Cooling system for reciprocating compressors comprising an atomizing nozzle (1) that supplies an atomized lubricating fluid inside the compressor cylinder (2), a heat exchanger (6) intended for cooling the lubricating fluid to be atomized at the nozzle (1), a fluid separator (5) for separating a mixture of cooling fluid and lubricating fluid and directing the lubricating fluid back from the system, and a blocking element (7) arranged between the atomizing nozzle (1) and the heat exchanger (6) to prevent the buildup of lubricating fluid in the cylinder. Reciprocating compressor having the cooling system as described.
COOLING SYSTEM FOR RECIPROCATING COMPRESSORS AND A RECIPROCATING COMPRESSOR

FIELD OF THE INVENTION

[0001] The present invention relates to a cooling system for compressors, and, more particularly, to a cooling system for alternating compressors. The present invention also relates to an alternating compressor having a cooling system.

BACKGROUND OF THE INVENTION

[0002] It is the function of a compressor to increase the pressure of a certain fluid volume to a pressure required for carrying out a certain work. For the refrigeration industry, the more used compressors are the alternating-type compressors. It is the function of these compressors to suck a cooling fluid at a low pressure and compress it towards the condenser at a high pressure and high temperature.

[0003] Alternating compressors are those wherein a certain driving mechanism provides an alternating motion to a piston inside a cylinder (such a mechanism may comprise, for example, a rod-lever system). Thus, the piston moves alternately inside a cylinder, and suction and discharge valves are provided to allow the suction and discharge of the cooling fluid.

[0004] The cooling of the compressor has a significant impact on the thermodynamic performance thereof. A great part of a compressor inefficiency is associated with the overheating of the cooling fluid that takes place along the suction path (located between the suction conveyor and the compressor cylinder). Another part, equally important, of a compressor inefficiency is associated with the heating of the cooling fluid during its compression.

[0005] The heating of the coolant in the suction path is caused by the heat exchanges with the compressor components that are at higher temperatures than that of the cooling fluid. On the other hand, the heating of the cooling fluid in the process of compression takes place mainly due to the work carried out by the piston, and also the heat transfer through the cylinder and piston walls at the beginning of the compression.

[0006] The overheating in the suction path reduces the volumetric efficiency of the compressor, since it increases the particular volume of the cooling fluid admitted into the compression chamber. In addition, the higher temperature at the start of the compression process also implies a major particular compression work, reducing the energy efficiency of the compressor.

[0007] In addition to the inefficiencies caused by the heating of the coolant during the compression, the coolant heated during its compression is a major source of heat for the compressor, and it is the main cause of the heating of the compressor other components, which, as a consequence, will heat the coolant along the suction path.

[0008] In view of the foregoing, it becomes apparent that the cooling of the coolant during the compression process thereof would have a positive impact on the compression efficiency and, as a consequence, would allow the decrease in the losses due to the overheating of the coolant during suction.

OBJECTS OF THE INVENTION

[0009] In view of the foregoing, it is one of the objects of the present invention to provide a cooling system for alternating compressors that is able to draw heat from the compressor cooling fluid during the compression process, decreasing its temperature and its specific volume.

[0010] It is another object of the present invention to provide a cooling system for alternating compressors that allows for a decrease in the temperature levels of the compressor during its operation.

[0011] It is still another object of the present invention to provide a cooling system for compressors that improves the volumetric efficiency and the energy efficiency of the compressor.

SUMMARY OF THE INVENTION

[0012] The present invention achieves these and other objects through a cooling system for an alternating-type compressor comprising a housing and a compression chamber inside the housing, the system comprising:

[0013] an atomizing nozzle, which provides an atomized lubricating fluid inside the compressor cylinder;

[0014] a heat exchanger designed to cool the lubricating fluid that will be atomized at the nozzle;

[0015] a fluid separator to separate a mixture of cooling fluid and lubricating fluid and direct the lubricating fluid back from the system; and

[0016] a blocking element for preventing the buildup of lubricating fluid inside the cylinder.

[0017] The blocking element may be arranged, for example, between the atomizing nozzle and the heat exchanger, or even integrated into the atomizing nozzle.

[0018] In the preferred embodiment of the present invention, the blocking element is a blocking valve that remains open during the compressor operation and is closed after it is turned off. However, the blocking element may comprise other types of device, such as, for example, an electric blocking element or an electronic blocking element.

[0019] In addition, the blocking element may be arranged inside the compressor housing, very close to the compressor cylinder.

[0020] In the preferred embodiment of the present invention, the fluid separator receives a mixture of cooling fluid and lubricating fluid discharged from the compression chamber and directs the lubricating fluid back to the heat exchanger.

[0021] However, in one embodiment of the present invention, the lubricating fluid separator and the heat exchanger may be in a mutually inverted position, wherein the fluid separator receives the mixture of cooling fluid and lubricating fluid from the heat exchanger.

[0022] Also, in yet another embodiment of the present invention, the lubricating fluid separator and the heat exchanger may comprise a single component, and such component may be arranged inside or outside the compressor housing.

[0023] In one embodiment of the present invention, the lubricating fluid separator and the heat exchanger are arranged outside the housing.

[0024] In yet other embodiments, the lubricating fluid separator and the heat exchanger are arranged inside the housing, making the assembly more compact.

[0025] The injecting nozzle may be arranged such that its dispensing end touches lightly the side wall of the compressor cylinder block, or such that the injecting nozzle dispensing end is arranged in the compressor valve plate.
BRIEF DESCRIPTION OF THE DRAWINGS

[0026] The figures show:
[0027] FIG. 1 illustrates a first embodiment of refrigerating system of the present invention;
[0028] FIG. 2 illustrates a second embodiment of the refrigerating system of the present invention;
[0029] FIG. 3 illustrates a third embodiment of the refrigerating system of the present invention;
[0030] FIG. 4 illustrates a fourth embodiment of the refrigerating system of the present invention;
[0031] FIG. 5 illustrates a fifth embodiment of the refrigerating system of the present invention; and
[0032] FIG. 6 illustrates a sixth embodiment of the refrigerating system of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0033] The present invention will be described in further detail below based on the performance examples shown in the drawings. The figures illustrate six alternative embodiments of the refrigerating system of the present invention.

[0034] In the embodiments illustrated in the figures, the refrigerating system is applied to an alternating compressor 10 of the type comprising a housing 11 and a compression chamber 2 arranged inside the housing. The main components of compressor 10 are those of a conventional alternating compressor known by those skilled in the art, and, therefore, the operation and specific construction of these components will be described as long as such description is necessary to the understanding of the cooling system of the present invention. While the drawings show a compressor wherein the piston driving mechanism is of the rod-lever type, any person skilled in the art will understand that another device that provides the piston alternating motion may be also employed within the inventive concept of the present invention.

[0035] The cooling system of the present invention contemplates the atomization of the lubricating fluid inside the cylinder, and this fluid must be atomized at the lowest possible temperature.

[0036] Thus, the system of the present invention primarily comprises an atomizing nozzle 1, which supplies an atomized lubricating fluid inside the compressor cylinder, a heat exchanger 6 designed to cool the lubricating fluid, which will be atomized at nozzle 1, a lubricating fluid separator 5, which receives the mixture of cooling fluid and lubricating fluid discharged from the compressor and directs the separated lubricating fluid back to the heat exchanger, and a blocking element 7, the function of which is to prevent the build-up of lubricating fluid in the cylinder when the compressor is turned off.

[0037] In the preferred embodiment of the present invention, blocking element 7 is a blocking valve, however, another suitable type of blocking element could be equally utilized, such as, for example, a mechanically or electrically-driven blocking element, an electrically-driven blocking system, an electronically driven blocking system or a magnetically driven blocking element.

[0038] In that direction, an electrically or electronically driven blocking element may be designed so as to use the information from the compressor electric engine, such as, for example, a driving current. Similarly, in compressors that apply on board electronics—as in variable speed compressors—the electronics required to control the blocking element may be integrated with the compressor electronics.

[0039] The blocking element of the system of the present invention may be located, for example, between the atomizing nozzle 1 and heat exchanger 6, or it may be integrated into injecting nozzle 1. In the latter case, the atomizing nozzle itself, with an integrated blocking element, could block the flow when necessary.

[0040] Further, while in FIGS. 1 to 6 the blocking element is shown as a part external to the compressor housing 11, such element could be inside this housing. This particularly advantageous possibility allows the blocking element to be arranged very close to the compressor cylinder, thus reducing the oil volume between the cylinder and the blocking element. Since, when turning off the compressor, the oil contained in this volume ends up going to the cylinder, this reduction in the volume has a quite positive impact.

[0041] The system of the present invention allows for a decrease in the overall heating of the compressor and achieves a decrease in the temperature of the coolant during the entire compression cycle.

[0042] Thus, in the first embodiment of the present invention, atomizing nozzle 1, connected to a lubricating fluid feed line 8, is positioned inside housing 11, with its hole (or its dispensing end) touching lightly the cylinder inner wall, such that the lubricating fluid is atomized inside the cylinder in the period of the compression cycle during which the piston is not covering the hole.

[0043] As the atomized lubricating fluid droplets exhibit a large surface area, the potential for heat exchange with the cooling fluid during compression is significant, reducing the increase in the coolant vapor temperature during its compression.

[0044] To assure the atomization of the lubricating fluid at the lowest possible temperature, atomizing nozzle 1 is connected to heat exchanger 6, which, in the embodiment illustrated in FIG. 1, is located outside housing 11.

[0045] Between atomizing nozzle 1 and heat exchanger 6 is a blocking element 7, such as, for example, a blocking valve 7, which remains open during the compressor operation and is closed after the same is turned off.

[0046] After reaching the discharge pressure, the lubricating fluid, along with the cooling fluid, is discharged from the compression chamber through a discharge valve 3 and follows a discharge line 4.

[0047] The lubricating fluid separator 5 is connected to discharge line 4 and to heat exchanger 6, so that the lubricating fluid from the discharge line is separated from the cooling fluid and directed towards the heat exchanger, starting the cycle again.

[0048] FIG. 2 provides one embodiment similar to that of FIG. 1, the lubricating fluid separator 5 being arranged inside housing 11 of compressor 10. Thus, in this embodiment, the cooling fluid, along with the lubricating fluid, is discharged from the compression chamber through discharge valve 3, following discharge line 4, lubricating fluid separator 5 being positioned in the inner discharge line of compressor 10. This embodiment, apart from providing a more compact structure than that illustrated in FIG. 1, causes separator 5 to act as a pressure attenuator, filtering the pressure pulses generated during the coolant discharge. Also, since heat exchanger 6 remains outside the compressor, the heat exchange efficiency is preserved.
FIG. 3 depicts a third alternative embodiment of the present invention, wherein both lubricating oil separator 5 and heat exchanger 6 are located inside housing 11 of compressor 10.

In this embodiment, the lubricating fluid feed line 8 and blocking element 7 also remain inside compressor 10, being arranged inside housing 11. It should be noted that this embodiment allows for compressor construction extremely compact.

In the embodiment illustrated in FIG. 3, heat exchanger 6 is submerged in the compressor crankcase oil. This configuration increases the oil temperature in the crankcase, which may have an additional effect on the increase of the compressor efficiency. The reason for this is that, with the injection of cold oil droplets in the cylinder and the subsequent cooling of the compressed gas, the expected result is an overall reduction in the compressor temperature levels. This reduction in temperature will cause an increase in the oil viscosity, increasing the mechanical losses. Upon placing the heat exchanger in the oil, part of this problem is compensated for, by supplying part of the heat directly removed from the compression gas to the oil in the crankcase, and, thus, part of the losses added up by the increase in viscosity is recovered.

FIG. 4 illustrates a fourth embodiment of the present invention, where injecting nozzle 1 is positioned on the compressor 10 valve plate. This construction allows the oil to be atomized at any moment in the compressor compression cycle, and not only during one period of the compression cycle, as foreseen in the embodiments of FIGS. 1 to 3. This embodiment is particularly convenient when there is a low solubility of the cooling fluid in the lubricating fluid, or when a highly efficient separator is used to separate the lubricating fluid from the cooling fluid.

It will be appreciated that, while FIG. 4 illustrates an embodiment where separator 5 and heat exchanger 6 are outside housing 11, the arrangement of the injecting nozzle foreseen in this embodiment could be used with these parts inside the compressor, as in the embodiments illustrated in FIGS. 2 and 3.

FIG. 5 illustrates a fifth embodiment of the present invention, where separator 5 and heat exchanger 6 comprise a single component the function of which is both of a separator and a heat exchanger.

Thus, as illustrated in this Figure, this single component may comprise a heat separator with a heat dissipating element (e.g., vanes), which removes from the oil the heat obtained in the compression process. Naturally, other constructions may be equally used, such as, for example, a coil-shaped heat exchanger arranged around the separator.

In addition, while the single component is shown outside compressor housing 11, such part could be housed inside housing 11, as foreseen in the embodiments in FIGS. 3 and 4.

FIG. 6 illustrates still another embodiment of the present invention, where heat exchanger 6 and separator 5 are positioned, considering the circuit as formed, in an inverted manner to that shown in the previous embodiment, this inverted arrangement allowing the removal of heat before separation.

Naturally, the inverted arrangement shown in FIG. 6 may be combined with the variations described in the previous embodiments, regarding both the atomizing nozzle position and the possibility of positioning the component parts inside housing 11.

By means of the described system, the present invention allows for the achievement of improvements in the reliability and performance of the compressor.

Regarding reliability, the lowering of the compressor thermal profile caused by the atomization of the lubricating fluid in the compression chamber avoids critical temperatures at points in the compressor where the oil may undergo degradation and irreversible changes in the thermo-physical properties. With the compressor thermal profile lowered, it is also possible to attenuate the severity of the product approval, wear and robustness tests.

Regarding the performance, in its turn, the advantages provided by the present invention are associated with the increase in the volumetric efficiency and the energy efficiency of the compressor.

With the compressor temperature levels lowered, the overheating of the gas in the suction path decreases, resulting in an increase in the coolant density at the start of the compression process and, thus, in an increase in the amount of mass compressed and pumped by the compressor. Thus, the compressor volumetric efficiency increases, and, for the same pumping capacity, it may be constructed in smaller dimensions.

In addition to the effects on the overheating along the suction path, the oil atomized inside the compression chamber draws heat from the cooling fluid during the compression process, decreasing its temperature and specific volume. Thus, the compression work decreases and the compressor efficiency increases.

As a consequence, as a function of the increase in the pumped mass and the decrease in the specific work, there is an increase in the compressor energy efficiency, usually characterized by the compressor Performance Coefficient (PCO).

Another benefit of the reduction of overheating during the compression process is the decrease in the fluid flow rate in the compressor valves, reducing the energy losses due to the viscous friction and, thus, contributing to the increase in the PCO.

It should be pointed out that, in compressors with low capacity for refrigeration applications, the presence of oil inside the cylinder at the end of the compression process provides an extra benefit since it reduces the amount of coolant in the dead volume, increasing the volumetric efficiency.

Another complementary benefit lies in the better sealing of the clearance between the piston and the cylinder by the oil, which may favor the reduction of the losses inherent in the leak of gas from within the compression chamber.

Eventually, it will be appreciated that description provided based on the figures above relates only to embodiments possible for the system of the present invention, the true scope of the object of the invention being defined in the appended claims.

1. A cooling system for an alternating-type compressor (10), the compressor comprising a housing (11) and a compressor chamber (2) inside the housing (11), CHARACTERIZED IN that it comprises:
   an atomizing nozzle (1), which supplies an atomized lubricating fluid inside the compressor cylinder;
   a heat exchanger (6) designed to cool the lubricating fluid to be atomized at the nozzle (1);
   a fluid separator (5) to separate a mixture of refrigerating fluid and lubricating fluid and direct the lubricating fluid back from the system; and
a blocking element (7) to prevent the build-up of lubricating fluid in the cylinder.

2. A cooling system, according to claim 1, CHARACTERIZED in that the blocking element (7) is arranged between the atomizing nozzle (1) and the heat exchanger (6).

3. A cooling system, according to claim 1, CHARACTERIZED in that the blocking element (7) is integrated to the injecting nozzle (1).

4. A cooling system, according to any of claims 1 to 3, CHARACTERIZED in that the blocking element (7) is a blocking valve.

5. A cooling system, according to any of claims 1 to 3, CHARACTERIZED in that the blocking element is an electronic blocking element.

6. A cooling system, according to any of claims 1 to 3, CHARACTERIZED in that the blocking element is an electronic blocking element.

7. A cooling system, according to any of claims 1 to 6, CHARACTERIZED in that the blocking element (7) is arranged inside the housing (11).

8. A cooling system, according to any of claims 1 to 7, CHARACTERIZED in that the fluid separator (5) receives the mixture of cooling fluid and lubricating fluid discharged from the compression chamber (2) and directs the lubricating fluid back to the heat exchanger (6).

9. A cooling system, according to any of claims 1 to 7, CHARACTERIZED in that the fluid separator (5) receives the mixture of cooling fluid and lubricating fluid from the heat exchanger (6) and directs the lubricating fluid back to the blocking element (7).

10. A cooling system, according to any of claims 1 to 7, CHARACTERIZED in that the lubricating fluid separator (5) and the heat exchanger (6) comprise a single component.

11. A cooling system, according to claim 9, CHARACTERIZED in that the single component is arranged inside the housing (11).

12. A cooling system, according to any of claims 1 to 8, CHARACTERIZED in that the lubricating fluid separator (5) is arranged inside the housing (11).

13. A cooling system, according to any of claims 1 to 8, CHARACTERIZED in that the heat exchanger (6) is arranged inside the housing (11).

14. A cooling system, according to any of claims 1 to 8, CHARACTERIZED in that the lubricating fluid separator (5) and the heat exchanger (6) are arranged inside the housing (11).

15. A cooling system, according to claim 13 or 14, CHARACTERIZED in that the heat exchanger is arranged in the space in the housing (11) intended for storing the lubricating fluid, the heat exchanger (6) being submerged in the lubricating fluid.

16. A cooling system, according to any of claims 1 to 15, CHARACTERIZED in that the injecting nozzle (1) dispensing end touches lightly the sidewall of the compressor (10) cylinder block.

17. A cooling system, according to any of claims 1 to 15, CHARACTERIZED in that the injecting nozzle (1) dispensing end is arranged on the compressor (10) valve plate.

18. An alternating compressor (10), CHARACTERIZED in that it is of the type comprising a cooling system as defined in any of claims 1 to 17.