant dehumidifying apparatus according to the second embodiment of the present invention;

[0026] FIG. 6 is a schematic view showing the structure of a hybrid desiccant dehumidifying apparatus according to the third embodiment of the present invention;

[0027] FIG. 7 is a block view showing the structure of a hybrid desiccant dehumidifying apparatus according to the third embodiment of the present invention;

[0028] FIG. 8 is a schematic view showing the structure of a hybrid desiccant dehumidifying apparatus according to the fourth embodiment of the present invention; and

[0029] FIG. 9 is a block view showing the structure of a hybrid desiccant dehumidifying apparatus according to the fourth embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0030] Hereinafter, exemplary embodiments of the present invention will be described in detail with reference to accompanying drawings.

[0031] In the following description and drawings, O.A refers to external air, E.A refers to exhaust air and S.A refers to supply air. In addition, thick lines represent the fluid flow and thin lines represent no fluid flow.

[0032] First, the structure of the hybrid desiccant dehumidifying apparatus according to the present invention will be described.

[0033] FIG. 1 is a schematic view showing the structure of the hybrid desiccant dehumidifying apparatus according to the present invention.

[0034] As shown in FIG. 1, the hybrid desiccant dehumidifying apparatus according to the present invention includes a first external air receiving line 1 into which external air is introduced, an evaporator V installed in the first external air receiving line 1 to cool the external air through a heat exchange reaction, a compressor P for compressing a refrigerant that has passed through the evaporator V, a condenser C for condensing the refrigerant that has passed through the compressor, a capillary tube E for expanding the refrigerant that has passed through the condenser, a desiccant rotor R for dehumidifying and heating the external air cooled by the evaporator, a heated air supply line L1 for supplying the external air, which is introduced through a second external air receiving line 2 connected to the condenser C, to the desiccant rotor R after the external air is heated by condensation heat of the condenser C, a regeneration air exhaust line L3 which exhausts regeneration air having high-temperature and high-humidity by receiving the regeneration air from the desiccant rotor R, an air feeding line L2 for feeding processed air, which is dehumidified and heated while passing through the desiccant rotor R, to a dehumidifying space T such that the dehumidifying space T keeps predetermined internal temperature and internal humidity, and a controller selectively cooling, dehumidifying or heating the external air according to external temperature and humidity conditions to supply dried air to the dehumidifying space such that the dehumidifying space can be maintained with the target temperature and humidity.

[0035] The first external air receiving line 1 is a duct that receives the external air from the outside and transfers the external air to the evaporator V.

[0036] A filter F is installed at an inlet side of the evaporator V and an eliminator G is installed at an outlet side of the evaporator V so that condensing water contained in the external air can be easily removed without being scattered.

[0037] A first bypass BP1 is provided to connect the first external air receiving line 1 adjacent to the outlet side of the evaporator V to the regeneration air exhaust line L3. The regeneration air exhausted from the desiccant rotor R is transferred to the regeneration air exhaust line L3. A damper CV is installed in the first bypass BP1.

[0038] Thus, the fluid flows only from the first external air receiving line 1 to the regeneration air exhaust line L3 by the damper CV.
In addition, a second bypass BP2 is provided to connect the heated air supply line L1 to the air feeding line L2, which will be described later in more detail.

The evaporator V is installed in the first external air receiving line I to cool the external air through the heat exchange reaction.

That is, the evaporator V includes a cooling coil for circulating the refrigerant. The refrigerant is evaporated while passing through the cooling coil by absorbing heat from the ambient air so that cooled air can be exhausted into the interior of the room.

The refrigerant that has passed through the evaporator V is compressed by the compressor P. In addition, the refrigerant that has passed through the compressor P is condensed by the condenser C and the refrigerant that has passed through the condenser C is expanded by the capillary tube E.

The desiccant rotor R is generally known in the art, so that detailed description thereof will be omitted.

For reference, a conventional desiccant dehumidifier is disclosed in Korean Registered Utility Model Publication No. 0523078.

The desiccant rotor R is divided into a processing unit and a regeneration unit. An area ratio between the processing unit and a regeneration unit is set to 1:1 to 5:3 according to the size of the apparatus.

The processing unit includes an absorbent agent, such as silica gel, so that humidity contained in the air passing through the desiccant rotor R is absorbed in the absorbent agent. The heated external air passes through the regeneration unit so that the heated external air is converted into the regeneration air through the heat exchange reaction.

The regeneration air generated from the desiccant rotor R is exhausted to the outside through the regeneration air exhaust line L3.

Meanwhile, the second bypass BP2 is installed between the heated air supply line L1 and the air feeding line L2.

The external air heated by the condenser C can be supplied to the air feeding line L2 through the second bypass BP2 without being supplied to the desiccant rotor R. Thus, in the winter season, in which the external air has low temperature and low humidity, the external air heated by the condenser C is supplied to the dehumidifying space T through the air feeding line L2 without driving the desiccant rotor R.

In addition, the heater H is installed in the heated air supply line, so that the external air heated while passing through the condenser C can be further heated by the heater H.

Hereinafter, the control method for the hybrid desiccant dehumidifying apparatus according to the present invention will be described.

According to the present invention, the controller selectively cools, dehumidifies, heats or blows the external air according to external temperature and humidity conditions to generate the processed air which is supplied to the dehumidifying space such that the temperature and the humidity in the dehumidifying space can be maintained at a target level.

The present invention provides four basic control modes according to external climate conditions:

1. In the summer season, the dehumidifying apparatus is operated in the cooling-dehumidifying mode under the high temperature-high humidity condition and the intermediate temperature-high humidity condition, and operated in the cooling mode under the high temperature-intermediate humidity condition.

2. In the spring and autumn seasons, the dehumidifying apparatus is operated in the blowing mode if the cooling operation can be naturally achieved by the external air.

3. In the winter season, the dehumidifying apparatus is operated in the heating mode.

4. Especially, the summer season is classified into the dry season and the rainy season. The dehumidifying apparatus is operated in the cooling mode in the dry season, and operated in the cooling-dehumidifying mode in the rainy season.

FIG. 2 is a schematic view showing the structure of the hybrid desiccant dehumidifying apparatus according to the first embodiment of the present invention, and FIG. 3 is a block view showing the structure of the hybrid desiccant dehumidifying apparatus according to the first embodiment of the present invention.

As shown in FIGS. 2 and 3, the dehumidifying apparatus is operated in the cooling-dehumidifying mode in the severe hot season or the rainy season.

The external air may have the high temperature and high humidity in the severe hot season, and the external air may have low temperature and high humidity in the rainy season.

In this case, in order to properly keep the temperature and humidity in the dehumidifying space T, the cooling-dehumidifying mode is performed by operating the compressor P, the condenser C, the evaporator V and the capillary tube E to cool the external air introduced through the first external air receiving line I, supplying the external air, which is heated by condensation heat of the condenser C, to the desiccant rotor R through the heated air supply line L1; and supplying the processed air, which is obtained by heat-exchanging the regeneration air with the external air supplied through the first external air receiving line I in the desiccant rotor R, to the dehumidifying space T through the air feeding line L2.

The external air heated by the condensation heat of the condenser C may have the temperature of about 60 to 80°C.

Since the heater H is installed in the heated air supply line L1, the external air heated by the condensation heat of the condenser C can be further heated by the heater H so that the external air may have the higher temperature.

Therefore, the heated external air can be used as the regeneration air source of the desiccant rotor R.

FIG. 4 is a schematic view showing the structure of the hybrid desiccant dehumidifying apparatus according to the second embodiment of the present invention, and FIG. 5 is a block view showing the structure of the hybrid desiccant dehumidifying apparatus according to the second embodiment of the present invention.

As shown in FIGS. 4 and 5, in the summer season in which the external air has the high temperature and high humidity, in order to properly keep the temperature and humidity in the dehumidifying space T, the cooling mode and the cooling-dehumidifying mode are simultaneously performed by operating the compressor P, the condenser C, the evaporator V and the capillary tube E to cool and dehumidify the external air introduced through the first external air receiving line I, supplying the external air, which is heated by condensation heat of the condenser C, to the desiccant rotor R through the heated air supply line L1; supplying the processed air, which is dehumidified and heated by heat-exchanging the regeneration air with the external air supplied through the first external air receiving line I in the desiccant rotor R.
rotor R, to the dehumidifying space through the air feeding line; supplying some of the external air, which has been cooled and dehumidified, to the air feeding line L2 through a third bypass BP3 to cool the external air; and supplying the cooled external air to the dehumidifying space T, thereby keeping the dehumidifying space T with the proper temperature and humidity.

The external air cooled through the evaporator V is supplied to the air feeding line L2 through the third bypass BP3, so that the cooled external air can be mixed with the regeneration air, which is dehumidified and heated while passing through the desiccant rotor R.

In addition, if it is necessary to lower the temperature regardless of the humidity, the operation of the desiccant rotor R is stopped and the regeneration air is exhausted to the outside through the regeneration air exhaust line.

FIG. 6 is a schematic view showing the structure of a hybrid desiccant dehumidifying apparatus according to the third embodiment of the present invention, and FIG. 7 is a block view showing the structure of the hybrid desiccant dehumidifying apparatus according to the third embodiment of the present invention.

As shown in FIGS. 6 and 7, in the spring season and the autumn season in which the external air has the low temperature and low humidity so that the cooling operation is performed through circulation of the external air without operating the cooler, in order to properly keep the temperature and humidity in the dehumidifying space T, the dehumidifying apparatus is operated by stopping operation of the compressor P, the condenser C, the evaporator V and the capillary tube E; and shutting off a regeneration part of the desiccant rotor R using a damper and opening the second bypass BP2 to allow the external air passing through a coil of the condenser C to be supplied to the dehumidifying space T through the air feeding line L2.

FIG. 8 is a schematic view showing the structure of a hybrid desiccant dehumidifying apparatus according to the fourth embodiment of the present invention and FIG. 9 is a block view showing the structure of the hybrid desiccant dehumidifying apparatus according to the fourth embodiment of the present invention.

As shown in FIGS. 8 and 9, in the winter season in which the external air has the low temperature and the low humidity, the dehumidifying apparatus is operated by operating the compressor P, the condenser C, the evaporator V and the capillary tube E to cool the external air introduced through the first external air receiving line L1; opening the first bypass BP1 to exhaust the external air cooled by the evaporator V through the regeneration air exhaust line L3; and shutting off a regeneration part of the desiccant rotor R and opening the second bypass BP2 to supply the external air heated by condensation heat of the condenser C to the dehumidifying space T through air feeding line L2.

That is, the external air cooled by passing through the evaporator V is exhausted to the outside through the regeneration air exhaust line L3 without being supplied to the desiccant rotor R.

The external air heated by the condensation heat of the condenser C may have the temperature of about 30 to 40° C., and this external air can be used as a heat source during the heating operation.

Although the exemplary embodiments of the present invention have been described, it is understood that the present invention should not be limited to these exemplary embodiments but various changes and modifications can be made by one ordinary skilled in the art within the spirit and scope of the present invention as hereinafter claimed.

What is claimed is:

1. A hybrid desiccant dehumidifying apparatus comprising:
   - a first external air receiving line into which external air is introduced;
   - an evaporator installed in the first external air receiving line to cool the external air through a heat exchange reaction;
   - a compressor for compressing a refrigerant that has passed through the evaporator;
   - a condenser for condensing the refrigerant that has passed through the compressor;
   - a capillary tube for expanding the refrigerant that has passed through the condenser;
   - a desiccant rotor for dehumidifying and heating the external air cooled by the evaporator;
   - a heated air supply line for supplying the external air, which is introduced through a second external air receiving line connected to the condenser, to the desiccant rotor after the external air is heated by condensation heat of the condenser;
   - a regeneration air exhaust line which exhausts regeneration air having high-temperature and high-humidity by receiving the regeneration air from the desiccant rotor;
   - an air feeding line for feeding processed air, which is dehumidified and heated while passing through the desiccant rotor, to a dehumidifying space such that the dehumidifying space keeps predetermined internal temperature and internal humidity; and
   - a controller selectively cooling, dehumidifying or heating the external air according to external temperature and humidity conditions,

wherein a filter is installed at an inlet side of the evaporator and an eliminator is installed at an outlet side of the evaporator.

2. The hybrid desiccant dehumidifying apparatus as claimed in claim 1, wherein a first bypass is provided to connect the outlet side of the evaporator to the regeneration air exhaust line.

3. The hybrid desiccant dehumidifying apparatus as claimed in claim 1, wherein a second bypass is provided to connect the heated air supply line to the air feeding line such that the external air heated by the condenser is introduced into the dehumidifying space through the air feeding line without driving the desiccant rotor under a condition of low temperature and low humidity.

4. The hybrid desiccant dehumidifying apparatus as claimed in claim 1, wherein a heater is installed in the heated air supply line to heat the air that has passed through the condenser such that the air has a higher temperature.

5. A method of controlling a hybrid desiccant dehumidifying apparatus including a first external air receiving line into which external air is introduced, an evaporator installed in the first external air receiving line to cool the external air through a heat exchange reaction, a compressor for compressing a refrigerant that has passed through the evaporator, a condenser for condensing the refrigerant that has passed through the compressor, a capillary tube for expanding the refrigerant that has passed through the condenser, a desiccant rotor for dehumidifying and heating the external air cooled by the evaporator, a heated air supply line for supplying the external air, which is introduced through a second external air receiv-
ing line connected to the condenser, to the desiccant rotor after the external air is heated by condensation heat of the condenser, a regeneration air exhaust line which exhausts regeneration air by receiving the regeneration air from the desiccant rotor, an air feeding line for feeding processed air, which is dehumidified and heated while passing through the desiccant rotor, to a dehumidifying space such that the dehumidifying space keeps predetermined internal temperature and internal humidity, and a controller selectively cooling, dehumidifying, heating or blowing the external air according to external temperature and humidity conditions to generate the processed air which is supplied to the dehumidifying space such that the temperature and the humidity in the dehumidifying space are maintained in a target level, the method comprising:

operating the compressor, the condenser, the evaporator and the capillary tube to cool and dehumidify the external air introduced through the first external air receiving line;

supplying the external air, which is heated by condensation heat of the condenser, to the desiccant rotor through the heated air supply line;

supplying the processed air, which is dehumidified and heated by heat-exchanging the regeneration air with the external air supplied through the first external air receiving line in the desiccant rotor, to the dehumidifying space through the air feeding line;

supplying some of the external air, which has been cooled and dehumidified, to the air feeding line through a third bypass to cool the external air; and

supplying the cooled external air to the dehumidifying space, thereby keeping the dehumidifying space with proper temperature and humidity in a summer season in which the external air has higher temperature and higher humidity.

6. The method as claimed in claim 5, further comprising: stopping operation of the compressor, the condenser, the evaporator and the capillary tube; and shutting off a regeneration part of the desiccant rotor using a damper and opening a second bypass to allow the external air passing through a coil of the condenser to be supplied to the dehumidifying space through the air feeding line in such a way that a cooling operation is performed through circulation of the external air without operating a cooler in a spring season or an autumn season in which the external air has low temperature and low humidity.

7. The method as claimed in claim 5, further comprising: operating the compressor, the condenser, the evaporator and the capillary tube to cool the external air introduced through the first external air receiving line; opening a first bypass to exhaust the external air cooled by the evaporator through the regeneration air exhaust line; and shutting off a regeneration part of the desiccant rotor and opening a second bypass to supply the external air heated by condensation heat of the condenser to the dehumidifying space through air feeding line in such a way that the external air heated by the condensation heat of the condenser is further heated by a heater in a winter season in which the external air has low temperature and low humidity.

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