REGENERATIVE DRIER FOR AIR TO BE CONDITIONED

Inventor: Per Gunnar Norbäck, Lidingo, Sweden
Assignee: Carl Georg Munters, Stocksund, Sweden
Filed: Nov. 27, 1970
Appl. No.: 92,991

Foreign Application Priority Data
Dec. 1, 1969 Sweden..............................16493/69

U.S. Cl. ........................................... 55/20, 55/23, 55/34, 55/51, 55/163, 55/208
Int. Cl. ............................................ B01D 53/06
Field of Search..................55/163, 20, 23, 34, 35, 208, 55/51

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Primary Examiner—John Adee
Attorney—Sol B. Wiczer

ABSTRACT

A regenerative drier primarily intended for air to be conditioned compressed to superatmospheric pressure and comprising a drying rotor containing a moisture absorbing mass and mounted for rotation between two air passageways thru which one is passed by the air to be conditioned and the second by regenerating air for the moisture absorbing mass, said second air housing a heater the supply of heat to which is controlled by a hygrostat disposed in said second passage at the outlet side as it passes from the rotor. When the regenerating air is circulated in a closed circuit, a portion of said circuit is constituted by said first passage so that the dehumidification of the regenerating air is partially effected within said rotor.

8 Claims, 2 Drawing Figures
REGENERATIVE DRIER FOR AIR TO BE CONDITIONED

BACKGROUND OF THE INVENTION

This invention relates to a regenerative drier for air to be conditioned.

More particularly this invention relates to an improvement in a regenerative drier primarily for air to be conditioned, which is compressed to superatmospheric pressure. The drier has a drying rotor containing a moisture absorbing mass and is rotated between two passages connected to a surrounding casing. A first passage of said passages is passed by the air to be conditioned for the purpose of becoming dehumidified, and a second passage by regenerating air preferably circulating in a closed circuit and dehydrates said mass. A heater is provided in said second passage at the side thereof opening towards the rotor. The moisture content of the air to be conditioned is controlled by a hygrostat. The most important field of application of the invention is constituted by driers or dehumidifiers for air which has been compressed to a superatmospheric pressure of e.g. 7 kgs/cm², and the invention will be described hereinafter in connection with said type of driers.

In connection with the compression in a compressor, the air will contain a greater quantity of humidity which must be removed, as it otherwise would cause serious difficulties, e.g. by enhancing corrosion of those metal surfaces with which it establishes contact or on which humidity is deposited in the state of water or ice e.g. in feed pipes or in tools operated by compressed air, or deteriorate the operative properties of said tools. Normally, a first precipitation of humidity is effected in a condenser by means of water or air acting as cooling agent. However, in many cases this drying operation is not sufficient to lower the moisture content to a required degree and for this reason when very dry air is required a drier assembly or unit is interposed following the precooler in which assembly the main part of the remaining humidity is removed. The lowest and most uniform drying is attained with apparatus of the sorption type the sorption agent of which is continuously regenerated. It has been proposed in order to control that a desired dry content of the conditioned air be attained under different conditions of operation while maintaining good working economy, to control also the regeneration of the drier by means of a hygrostat which is located in the way of the air to be conditioned, when it is discharged from the drier and its humidity content has been lowered to one or several few percents of relative moisture content. It has proved, however, this method has several drawbacks. It is difficult to have the hygrostat to maintain its reliability constant at such low values of the relative humidity. The calibration hygrostat changes as time passes, and it requires adjustments. In addition, it may occur in connection with partial loads that those portions of the moisture absorbing mass which are the first to be met by the air saturated with humidity when leaving the compressor, may become supersaturated without activating the hygrostat to emit an impulse. When the absorbing agent is a salt such as lithium chloride, such excess of saturation may result in so much liquid being taken up by the salt that it is dissolved into a free solution within the drying mass which can be displaced within the rotor and even be carried along by the air and thus escape from the rotor, whereby the capacity of said rotor is impaired to a corresponding degree.

SUMMARY OF THE INVENTION

One main object of the invention is to eliminate said drawbacks. According to one main feature of the invention the hygrostat controlling the supply of heat to the heater is disposed in the second passage at the outlet side thereof from the rotor. During passage through the regenerating sector of the rotor the regenerating air absorbs gradually more and more moisture so that its relative moisture content when leaving the rotor amounts to e.g. 50 to 60 and up to about 90 percent. At such high percent values the hygrostat reacts highly sensitively so that it can start the heater in time and thereby intensify the regeneration so that the moisture content in the rotor is maintained below the critical values. In addition, the hygrostat retains its calibration at so high relative moisture values over very long periods of time for which reason interruptions for adjusting said hygrostat need not be made but only at very long intervals. Further, in the practice of the invention the consumption of energy such as electric current, for the heater is maintained within favorable economical limits. Due to the fact that the circulation of the regenerating air in the closed circuit is continuous, the degree of saturation of the rotor is scanned continuously and the heater is thus switched in only when the hygrostat indicates that the quantity of moisture in the rotor has partially exceeded permissible values.

SHORT DESCRIPTION OF THE DRAWINGS

Further objects and advantages of the invention will become apparent from the following description, considered in connection with the accompanying drawing which forms part of a specification and which shows one embodiment of the invention and of which:

FIG. 1 is a diagrammatic view of a drying apparatus embodying the invention and FIG. 2 is an axial view of the rotor forming part of said drying apparatus.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawing, reference numeral 10 denotes a compressor of a type known per se, such as a compressor of the two-stage type in which atmospheric air is compressed to superatmospheric pressure of 7 atmospheres excess pressure, for example. By the compression the air is imparted a considerably increased temperature, such as 120°C and more. The hot compressed air is conducted through a condenser 12, the cooling agent of which may be water, the air being cooled down to approximately the temperature prevailing in the surrounding atmosphere, e.g. down to about 5 to 40°C depending on the season. The compressed air has now a relative moisture content of about 100 percent or even higher, if also the water particles floating in the air are taken into account. The air is conducted via a conduit 14 through the larger drying zone or sector 16 of the cylindrical rotor 18 of a drying apparatus.

The rotor contains a mass which is moisture absorbing due to impregnation with a hygroscopic salt such as lithium chloride. The rotor may be built up as is dis-
closed in the U.S. Pats. Nos. 3,231,409 and 3,307,617, e.g. it is composed by alternate flat thin sheets 20 and corrugated thin sheets 22 of a fibrous material, such as asbestos, impregnated with the hygroscopic salt. The thin sheets form a very great number of narrow passages extending from end to end in parallel to the axis 24 of the rotor. The spacing between two adjacent flat sheets 20 may be less than 3 millimeters.

The drying sector or zone 16 may occupy more than half of the circumference of the rotor, such as three fourths thereof. The remaining sector or zone 26 is passed by the regenerating air which preferably is taken from the compressed air after that said air has passed through the drying zone 16 and has been dried to a very low both absolute and relative moisture content. The relative moisture content may amount to at the utmost one or several few per cents. Extending from the outlet conduit 28 which communicates with the place of consumption of the compressed or conditioned air, is a branch conduit 30 for regenerating air which passes first through a heater 32 and then streams through the sector 26 of the rotor 18 counter-current to the flow direction of the air being conditioned in passage through the other side of the rotor. The regenerating air leaves the sector 26 through a conduit 34 which houses a fan 36 and which is connected to the conduit 14. Provided in the conduit 34 may be a condenser 37 which is cooled by e.g. available water and which may be identical with the condenser 12.

It is assumed that the rotor 18 rotates as is indicated by the arrow 38 in FIG. 2. The rotational speed is low, such as only few revolutions per hour. The relative moisture content of the air to be conditioned which initially was 100 percent is during the passage gradually lowered to a predetermined low value, such as e.g. 1 to 5 to 10 percent. The impregnated mass of the sheets in the rotor picks up this moisture and transfers it to the sector 26 passed by the regenerating air. The relative moisture content of said air will increase so that it when leaving the rotor may amount to between 50 and 90 percent, depending on the temperature to which it is heated by the heater 32. The relative moisture content of the air leaving the regenerating sector varies also over the cross-sectional area in such a manner that it increases gradually from that part of the cross-sectional area where the rotor is on its way from the regenerating sector to the drying sector to that part where the rotor enters the regenerating sector from the drying sector.

According to the invention a hygrostat 40 is disposed in the conduit 34. This hygrostat in turn through a control device 42 and conductors 44 controls the supply of heat to the heater 32 so that the relative moisture content of the regenerating air when leaving the apparatus does not exceed a predetermined value which in turn determines the moisture content in the drying zone 16 of the rotor 18.

Most suitably, the hygrostat 40 is caused to react on the air which leaves the rotor at the place indicated by the cross 46 set out in FIG. 2. At this point the mass of the rotor has the highest moisture at the start of regeneration, the rotor having just passed the rotor sector 16 and under said passage during the whole time picked up air from the inlet side for the compressed air and where the emitted regenerating air, has the greatest relative moisture content. When the object is to obtain an even better working economy, the quantity of regenerating air may be lower while at the same time managing the supply of heat to become unnecessary, e.g. by reducing the number of revolutions of the fan 36 whereby the consumption of energy required for the circulation of the regenerating air is reduced. This is the reason why the cross 46 is located adjacent the partition wall 48 between the two sectors.

The circulation of the regenerating air in the closed circuit formed by the two sectors or zones 16, 26 of the rotor and the conduits 14, 28, 30 and 34 connected thereto may be brought about by an ejector utilizing a pressure drop created in the circulation circuit. The closed circulation circuit for the regenerating air need not necessarily pass through the drying sector 16 of the rotor, but may be located laterally thereof, the required drying of the regenerating air then being effected by means of a particular cooling condenser.

The invention is with advantage applicable also in the drying of air under normal atmospheric pressure, in particular in such cases of operation where a precooing is effected in a cooler assembly and where the air to be conditioned enters the drier while having a very high relative moisture content. In this connection the regenerating air instead of being returned to the conditioned air may be discharged into the surrounding atmosphere via the condenser.

While one more or less specific embodiment of the invention has been shown and described, it is to be understood that this is for purpose of illustration only and that the invention is not to be limited thereby, but its scope is to be determined by the appended claims.

What is claimed is:

1. In a regenerating drying system for compressed air having a compressor, a rotary moisture absorber having moisture absorbing material distributed thereon, said absorber being mounted to pass in rotation between a drying section and a regenerating section defined by dual compressed air streams continuously passed therethrough as said moisture absorber rotates, means for cooling the compressed air to remove moisture therefrom, duct means defining a first air stream passing the cooled compressed air from said cooling means to the drying section of said rotary dryer, there being dried to less than 10 percent relative humidity, duct means passing said cooled dried air emitted from the drying section of said rotor for use as dry compressed air, duct means defining a second air stream passing compressed regeneration air to the said regenerating section of said rotary moisture absorber for removing moisture therefrom, means for heating said compressed regeneration second air stream before it enters said absorber regeneration section and outlet duct means conveying said second moisture laden regeneration air stream from the regeneration section of said rotary moisture absorber, the improvement comprising mounting a hygrostat in said outlet second air stream duct means withdrawing moisture-laden air from said regeneration section to sense the moisture content thereof, and means controlled by said hygrostat responsive to a pre-set moisture content of said moisture-laden outlet second stream air to activate said heating means, whereby to accelerate the moisture regeneration by raising the temperature of said regeneration gas as it enters said regeneration section.
responsive to the moisture content of the regeneration gas evolved.

2. The regenerative drying system for compressed air as defined in claim 1 wherein the duct means conveying regeneration gas passed into said regeneration section is connected by duct means to the dry air stream withdrawn from said drying section as a regeneration gas source, whereby the regeneration gas comprises a portion of the first stream air dried in the drying section and recycled by the said duct means to said regeneration section as said second air stream.

3. The regenerative drying system for compressed air as defined in claim 1 wherein the said second stream moisture-laden regeneration gas outlet comprises duct means interconnected with said cooling means and, after cooling, then with duct means passing the cooled outlet regeneration gas to the air drying section of said rotary dryer.

4. The regenerative drying system for compressed air as defined in claim 1 wherein the total duct means forms in part a continuous cycling system, withdrawing some of the compressed dry air of said first stream from the dried compressed air outlet of the rotary dryer and passing a portion as compressed regeneration inlet air as the regeneration gas source, the duct means further returning the moisture-laden regeneration air from said second stream as compressed moisture-laden air to said first stream before cooling to deposit moisture therefrom.

5. The method of operating a regenerative drying system for compressed air with a rotary moisture absorber having a moisture absorbing desiccant therein, mounted to rotate between a compressed air stream to be dried and a compressed regeneration air stream to regenerate the rotary dryer, comprising compressing air in a first air stream, passing the compressed air to a cooler to cool and condense some moisture from the compressed air stream, passing the cooled stream through the drying section of said moisture absorbent dryer as it rotates to dry the compressed air to less than 10% relative humidity, and then passing the first compressed dry air stream to storage or to a means for using said dry compressed air stream; simultaneously passing a second heated compressed regeneration air stream through a separate regeneration section of said rotary dryer, said second stream being heated to variable degrees by heating means as it enters the regeneration section of said rotary dryer, expelling moisture as a heating and scavenging gas as it passes through the rotating dryer, mounting a hygrostat in the outlet stream to sense the moisture content of the moisture-laden compressed air as it leaves the said regeneration section, said hygrostat being connected to activate the heating means for the second compressed air stream as it enters said regeneration section, variably heating said entering gas responsive to a selected pre-set moisture content of the outlet gas from said regeneration section as sensed by said hygrostat.

6. The method as defined in claim 5 wherein the said compressed regeneration air is supplied as a recycled portion of the first compressed dry air stream dried in said air drying section.

7. The method as defined in claim 5 wherein the compressed outlet air stream from said regeneration section is cooled to remove moisture therefrom and recycled for further drying in said air drying section.

8. The method as defined in claim 5 wherein the compressed air outlet stream from said regeneration section and from said compressor are cooled as a single combined stream and to remove moisture therefrom, and passed thence for further drying to said air drying section.