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PROCESS AND SYSTEM FOR REMOVING CONDENSABLE VAPORS

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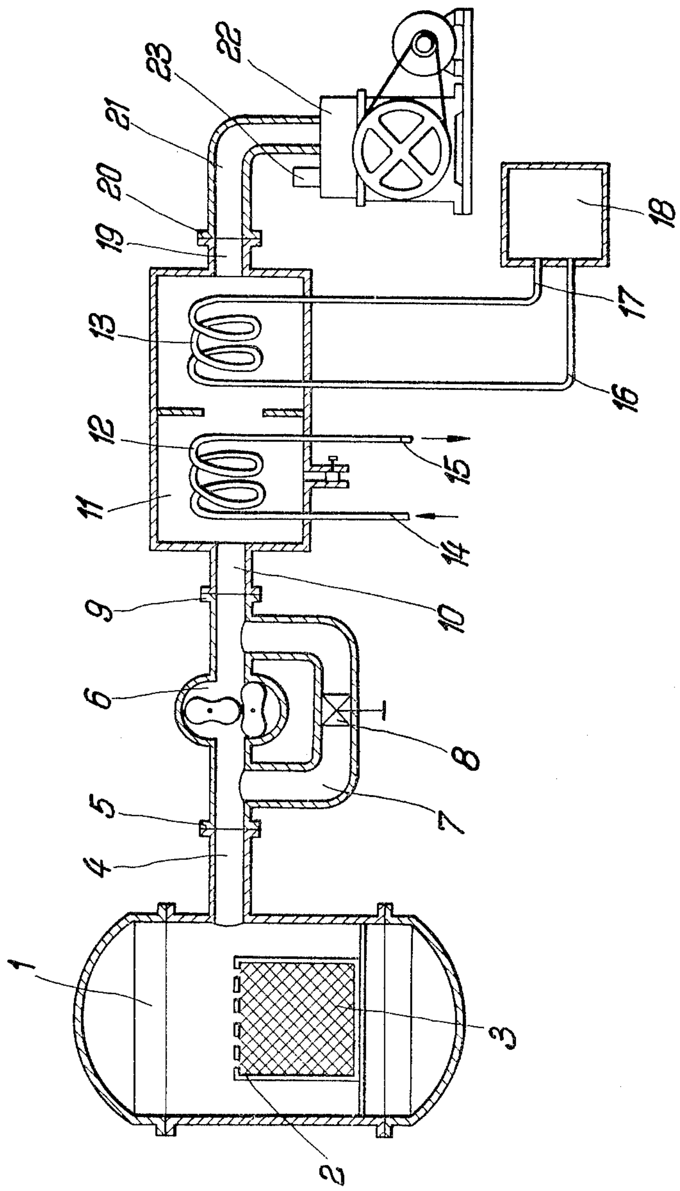

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PROCESS AND SYSTEM FOR REMOVING CONDENSABLE VAPORS

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The present invention relates to a process and system for pumping off great quantities of condensable vapors from a vessel, particularly of water vapor during a drying process by using a rotary compressor with a first stage pump connected by means of a pressure equalizing line, preferably said first stage pump being a gas ballast pump, and the system including a condenser inserted between a rotary compressor and the first stage pump.

If great quantities of condensable vapors are to be pumped from a vessel as may, for example, occur in cable drying, an evacuating device may be provided in a manner known per se, in which a plurality of rotary compressors of different sizes are arranged in series, and in which a gas ballast pump is provided as the high pressure stage pump. Between the individual rotary compressors, i.e., between the rotary compressor and the high pressure stage referred to as the first-stage pump, vapor condensers of a known construction are inserted which may be fed, for example, from a cooling water circuit. In such construction, by-pass lines for the rotary compressor and the condenser provided between the latter are required, said by-pass lines being closed or opened during certain process steps by means of valves. Such evacuation arrangement involves considerable expense of operation as a considerable number of valves have to be operated sequentially depending upon certain pressure values ascertained by measuring instruments.

It is an object of the present invention to provide a considerably simplified process and arrangement, by which great quantities of condensable vapors can be pumped off without complicated control devices by using a single rotary compressor.

It is another object of this invention to provide a process and device for pumping off large quantities of condensable vapors from a vessel, particularly of water vapor in a drying process, by employing a rotary compressor by-passed to a first-stage pump by a pressure equalizing circuit, said first-stage pump preferably being a gas ballast pump, and said system including a condenser unit inserted between the rotary compressor and the first-stage pump.

It is another object of the present invention to provide as the condenser unit selectively inserted in the system, a standard condenser with standard cooling means and a low temperature condenser with low temperature cooling means.

The vessel is first evacuated with the rotary compressor by-passed and by means of standard cooling means and the first-stage pump, to a pressure corresponding to the temperature of the standard cooling means, at which pressure the condensation in the standard cooling means ceases; and thereafter the condensation is continued at the low temperature unit until the evacuation has reached the pressure value corresponding to the temperature of the latter (i.e., low temperature-unit). Finally, by-passing of the rotary compressor is terminated during the final evacuation, whereupon the rotary compressor functions as a supercharger.

The new process results in a considerable technical advance, particularly because the apparatus necessary for its operation is greatly simplified over that in the known processes.

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Specifically, only a single valve-controlled pressure by-passing circuit is necessary to by-pass the rotary compressor during operation of the first evacuation and to connect the interior of the vessel directly to the condenser unit. It may be advantageous to use a temperature above 0° C., preferably about +15° in the standard cooling unit while the temperature of the low-temperature cooling unit should be below −20° C., preferably about −40°. Preferably, the standard cooling unit is operated in a known manner with cooling water, while for the feeding of the low-temperature cooling unit a one-stage compression cooling machine is provided. By means of such a cooling machine temperatures of about −40° C. in the low-temperature cooling unit of the low-temperature condenser may be relatively simply and reliably obtained.

Since, generally, the low-temperature cooling unit is only to be used if the condensation ceases at the standard cooling unit, special precautions are necessary for determining this condition and for the initiation of the required switching operations. It is, therefore, an additional object of this invention to use for the operation of the low-temperature cooling unit the temperature difference between the cooling medium entering and leaving the standard cooling unit as a control parameter, and to initiate the switching when the temperature difference is below a predetermined value. The input and output temperatures of the cooling water in the standard cooling unit can thus be observed, for example, by means of contact thermometers, and the refrigerator can be put in operation by relays if the temperature falls below said predetermined temperature value, i.e., after condensation has virtually ceased in the standard cooling unit.

In the first evacuation step, a pressure value of about 20 mm. mercury is obtained at a cooling water input temperature of about 15° C. in the water cooled by the standard cooling unit of the condenser. In the second step, a pressure drop to about 10 mm. mercury is reached by means of the low-temperature cooling unit connected to the refrigerator. At this point the by-passing of the rotary compressor can be terminated by opening the valve in the pressure equalizing circuit and the rotary compressor now acts as a supercharger to the subsequent low-temperature cooling condenser. In this case, pressure values to about 5×10^{-3} mm. mercury may be obtained. The new process and the system pertaining thereto is particularly advantageous for pumping off greater water vapor quantities in the order of kilograms per hour.

While in the usual case the low-temperature cooling unit is put in operation only after condensation in the standard cooling unit has ceased or almost ceased, for some purposes a different operation may be advantageous. In such case, the low-temperature cooling unit is put in operation from the beginning or after a certain time, while the standard condenser is still operative. In this case, a part of the water in the low-temperature cooling unit freezes and the ice mass in this way serves as a low-temperature storage medium which can be utilized in the following condensation and evacuation stage in the low-temperature cooling condenser. If in this stage a great amount of water accumulates due to the particular drying process, a refrigerator of considerable capacity would have to be provided in order to obtain substantially complete condensation in the condenser unit. By utilization of the cold stored due to the ice formation in the preceding evacuation state a smaller refrigerator may be used, whereby a considerable reduction in cost of the unit is obtained.

In the drawing, an embodiment of the device for carrying out the inventive process is schematically illustrated. **1** denotes a vessel enclosing in a container or box **2** a material **3** having a high degree of humidity.

The vessel is connected to a Roots-type first-stage compressor 6 via a pipe 4 and an intermediate flange joint 5 and wherein this compressor 6 is by-passed by a duct 7 when a valve 8 is opened so that the interior of the vessel 1 in this operating condition may be directly connected with the inlet pipe 10 of a condenser unit 11 formed as a twin condenser, via a further flange connection 9.

This twin condenser comprises in a common housing a first cooling coil 12 forming the standard higher-temperature cooling unit, and a second low-temperature coil 13. The first cooling coil 12 of the standard cooling unit is connected to a cooling-water circuit (not shown) via input and output pipes 14 and 15. A supply line 16 and a return line 17 connect the second cooling coil 13 with a compression-type refrigerator 18. The outlet pipe 19 of the twin condenser 11 is connected to a suction line 21 of a first-stage pump 22 designed as a gas ballast pump via a flange joint 20. The gas or vapor media expelled by the first-stage pump 22 are discharged at the exhaust opening 23.

After the material 3 in the perforated container 2 has been placed in the vessel 1, the first-stage pump 22 is put in operation through the by-pass line 7 while the valve 8 is opened. In addition, the cooling coil 12 which represents the standard cooling unit in the twin condenser 11 is connected to a cooling water circulation via the input and output pipes 14, 15. As a result of the pressure decrease in the interior of the vessel 1, said pressure decrease being obtained with the aid of the first-stage pump 22, a considerable water vapor escape takes place from the material 3, whereby the water vapors above a pressure value determined by the surface temperature of the first cooling coil 12 are condensed in the standard cooling unit of the twin condenser 11. The water vapor partial pressure cannot be lowered beyond the pressure value determined by the temperature of the first cooling coil 12 and, upon reaching this temperature value, condensation ceases at the standard cooling unit.

During condensation of the water vapor in the first cooling coil 12, the heat of condensation of the vapor is transferred to the cooling water, whereby an increase in the cooling water output temperature is obtained in comparison to the temperature value of the input cooling water. If the temperature difference between cooling water discharge and inlet falls below a predetermined value, as, for example, 2° C., this is indicative of the condensation having ceased in the standard cooling unit; thus, the condenser having become practically inoperative.

At this point, the second stage of the process begins, in which the low-temperature cooling unit and thereby the cooling coil 13 are put in operation. Due to the considerably lower surface temperature of the second cooling coil 13, a lower limit value of the water vapor partial pressure is obtained which can be adjusted by means of the twin condenser 11. The magnitude of the cooling effect of the second cooling coil 13 is measured such that during exchange of the heat of the condensation of the water vapor with the low-cooling medium a surface temperature of the cooling coil above the freezing point of about +2° C. is maintained. In this way, a continuous yield is obtained of liquid condensate and a freezing of the water on the surface of the second cooling coil 13 within a given pressure range is avoided.

The low cooling unit of the twin condenser 11 also attains a pressure value at which the water vapor partial pressure in the vessel 1 corresponds to the predetermined surface temperature of the second cooling coil 13, so that no further condensation can take place.

The final evacuation starts with the use of the rotary compressor 6 and for this purpose, the pressure equalizing circuit 7 is shut off by closing the valve 8. The rotary compressor 6 creates a pressure increase in the twin condenser 11 due to its supercharger effect, whereby said twin condenser becomes again operative. After the desired final pressure in the vessel 1 is obtained, the evacuation is stopped and the material 3 can be removed from the vessel 1 in a manner known per se.

The structure of the twin condenser has been described schematically in the simplified embodiment illustrated.

In practical apparatus, the standard cooling unit and the low-temperature cooling unit may be provided with different cooling surface arrangements. Basically, the use of multi-stage compression refrigerators is possible; however, the single-stage apparatus is recommended because of its simple and inexpensive design.

What is claimed is:

1. A system for removing from a vessel large quantities of condensable vapors, comprising a rotary compressor having its intake connected to said vessel; by-pass and valve means for selectively shunting said compressor; condenser means connected to receive the discharge from the compressor, said condenser having a higher-temperature cooling coil and a lower-temperature cooling unit; and a high-vacuum pump connected to the discharge end of the condenser means, whereby when the rotary compressor is initially by-passed, the higher-temperature cooling coil and the pump remove vapor down to a pressure corresponding with the temperature of said higher-temperature coil, and when the by-pass is thereafter closed by the valve means and the lower-temperature coil is cooled the rotary compressor acts as a supercharger.

2. In a system as set forth in claim 1, said condenser means comprising a twin unit with the vapor passing the higher-temperature coil first and then the lower-temperature coil.

3. In a system as set forth in claim 1, said lower-temperature coil being cooled by a one-stage compressor refrigeration machine.

4. The method of removing water vapor from a vessel comprising the steps of: condensing a major portion of the vapor under a partial vacuum at a temperature above the freezing point of the condensate; then condensing out more of the vapor at a temperature below the freezing point of the condensate; and supercharging the vapor from the vessel while feeding it and condensing it at the lower temperature and in the partial vacuum.

5. In a method as set forth in claim 4, the vapor being water and the first condensing step being conducted between 0° C. and 15° C., and the second condensing step being conducted between −20° C. and −40° C.

6. In a method as set forth in claim 4, the second condensing step being started when the rate of condensation in the first step approaches zero as determined by measurement of the heat of condensation absorbed during the first condensing step.

References Cited in the file of this patent

UNITED STATES PATENTS

2,345,548	Flosdorf et al.	Mar. 28, 1944
2,406,682	Hayes et al.	Aug. 27, 1946
2,453,033	Patterson	Nov. 2, 1948
2,564,475	Fischer	Aug. 14, 1951
2,731,734	Bancroft	Jan. 24, 1956
2,878,650	Krchma	Mar. 24, 1959