

(19)



Europäisches Patentamt

European Patent Office

Office européen des brevets



(11)

EP 1 007 852 B1

(12)

EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention
of the grant of the patent:

22.10.2003 Bulletin 2003/43

(21) Application number: **98940741.6**

(22) Date of filing: **21.08.1998**

(51) Int Cl.7: **F04C 18/16**, F04C 29/00

(86) International application number:
PCT/SE98/01500

(87) International publication number:
WO 99/011937 (11.03.1999 Gazette 1999/10)

(54) **COMPRESSOR HAVING A WATER CIRCULATION SYSTEM**

KOMPRESSOR MIT EINEM WASSERKREISLAUF

COMPRESSEUR EQUIPE D'UN SYSTEME DE CIRCULATION D'EAU

(84) Designated Contracting States:
BE DE FI FR GB IT NL SE

(30) Priority: **28.08.1997 SE 9703098**

(43) Date of publication of application:
14.06.2000 Bulletin 2000/24

(73) Proprietor: **SVENSKA ROTOR MASKINER AB**
S-104 65 Stockholm (SE)

(72) Inventor: **SALETTI, Hakan**
S-135 50 Tyresö (SE)

(74) Representative: **Wiedemann, Bernd**
Svenska Rotor Maskiner AB,
P.O. Box 15085
104 65 Stockholm (SE)

(56) References cited:
SE-B- 452 790 **US-A- 4 733 536**

EP 1 007 852 B1

Note: Within nine months from the publication of the mention of the grant of the European patent, any person may give notice to the European Patent Office of opposition to the European patent granted. Notice of opposition shall be filed in a written reasoned statement. It shall not be deemed to have been filed until the opposition fee has been paid. (Art. 99(1) European Patent Convention).

Description

[0001] The present invention relates to a rotary screw compressor that includes a water circulation system.

[0002] It is known to inject water into the working chamber of rotary screw compressor for lubricating, sealing and cooling purposes. Swedish Patent Specification 8502838-9 (Publication No. 452790) describes the injection of water into a high-speed compressor of the rotary screw type. Water is injected in a weight-quantity relative to the weight-quantity of supplied gas that is greater than that required for complete vaporisation of the water during compression but which is not greater than about four times this weight-quantity.

[0003] Under certain operating conditions, a compressor that includes a water circulation system will discharge more water than the amount of water delivered thereto with the air intake. Such conditions occur in desert climates and in extremely cold winter conditions. If the intake air is not enriched with water or is heated and enriched with water, more water will leave the system together with the hotter compressed air than that delivered to the system with the intake air. This water deficiency must be made-up with water taken from an external source.

[0004] The quality or pureness of water differs worldwide. Consequently, unless the water used has been distilled or demineralised, it is liable to contain different impurities to differing extents, e.g. foreign substances such as lime, the world over.

[0005] When such water, e.g. lake water or drinking water, is delivered to the compressor, the contaminants present in the water will have a negative effect on the compressor. One example in this regard is that lime present in the water may be deposited on all parts of the water circulation system. Those deposits that form in the working chamber of the compressor are particularly harmful to compressor performance.

[0006] The compressor and the entire water circulation system must be cleaned periodically. Cleaning of the compressor is a particular onerous task.

[0007] The object of the present invention is to prevent or at least greatly reduce the delivery of impurities or contaminants to the compressor with water taken from an external source, e.g. water-carried contaminants that are liable to form deposits.

[0008] This object is achieved in accordance with the invention, with a rotary screw compressor according to the preamble of Claim 1, wherein a steam generator is adapted for delivering steam to the water circulation system of the compressor.

[0009] Preferred embodiments will be apparent from the depending Claims.

[0010] The water condensed or separated from the air is clean and can be circulated in the system. When water is supplied from an external source, the impurities or contaminants present in the water will depend to a greater or lesser extent on the quality of the water entering

the circulation system. As a result of the vaporization that takes place in the steam generator, the large majority of impurities present in the incoming water will remain in the steam generator. The substantially pure water is delivered to the working chamber of the compressor in the form of steam.

[0011] Since the water supplied contains impurities or contaminants, the steam generator must be cleaned periodically. Those deposits formed in the generator will be restricted to a relatively limited area in which no movable parts work. Thus, only the steam generator need be cleaned, instead of needing to clean the compressor and remaining parts of the water circulation system.

[0012] The invention will now be described in more detail with reference to the accompanying drawing which illustrates schematically an advantageous embodiment of a compressor that includes a water circulation system to which a system for cleaning external water is connected.

[0013] Figure 1 shows a rotary screw compressor 1 driven by a motor M. The compressor 1 includes two mutually co-acting helical screw rotors mounted in a working chamber 2. A low-pressure gas, normally air, is delivered to an inlet channel 27 and passes therefrom into the working chamber 2 of the compressor 1, through an inlet port 3. The gas is compressed by the compressor 1 and leaves through an outlet port 4 connected to an outlet channel 5.

[0014] The compressor 1 is of the water-flow type, meaning that water is supplied to the compressor 1 at least for cooling, sealing and lubricating the rotors and the working chamber 2. Water is injected into the chamber 2 through an opening 6. The outlet channel 5 has provided therein a water separator 7 in which water is separated from the compressed gas and returned to the working chamber 2 through a conduit 8 and via the inlet opening 6. The compressed, water-depleted gas is taken out from the separator 7 through an outfeed channel 9.

[0015] The separator 7 includes a water separating element 10, preferably a mechanical element such as a cyclone, for instance. The water separated from the gas by the separating element 10 is collected on the bottom of a casing surrounding said element.

[0016] Excess water is carried away by a drainage conduit 11 connected to the water separator 7 or by the conduit 8 that connects the separator 7 to the compressor working chamber 2. The drainage conduit 11 includes a valve 18 which is controlled and actuated by a control device 6. The water separator 7 includes a level sensor 12, which is adapted to sense the presence of water at the highest permitted water level in the separator 7. The sensor 12 is connected to the control device 16 over a control unit 14.

[0017] The water separator 7 also includes a second level sensor 13 which is adapted to sense the presence of water at the lowest permissible water level in the separator 7. This sensor 13 is connected to an electric con-

trol device 17 over a second control unit 15.

[0018] The inventive arrangement also includes a steam generator 19. Steam is delivered to the compressor 1 to replace water carried away with the compressed gas, when the steam contains more water per unit of weight than the supplied gas. The steam generator 19 is connected to a water source 21, via a control and metering unit 20. The metering unit 20 functions to supply water to the steam generator 19 when actuated. A conduit 26 connects the water source 21 with the control-and-metering unit 20 which, in turn, is connected with a water inlet port 28 of the steam generator 19 by means of a conduit 22. The steam generator 19 includes a casing in which there is maintained a variable water level, which includes a lowest permitted level. A level sensing and indicating device 23 is provided in the steam generator 19. This sensing and indicating device is connected to the control-and-metering unit 20.

[0019] The steam generator 19 also includes a steam generating element 24, e.g. an electric immersion heater. The energy supplied to the steam generating element 24 is controlled by the electric control device 17.

[0020] Provided in the upper part of the steam generator 19, above a highest water level, is an outlet port 26 which is connected by a steam conduit 25 to the low-pressure gas inlet channel of the compressor 1.

[0021] When the compressor 1 is working, gas, preferably air, is supplied to the inlet channel 27 and into the working chamber 2 via the inlet port 3. The air compressed in the working chamber leaves compressor 1 through the outlet port 4 and is conducted to a cyclone 10 in the water separator 7, through the conduit 5. Water is collected in the lower part of the separator 7 while the air from which water has been extracted collects in the upper part of said separator. The air is taken from the separator through the conduit 9, whereas the water leaves the separator 7 through the conduit 8 and is injected into the working chamber 2 of the compressor 1 through the opening 6. The valve 18 in the drainage conduit 11 is closed.

[0022] When the air delivered to the compressor 1 has a high water content (amount of water per unit of weight air), i.e. a greater water content than the compressed air leaving through the conduit 9, water is delivered to the system and accumulates in the separator 7. The water level in the separator 7 will then rise. When the water level reaches the level of the sensor 12 that detects the highest permitted water level in the separator 7 a signal is sent from the level sensor 12 to the control unit 14. The control unit 14 then actuates the control device 16 which causes the valve 18 in the drainage conduit 11 to open for a predetermined period of time, after which the valve is closed. The water level in the separator is then brought to a level that is higher than the lowest permitted level.

[0023] When the air delivered to the compressor 1 has a low water content (amount of water per unit of weight air), i.e. lower than the water content of the compressed

air leaving through the conduit 9, the water present in the system will decrease as a result of water being continuously carried away. The water carried away from the system must be replaced with external water. According to the invention, water is delivered from the external source 21 to the control-and-metering unit 20 and from there to the steam generator 19.

[0024] Because more water is taken from the separator 7 than that contained in the air delivered to the compressor 1, the water level in the separator 7 will fall. When the water level has reached the level of the sensor 13 that detects the lowest permitted water level in the separator 7, the sensor 13 sends a signal to the electric control device 17. The control device 17 actuates the element 24 which then generates heat to convert the water in the steam generator 19 to steam. The steam leaves the generator 19 through the outlet port 26 and flows into the inlet channel 27 of the compressor 1, through the conduit 25. The steam accompanies the incoming air into the compressor and therewith increases the water content of the air.

[0025] As steam leaves the generator 19, the water level will fall in said generator. When the water level has reached the level of the sensor 23 that detects the lowest permitted water level in the generator, a signal is sent from the sensor 23 to the control-and-metering unit 20, which then dispenses water to the generator 19.

[0026] Since the generator 19 is dimensioned so that the amount of steam delivered to the compressor 1 is greater than that required to maintain a status quo, the water level in the separator 7 will rise. The generator 19 preferably generates steam over a given period of time during which the water level in the separator 7 rises, and is cut-off automatically when said level has reached above the lowest permitted water level. After the generator 19 has been shut down, the water level in the separator 7 will fall if the water content of the air supplied is constantly too low for equilibrium to prevail. When the water level has again fallen to the level of the sensor 13, the generator 19 will be re-activated. If the water content of the supplied air is now greater than the amount required to establish equilibrium, the water level in the separator will rise. When the water level has reached the level of the sensor 12, the valve 18 will be caused to open for a period of time required to lower the water level.

[0027] By water level is meant a level interval that depends on the physical size of the sensor used.

[0028] It will be understood that the water level in the separator 7 can be controlled also by other methods. For instance, the control device 17 can be actuated by the sensor 12 and the control unit 14, so that the supply of energy to the electric immersion heater 24 will be switched off when the highest permitted level is reached in the separator, instead of opening the valve 18. If this fails to lower the water level in the separator 7 within a given time period, the valve 18 can be caused to open for said determined time interval.

Claims

1. A rotary screw compressor (1) having a working chamber (2) for mutually co-acting rotors, gas inlet means (3, 27), compressed gas outlet means (4, 5), and a water circulation system that includes the compressor working chamber (2), a device (7) connected to the compressor outlet means and functioning to separate water from the compressed gas, and injection means (6, 8) for transferring water from the separator (7) to the working chamber (2), **characterized by** means (19, 26, 25, 28) for delivering steam to the water circulation system. 5
2. A compressor according to Claim 1, **characterized in that** the steam delivery means (19, 16, 25, 28) includes a water inlet port (28) that is connected to a water source (21) and a vaporizer (19) for vaporizing the delivered water. 10
3. A compressor according to Claim 2, **characterized in that** the vaporizer (19) includes an electric heating device (24). 15
4. A compressor according to one or more of Claims 1-3, **characterized in that** the steam delivery means (19, 26, 25) is connected to the inlet port (3) of said compressor. 20
5. A compressor according to Claim 2, **characterized by** a water delivery device (20) which is arranged upstream to the water inlet port (28) and which is actuable by a water level sensor (23) in said steam delivery means (19, 26, 25, 28). 25
6. A compressor according to one or more of Claims 2, 3 or 5, **characterized by** an energy source connected to said heating device (24), a control device (17) which controls the energy supply to the heating device (24) in response to signals received from a level sensor (13) in the separator (7). 30
7. A compressor according to Claim 5 or 6, **characterized in that** the water delivery device (20) functions to dispense a given quantity of water to the steam generating device (19). 35

Patentansprüche

1. Rotationsschraubenverdichter (1), der eine Arbeitskammer (2) für gegenseitig zusammenwirkende Rotoren, Gaseinlaßmittel (3, 27), Auslaßmittel (4, 5) für verdichtetes Gas und ein Wasserkreislaufsystem aufweist, das die Arbeitskammer (2) des Verdichters, eine Vorrichtung (7), die an die Verdichterauslaßmittel angeschlossen ist und zum Abscheiden von Wasser aus dem verdichteten Gas dient, 40

und Einspritzmittel (6, 8) zum Übertragen von Wasser aus dem Abscheider (7) zu der Arbeitskammer (2) umfaßt, **gekennzeichnet durch** Mittel (19, 26, 25, 28) zum Liefern von Dampf an das Wasserkreislaufsystem. 45

2. Verdichter nach Anspruch 1, **dadurch gekennzeichnet, daß** die Dampfliefermittel (19, 26) einen Wassereinlaß (28), der mit einer Wasserquelle (21) verbunden ist, und einen Verdampfer (19) zum Verdampfen des gelieferten Wassers umfassen. 50
3. Verdichter nach Anspruch 2, **dadurch gekennzeichnet, daß** der Verdampfer (19) eine elektrische Heizvorrichtung (24) besitzt. 55
4. Verdichter nach einem oder mehreren der Ansprüche 1 bis 3, **dadurch gekennzeichnet, daß** die Dampfliefermittel (19, 26, 25) mit der Einlaßöffnung (3) des Verdichters verbunden sind. 60
5. Verdichter nach Anspruch 2, **dadurch gekennzeichnet, daß** die Wasserliefervorrichtung (20) stromaufwärts des Wassereinlasses (28) liegt und durch einen Wasserniveausensor (23) in den Dampfliefermitteln (19, 26, 25, 28) auslösbar ist. 65
6. Verdichter nach einem oder mehreren der Ansprüche 2, 3 oder 5, **gekennzeichnet durch** eine Energiequelle, die mit der Heizvorrichtung (24) verbunden ist, und eine Steuervorrichtung (17), die die Energiezufuhr zu der Heizvorrichtung (24) in Abhängigkeit von Signalen steuert, die von einem Niveausensor (13) in dem Abscheider (7) empfangen werden. 70
7. Verdichter nach Anspruch 5 oder 6, **dadurch gekennzeichnet, daß** die Wasserliefervorrichtung (20) dazu dient, eine gegebene Menge an Wasser an die Dampferzeugungsvorrichtung (19) abzugeben. 75

Revendications

1. Compresseur à vis rotative (1) ayant une chambre de travail (2) pour des rotors coopérant réciproquement, des moyens d'entrée de gaz (3, 27), des moyens de sortie de gaz comprimé (4, 5) et un système de circulation d'eau qui comprend la chambre de travail du compresseur (2), un dispositif (7) relié aux moyens de sortie du compresseur et fonctionnant pour séparer l'eau du gaz comprimé et des moyens d'injection (6, 8) pour transférer l'eau du séparateur (7) à la chambre de travail (2), **caractérisé par** des moyens (19, 26, 25, 28) pour fournir de la vapeur au système de circulation d'eau. 80

2. Compresseur selon la revendication 1, **caractérisé en ce que** les moyens de fourniture de vapeur (19, 16, 25, 28) comprennent un orifice d'entrée d'eau (28) qui est relié à une source d'eau (21) et un évaporateur (19) pour vaporiser l'eau fournie. 5
3. Compresseur selon la revendication 2, **caractérisé en ce que** l'évaporateur (19) comprend un dispositif de chauffage électrique (24). 10
4. Compresseur selon une ou plusieurs des revendications 1-3, **caractérisé en ce que** les moyens de fourniture de vapeur (19, 26, 25) sont reliés à l'orifice d'entrée (3) dudit compresseur. 15
5. Compresseur selon la revendication 2, **caractérisé par** un dispositif de fourniture d'eau (20) qui est disposé en amont de l'orifice d'entrée d'eau (28) et qui est actionnable par un capteur de niveau d'eau (23) dans lesdits moyens de fourniture de vapeur (19, 26, 25, 28). 20
6. Compresseur selon une ou plusieurs des revendications 2, 3 ou 5, **caractérisé par** une source d'énergie connectée audit dispositif de chauffage (24), un dispositif de commande (17) qui commande l'alimentation d'énergie au dispositif de chauffage (24) en fonction de signaux reçus d'un capteur de niveau (13) dans le séparateur (7). 25 30
7. Compresseur selon la revendication 5 ou 6, **caractérisé en ce que** le dispositif de fourniture d'eau (20) fonctionne pour distribuer une quantité d'eau déterminée au dispositif de production de vapeur (19). 35

40

45

50

55

