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Screw compressor and method of operation thereof.

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DE-A- 2 853 264
FR-A- 2 603 666
GB-A- 1 413 426
US-A- 3 535 057

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Description

The invention relates to a screw compressor with two parallel screws engaging with each other, one of which is driven while the other is carried, surrounded by a stator housing and provided with an inlet for the gas to be compressed and an outlet for the compressed gas, said stator housing also having an injection point through which water is directly injected into the stator housing, and to a method of operation thereof.

Such a compressor and method is known from US Patent Specification 3,535,057, in the embodiment described in Col. 6, lines 27 - 38, i.e. the embodiment without mechanical coupling between the two rotors.

In the known compressor and method, water only is injected at one point, i.e. near the outlet for the compressed gas.

The purpose of the water injection is to lower the temperature of the compressed gas and make it as far as possible the same as the inlet temperature of the gas, in particular air.

It is not stated anywhere in this patent specification that, due to the injection of water, the mechanical coupling between the rotors can also be omitted. Nor are any instructions given concerning the quantity of water to be injected and its temperature.

This suggestion, which was already made in 1968, has never been successful in practice. In practice, compressors working without mechanical coupling virtually all have oil injection. This oil is then used for lubricating, sealing and cooling of the compressor. After compression, this oil must be carefully removed from the compressed gas, generally air, using expensive oil separators, because the presence of oil in any kind of pneumatic device is disastrous.

A so-called oil-free compressor therefore has great advantages, but no practical embodiments are known in practice.

The object of the invention is to produce a compressor and a method of operation thereof by means of which it is in fact possible to obtain isothermal compression economically with water injection alone, provided that a number of conditions are met.

The screw compressor according to the invention is characterized in that said injection point is located at a place in the stator housing where the pressure is equal to $2\sqrt[3]{P}$ plus or minus 0.5 bar, and in that further injection points are provided at a place in the stator housing where the pressure is equal to $\sqrt[3]{P}$ plus or minus 0.5 bar and at the inlet side of the gas, P being equal to the absolute final pressure of the compressor.

The water therefore has to be injected simultaneously at several, very specific points.

The method according to the invention is charac-

terized in that the quantity of water injected per unit time is 1% and 2% of the capacity of the compressor, and the temperature of the injected water is at least 5 K lower than the temperature of the gas at the inlet of the compressor.

Through these measures a considerable improvement is obtained in the power which is needed to drive the compressor.

It is remarked that from DE-A-2801408 a compressor is known similar to that of the present invention whereby cooling fluid is injected directly into the compressor chamber. However in this case not water is used but a mixture of oil and coolant.

The invention will be explained in greater detail with reference to schematic drawings, in which:

Fig. 1 is a longitudinal section of a conventional screw compressor, in which one screw or rotor is driven and the other is carried;

Fig. 2 is a view from the rear end of Fig. 1.

The compressor, which is conventional per se, comprises a screw 1 with a driving shaft 2.

A screw 3 is in engagement with said screw 1 and in operation is carried by the screw 1. There is no mechanical coupling between the two screws or rotors.

The screws 1 and 3 are supported in and enclosed by a stator housing 4.

The gas to be compressed is fed in at the left-hand side of the housing 4, through a transverse feed 5 (see Fig. 2).

The compressed gas is discharged at the right-hand side of the housing 4, through an axial outlet 6.

In order to ensure an essentially isothermal compression of the gas, generally air, water is injected into the interior of the compressor. This water serves not only for cooling of the gas, but also for lubrication of the contact faces of the rotors 1 and 3.

In the compressor known from US Patent Specification 3,535,057, this water is injected only at the outlet side of the rotors. In the compressor according to the invention water is injected at different, and at several, places.

According to the invention, an injection point is located at point A. This injection point A is directed towards the contact face of the rotors 1 and 3.

Viewed in the lengthwise direction of the compressor, point A lies at a place where the pressure is equal to $2\sqrt[3]{P}$ plus or minus 0.5 bar, P being equal to the absolute final pressure at the compressor outlet.

Water is also injected at points B and C.

Viewed in the lengthwise direction of the compressor, the two points B lie at a place where the pressure is equal to $\sqrt[3]{P}$ plus or minus 0.5 bar.

The two points C lie at a place where the pressure is equal to the inlet pressure.

It can be seen from the drawings that the two

points B and the two points C always lie on either side of the plane in which point A is situated. Points B and C are also preferably slanted outwards.

Apart from the place of the injection points, in particular the quantity of injected water and the temperature thereof are of essential importance for the invention.

The injected quantity of water per unit time must lie between 1% and 2% of the capacity of the compressor. As regards the distribution of the quantity of water per injection point, according to the invention approximately 50% of the total quantity of water must be injected in point A, approximately 20% in each point B, and approximately 5% in each point C.

The temperature of the injected water is also of essential importance and must be at least 5 K lower than the temperature of the gas sucked in.

The example taken is a compressor with an absolute pressure of 7 bar and a speed of 6,475 r.p.m.

With oil injection the power at the shaft 2 is 8.33 kW/m³/min.

With injection of water in the same compressor in a quantity of 1% - 2% of the compressor capacity and at a temperature which is at least 5 K lower than the temperature of the gas sucked in, the shaft power is 7.38 kW/m³/min.

In a compressor with the proposed distribution of the injection points, the shaft power is 6.03 kW/m³/min.

By comparison with the oil compressor, a saving of approx. 27% is thus achieved.

Claims

1. Screw compressor with two parallel screws (1,3) engaging with each other, one of which (1) is driven while the other (3) is carried, surrounded by a stator housing (4) and provided with an inlet (5) for the gas to be compressed and an outlet (6) for the compressed gas, said stator housing (4) also having an injection point through which water is directly injected into the stator housing (4), characterized in that said injection point is located at a place (A) in the stator housing (4) where the pressure is equal to $2\sqrt[3]{P}$ plus or minus 0.5 bar, and in that further injection points (B and C) are provided respectively at a place in the stator housing (4) where the pressure is equal to $\sqrt[3]{P}$ plus or minus 0.5 bar and at the inlet side of the gas, P being equal to the absolute final pressure of the compressor.
2. Screw compressor according to claim 1, characterized in that the first-mentioned injection point (A) is directed towards the contact face between the two screws (1,3) and the remaining injection

points (B and C) are arranged in two groups of two and slant outwards.

3. Method of operating a screw compressor as claimed in claim 1 characterized in that the quantity of water injected per unit time is 1% - 2% of the capacity of the compressor, and the temperature of the injected water is at least 5 K lower than the temperature of the gas at the inlet (5) of the compressor.
4. Method according to claim 3, characterized in that the quantity of water injected in the first-mentioned injection point (A) is approximately 50% of the total quantity of injected water, in each of the set of injection points (B) located at $\sqrt[3]{P}$ plus or minus 0.5 bar it is approximately 20%, and in each of the set of injection points (C) located at the inlet side approximately 5%.

Patentansprüche

1. Schraubenverdichter mit zwei zueinander parallelen und aneinander angreifenden Schrauben (1, 3), von denen die eine (1) angetrieben wird, während die andere (3) mitgenommen wird, umgeben von einem Statorgehäuse (4) und versehen mit einem Einlaß (5) für das zu verdichtende Gas, sowie mit einem Auslaß (6) für das verdichtete Gas versehen sind, wobei das Statorgehäuse (4) außerdem einen Einspritzpunkt aufweist, durch den Wasser direkt in das Statorgehäuse (4) eingespritzt wird, dadurch gekennzeichnet, daß sich der Einspritzpunkt an einer Stelle (A) in dem Statorgehäuse (4) befindet, wo der Druck $2\sqrt[3]{P}$ plus oder minus 0,5 bar beträgt, und daß weitere Einspritzpunkte (B und C) jeweils an einer Stelle in dem Statorgehäuse (4) vorgesehen sind, wo der Druck $\sqrt[3]{P}$ plus oder minus 0,5 bar ist bzw. an der Einlaßseite des Gases, wobei P der absolute Enddruck des Verdichters ist.
2. Schraubenverdichter nach Anspruch 1, dadurch gekennzeichnet, daß der erstgenannte Einspritzpunkt (A) in Richtung auf die Kontaktfläche zwischen den beiden Schrauben (1, 3) gerichtet ist und die übrigen Einspritzpunkte (B und C) in zwei Gruppen von je zwei angeordnet und schräg nach außen gerichtet sind.
3. Verfahren zum Betreiben eines Schraubenverdichters nach Anspruch 1, dadurch gekennzeichnet, daß die Menge des pro Zeiteinheit eingespritzten Wassers 1 % bis 2 % der Kapazität des Ver-

dichters beträgt und die Temperatur des eingespritzten Wassers wenigsten 5 K niedriger als die Temperatur des Gases am Einlaß (5) des Verdichters ist.

4. Verfahren nach Anspruch 3, dadurch gekennzeichnet, daß die Menge des eingespritzten Wassers an dem erstgenannten Einspritzpunkt (A) ca. 50 % der Gesamtmenge des eingespritzten Wassers beträgt, an jedem des Satzes der bei $\sqrt[3]{P}$ plus oder minus 0,5 bar liegenden Einspritzpunkte (B) ca. 20 % beträgt und an jedem des Satzes der an der Einlaßseite liegenden Einspritzpunkte (C) ca. 5 % beträgt.

tale d'eau injectée, dans chaque groupe de points d'injection (B) situé à $\sqrt[3]{P}$ plus ou moins 0,5 bar elle est d'environ 20 %, et dans chaque groupe de points d'injection (C) situé sur le côté d'entrée elle est de 5 % environ.

Revendications

1. Compresseur à vis avec deux vis parallèles (1,3) s'engageant mutuellement, l'une (1) étant entraînée tandis que l'autre (3) est supportée, entourée par un logement de stator (4) et dotée d'une entrée (5) pour le gaz à comprimer et d'une sortie (6) pour le gaz comprimé, ledit logement de stator (4) comportant également un point d'injection par lequel de l'eau est directement injectée dans le logement de stator (4), caractérisé en ce que ledit point d'injection est situé en un emplacement (A) dans le logement de stator (4) où la pression est égale à $2 \sqrt[3]{P}$ plus ou moins 0,5 bar, et en ce que d'autres points d'injection (B et C) sont situés respectivement en un emplacement dans le logement de stator (4) où la pression est égale à $\sqrt[3]{P}$ plus ou moins 0,5 bar et sur le côté d'entrée du gaz, P étant égal à la pression finale absolue du compresseur.
2. Compresseur selon la revendication 1, caractérisé en ce que le premier point d'injection mentionné (A) est dirigé vers la face de contact entre les deux vis (1,3) et les points d'injection restants (B et C) sont agencés en deux groupes de deux et inclinés vers l'extérieur.
3. Procédé de fonctionnement d'un compresseur à vis selon la revendication 1, caractérisé en ce que la quantité d'eau injectée par unité de temps est comprise entre 1 % et 2 % de la capacité du compresseur, et la température de l'eau injectée est au moins inférieure de 5 K à la température du gaz à l'entrée (5) du compresseur.
4. Procédé de fonctionnement selon la revendication 3, caractérisé en ce que la quantité d'eau injectée dans le premier point d'injection mentionné (A) est égale à environ 50 % de la quantité to-

fig - 1

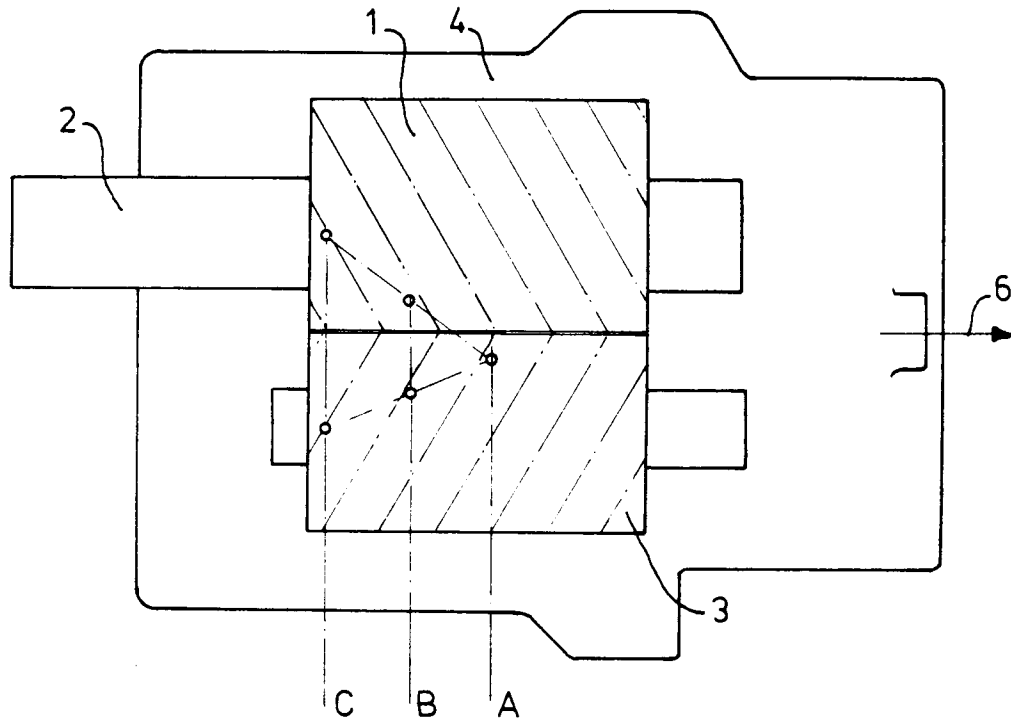


fig - 2

