

A REFRIGERATION CIRCUIT ARRANGEMENT FOR A
REFRIGERATION SYSTEM

Field of the Invention

5 The present invention refers to a refrigeration
circuit arrangement for a refrigeration system of the
type comprising a hermetic compressor mounted in a gas
pumping circuit including a condenser, an evaporator
and a restriction in the refrigerant fluid flow to
10 said evaporator.

Background of the Invention

In the conventional refrigeration systems, the
refrigeration circuit comprises, essentially and
sequentially, a hermetic compressor, a condenser, a
15 pressure reducing element, such as a capillary tube,
and an evaporator.

In this circuit, the hermetic compressor draws low
pressure refrigerant gas, pumping the latter to the
condenser as a heated gas under high pressure. During
20 the passage through the condenser, said gas is
liquefied, losing heat to the environment.

From the condenser, the refrigerant liquid is
conducted, after its pressure has been reduced in the
capillary tube, to the evaporator, where it will reach
25 again the gaseous condition, before being drawn by the
compressor, in order to begin a new cycle.

The change of the refrigerant fluid from the liquid
condition to the gaseous condition during its passage
through the evaporator removes heat from the
30 environment in which is placed the evaporator, cooling
the internal environment of the refrigeration
appliance to which the refrigeration circuit is
associated.

In the refrigeration circuits, the temperatures in the
35 evaporator, the pressures in the compressor and the

- temperature and pressure in the condenser are governed by the capillary tube, which is dimensioned as a function of a given average operational condition of the system. Due to its rigid construction, the capillary tube avoids the operation of the system to be optimized in its several stages (start, regimen operation and stop). The dimensioning of the capillary tube is determined, taking into account its optimum point of performance.
- 10 The optimization of the capillary tube is a function of the room temperature of the installation place of the refrigeration appliance provided with the refrigeration circuit, the temperature of the refrigeration cabinet and the temperature of the condenser of said refrigeration circuit. To each one of these temperatures corresponds a pressure inside the refrigeration system and consequently a load in the compressor. The reduction in the room temperature causes the reduction in all pressures of the system.
- 15 In this condition, the compressor will pump a low amount of gas, reducing its efficiency. An increase in the room temperature means a load increase to the compressor, requiring from the latter an additional capacity, which is necessary to increase the pumping of refrigerant gas to the system. This capacity increase consequently causes the elevation of the compressor temperature, with an eventual reduction of its useful life, higher probability of valve breakdown or even motor burnout.
- 20 Another consequence of room temperature increase, externally to the refrigerated environment, is the increase in the condensation temperature of the gas pumped by the compressor and directed to the condenser. Since the condensation occurs by heat exchange between the condenser and the environment, an
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increase in the room temperature will mean an increase in the condensation temperature of the refrigerant fluid. The condensed refrigerant fluid is conducted to the evaporator at a higher temperature, diminishing the evaporation efficiency and consequently the refrigeration of the environment with which the evaporator exchanges heat.

Moreover, in the conventional refrigeration circuit arrangements, when the temperature of the evaporator reaches a predetermined value and the compressor turns off, the condensed fluid, which is present in a high pressure portion of the system where the condenser is located, migrates to a low pressure portion of said system where is found the evaporator. This migration of the condensed refrigerant fluid to the evaporator, at each condenser stop, causes a decrease in the efficiency of the refrigeration system, with an increase in the energy consumption of said system.

A solution which partially minimizes these problems is the use of compressors with variable speed. Nevertheless, the effectiveness of this solution is partial, since the capillary tube has a constant restriction and, upon increasing the rotation of the rotor, there is a reduction in the suction pressure, consequently reducing the efficiency of the compressor and eventually increasing the mass flow which is not directly proportional to the rotation increase.

Disclosure of the Invention

Thus, it is an objective of the present invention to provide a refrigeration circuit arrangement for a refrigeration system, which obtains maximum efficiency from the compressor without requiring said compressor to operate in limit operational conditions.

A more specific objective of the present invention is to provide a refrigeration circuit arrangement which

permits a constant adjustment of the condensed fluid flow to the evaporator at a temperature close to the nominal condensation temperature, and which considers the refrigeration needs of the environment under refrigeration, as well as the operational conditions of the load imparted to the compressor.

Another objective of the present invention is to provide a refrigeration system with a refrigeration circuit which, when the compressor stops, prevents the heated refrigerant fluid from migrating from the condenser to the evaporator.

The objectives above are attained by a refrigeration circuit arrangement for a refrigeration system including a hermetic compressor, a condenser having an inlet connected to a discharge outlet of the compressor, and an outlet; an evaporator, having an inlet connected to the outlet of the condenser, and an outlet, said arrangement comprising, between the outlet of the condenser and the inlet of the evaporator, a valve of refrigerant fluid flow control, provided with a refrigerant fluid passage, whose cross-section varies during the operation of the hermetic compressor in a manner which is inversely proportional to the variation of the condensation temperature, in order to allow the condensed refrigerant fluid supplied to the evaporator to have a temperature substantially corresponding to a nominal condensation temperature of the system, said refrigerant fluid passage having its cross-section closed, completely interrupting the fluid communication between the condenser and the evaporator when the hermetic compressor turns off.

Brief Description of the Drawings

The invention will be described below, with reference to the attached drawings, in which:

Figure 1 shows, schematically, a refrigeration circuit for a refrigeration appliance, such as a refrigerator, constructed according to the prior art;

Figure 2 shows, schematically, the refrigeration circuit of figure 1, constructed according to the present invention; and

Figure 3 shows, schematically and in a longitudinal sectional view, a valve of refrigerant fluid flow control of the present invention.

10 Best Mode of Carrying Out the Invention

As illustrated in figure 1, a conventional refrigeration system comprises a refrigeration circuit including a hermetic compressor 1, having a discharge outlet 2 and suction inlet 3; a condenser 4 having a gaseous fluid inlet 5, which is operatively connected to the discharge outlet 2 of the hermetic compressor 1, and a condensed fluid outlet 6, which is connected to a capillary tube 7; and an evaporator 8 having a condensed fluid inlet 9 which is operatively connected to the capillary tube 7, and a gas outlet 10 in fluid communication with the suction inlet 3 of the hermetic compressor 1.

In this circuit, low pressure refrigerant gas is drawn by the hermetic compressor 1 and pumped, as a high pressure heated gas, to the condenser 4, where said gas is liquefied, losing heat to the environment. Condensation occurs by heat exchange between the condenser 4 and its external environment.

The passage of the liquefied fluid through the capillary tube 7 reduces the pressure of said gas, before it reaches evaporator 8, wherefrom, after exchanging heat with the internal environment of the refrigerator and in the form of a low pressure gas, it is drawn by the compressor 1, in order to start a new cycle.

According to this construction, the heat exchange efficiency in the condenser 4 is reduced due to the difference between a predetermined condensation nominal temperature and that temperature at which effectively occurs the condensation of the gas pumped to the condenser 4 by compressor 1. This construction further has the deficiencies of compressor overload, as discussed above.

According to the present invention, the refrigeration circuit includes between the condensed fluid outlet 6 of the condenser 4 and the condensed fluid inlet 9 of the evaporator 8, a valve 20 of refrigerant fluid flow control, which automatically and constantly varies the flow rate of the condensed fluid from condenser 4 to the evaporator 8 during the operation of the hermetic compressor 1, between a minimum and maximum value of refrigerant fluid flow, interrupting said fluid communication when the hermetic compressor 1 turns off. This compressor turn-off occurs, for instance, as a function of the temperature in the evaporator 8, when said hermetic compressor 1 is of the type having a temporary turn-off operational condition, which is obtained and maintained while a determined temperature condition is detected in evaporator 8 by means of a temperature sensor provided therein.

Valve 20 of the present invention is constructed in order to vary the flow rate of the condensed refrigerant fluid to the evaporator 8, in a manner inversely proportional to the variation of the condensation temperature of the refrigerant fluid in the condenser 4, allowing the condensed refrigerant fluid conducted to evaporator 8 to reach the latter at a temperature substantially close to a nominal condensation temperature, which is defined considering optimum operational conditions of the refrigeration

system, such as room temperature and cabinet temperature optimum conditions.

The minimum flow rate value of the condensed fluid to evaporator 8 is achieved, in compressors of the ON/OFF type having one or more rotational speeds, as well as in variable speed compressors, when the required condensation temperature is higher than the nominal condensation temperature. This minimum flow rate condition is achieved due to a pressure increase upstream the valve 20, said pressure increase being proportional to an increase in the amount of refrigerant mass of the refrigeration circuit in the condenser 4.

According to the present invention, valve 20 has a valve body 21 which is for example mounted in evaporator 8 and in which is defined a refrigerant fluid passage 22, whose cross-section varies during the operation of the hermetic compressor 1 in a way inversely proportional to the condensation temperature of the refrigerant fluid in the condenser 4, in order to allow the condensed refrigerant fluid supplied to the evaporator 8 to have a temperature which is substantially close to the nominal condensation temperature of the system.

The refrigerant fluid passage 22 is closed when the hermetic compressor 1 turns off, for example as a function of the temperature of evaporator 8.

The valve body 21 further has an opening 23, in permanent fluid communication with the condensed fluid inlet 9 in the evaporator 8.

Inside valve body 21 is defined a valve seat 24, against which is selectively seated a sealing means 25 when the hermetic compressor 1 turns off, said sealing means 25 being operatively associated with the refrigerant fluid passage 22 in order to be directly

and simultaneously submitted to a condensation pressure upstream valve 20 and to a suction pressure downstream valve 20.

The variation in the cross-section of the refrigerant fluid passage 22 between the full closing condition of said refrigerant fluid passage 22, which is obtained with the sealing means 25 seating on the valve seat 24, and each opening condition corresponding to a temperature substantially close to the nominal condensation temperature, results from the balance between the condensation and suction pressures which are simultaneously acting over the sealing means 25 during the operation of the hermetic compressor 1.

The condensation pressure is that necessary to achieve the transformation of the refrigerant fluid to a gaseous form in the condenser 4 and the suction pressure is that obtained by operation of the compressor.

The displacement of the sealing means 25 between the full closing condition and each opening position of the refrigerant fluid passage 22 is defined as a function of a force resulting from the condensation and suction pressures and which causes the cross-section variation of the refrigerant fluid passage 22.

The sealing means 25 has a sealing portion, which is submitted to a condensation pressure and which is defined upstream valve 20, and an impelling portion which is located downstream the valve seat, in order to be sensitive to the suction pressure in this region, said impelling portion being connected to the valve body 21 by means of a spring element 26 constantly forcing the sealing means 25 to the closing condition of the refrigerant fluid passage 22.

According to the illustrations, the impelling portion of the sealing means 25 is adjustably connected to the

spring element 26 by means of an annular connecting means 29, which is mounted in the spring element 26 and in which inside an end portion of the sealing means 25 is displaced against the sealing portion thereof, allowing continuous dampening adjustments is the movement of the sealing means.

According to a constructive option of the present invention, the sealing means 25 is provided in valve 20 thorough the valve seat 24, so that its sealing portion, with a profile mating with the profile of the valve seat 24, seats onto the latter and so that its impelling portion be constantly located inside the valve body 21.

According to the present invention the valve body 21 defines, internally, a chamber 27 for the passage of refrigerant fluid and communicating with the condensed fluid outlet 5 of the condenser 4 through the valve seat 24 and, continuously, with the condensed fluid inlet 9 of the evaporator 8, through the opening 23. In this construction, the spring element 26 is in the form of a diaphragm defining a wall of the chamber 27 for the passage of refrigerant fluid opposite to the valve seat 24.

The operation of the hermetic compressor 1 drawing refrigerant gas results in a sub-pressure in said chamber 27 of the valve body 21 acting on the spring element 26, causing the variation of the relative position between the sealing means 25 and valve seat 24.

The refrigerant fluid passage 22 is defined by an annular space formed between a valve seat 24 and the sealing means 25.

In the illustrated constructive form, the variation of the cross-section of the refrigerant fluid passage 22 is also a function of the thermal variation of the

evaporator 8, which determines the contracting and expanding conditions of a temperature variation sensitive fluid, which is provided inside valve 20 and which acts over the sealing means 25, as described
5 below.

The spring element 26 is mounted in the valve body 21, so as to constantly force the sealing means 25 to the closing condition of the refrigerant fluid passage 22. According to the present invention, the spring element
10 26 has a sealing position, which is obtained when the hermetic compressor 1 is turned off, and a plurality of fluid passage positions, which are obtained by the elastic deformation of the spring element 26 when suction occurs in the chamber 27 for the passage of
15 refrigerant fluid.

In the illustrated construction, the spring element 26 divides, transversely, the valve body 21 in the chamber 27 for the passage of refrigerant fluid and in a hermetic chamber 28, which contains the temperature
20 variation sensitive fluid in the evaporator 8, and which forces the spring element 26 to different bending conditions, as a function of the temperature variation in evaporator 8.

The thermically sensitive element is defined as a
25 function of its characteristics of responding to the thermal variation in the evaporator 8, so that, when the compressor 1 reaches its inoperative condition, said thermically sensitive fluid guarantees the sealing position of the spring element 26 and, during
30 the compressor operation, the contraction of the thermically sensitive fluid continuously forces the spring element 26 towards its sealing position when the temperature in evaporator 8 decreases and, towards its separation position when the temperature
35 in evaporator 8 increases.

The provision of the spring element 26 inside the valve body 21 determines substantially equal areas to the chamber 27 and to the hermetic chamber 28 of said body valve 21.

- 5 The spring element 26 is affixed to the impelling portion of the sealing means 25 and to the body valve 21, in order to constantly force the sealing means 25 to the full closing condition of the refrigerant fluid passage 22 during the operation of the hermetic
10 compressor 1. Each fluid passage position of the spring element 26 is obtained as a function of a difference between the forces acting over said spring element 26, particularly the forces resulting from condensation and suction pressures and, according to
15 the preferred constructive operation, the forces resulting from temperature variation acting on the temperature variation sensitive fluid.

In the illustrated construction, the sealing position of the spring element 26 is achieved when the suction
20 pressure is nule and, for example, the contraction of the thermically sensitive fluid produces a force on said spring element 20 which forces the latter to move away from the valve seat 24, conducting and maintaining the sealing means 25 in the condition in which the
25 sealing portion thereof is seated on the valve seat 24 until the compressor turns on again.

Each of the fluid passage positions of the spring element 26 is achieved by a corresponding bending of said spring element, in order to approximate it to the
30 valve seat 24, making the sealing means 25 move away from its sealing portion in relation to the valve seat 24.

For the ON/OFF type compressors having a constant speed or with at least two operational speeds, when
35 the temperature in the evaporator 8 reaches a

determined value for the actuation of the hermetic compressor 1, the operation of the latter generates a suction pressure located on the low pressure side of the refrigeration circuit and acting over the impelling portion of the sealing means 25, forcing the sealing portion thereof to move away from the valve seat 24.

Suction in these compressors remains constant during the operative period of the hermetic compressor 1. In this case, the pressure variation over said sealing means 25 is a function of the condensation temperature and of the pressure of the condensed refrigerant fluid inside the condenser 4.

In the variable speed compressors, in which there is an operational stop of the hermetic compressor 1, the low temperature inside evaporator 8 causes a decrease in the rotational speed of the compressor and a decrease in the suction pressure. The flow variation of the condensed fluid to the evaporator 8 results from the sum of the forces resulting from the suction pressure inside the chamber 27 and from the conditions of condensation temperature and condensation pressure in the condensed refrigerant fluid.

During the compressor operation, a suction pressure is formed in the chamber 27 of the valve body 21, through the fluid communication between said valve and the suction inlet 10 of the hermetic compressor 1. This suction pressure forces the spring element 26 to bend towards the valve seat 24 of the valve body 21, decreasing the volume in the chamber 27 and, proportionally, expanding the hermetic chamber 28, said movement leading the sealing means 25 to a spaced position from the valve seat 24 and thus allowing a determined amount of condensed refrigerant fluid to

pass to the evaporator 8 at a condensation temperature which is substantially close to the nominal condensation temperature and which no more affects the evaporation efficiency of the evaporator 8.

5 According to the sealing means and sealing means seat as illustrated, the condensed fluid flow which flows through the refrigerant fluid passage is proportional to the spacing between the external lateral surface of the sealing portion of the sealing means 25 and the
10 annular surface of the valve seat 24. As a function of the operation of the hermetic compressor 1 and consequently as a function of the existing suction pressure during the compressor operation, the sealing means 25 does not reach the seating position of its
15 sealing portion in relation to the valve seat 24.

As the condensation temperature of the fluid being pumped to the condenser increases, there is a pressure increase over the sealing portion of the sealing means 25, conducting the latter to an approximation position
20 towards the valve seat 24 and thus restricting the flow of the refrigerant fluid passing through the valve 20 of refrigerant fluid flow control and consequently to the evaporator 8.

The maximum pressure condition over the sealing means
25 25 determines a minimum value of refrigerant fluid flow through the valve 20 of refrigerant fluid flow control. The restriction of fluid to the evaporator 8 will make the suction of the compressor take place with a volume of refrigerant gas which is
30 progressively smaller on the low pressure side of the refrigeration circuit. The reduction of the mass flow avoids overload on the hermetic compressor 1.

With the increase in the restriction of the refrigerant fluid flow to the evaporator 8, there will
35 be a fluid build up in the condenser 4, thus

increasing the pressure and temperature therein, up to a temperature which permits the heat exchange of said fluid with the environment outside the condenser 4, resulting in the condensation of said fluid. The restriction will remain until the condensed refrigerant fluid has its temperature decreased, thus decreasing the pressure over the sealing means 25 and allowing the latter to separate from the valve seat 24. With this separation, there is a gradual increase of the cross-section of the refrigerant fluid passage 22 and, consequently, of the condensed fluid flow to the evaporator 8. The pressure variation over the sealing means 25 controls the refrigerant fluid flow to the evaporator 8 during the operation of the hermetic compressor 1, automatically and continuously adjusting said flow, thereby increasing the efficiency of the condenser 4, mainly when the outside temperature surpasses the nominal condensation temperature, alleviating the load over the hermetic compressor 1.

The constructive characteristics of the device just described are defined so that the separation of the sealing means from the valve seat 24 occurs when the hermetic compressor 1 restarts. The movement of the spring element 26 due to temperature variation in the evaporator 8 during operation of the hermetic compressor 1 determines a composition of forces over the sealing means 25.

CLAIMS

1. A refrigeration circuit arrangement for a refrigeration system, including a hermetic compressor (1), a condenser (4) having an inlet connected to a discharge outlet of the compressor (1), and an outlet; an evaporator (8), having an inlet connected to the outlet of the condenser (4), and an outlet, characterized in that it comprises, between the outlet of the condenser (4) and the inlet of the evaporator (8), a valve (20) of refrigerant fluid flow control, provided with a refrigerant fluid passage (22), whose cross-section varies during the operation of the hermetic compressor (1) in a manner which is inversely proportional to the variation of the condensation temperature, in order to allow the condensed refrigerant fluid supplied to the evaporator (8) to have a temperature substantially corresponding to a nominal condensation temperature of the system, said refrigerant fluid passage (22) having its cross-section closed, completely interrupting the fluid communication between the condenser (4) and the evaporator (8) when the hermetic compressor (1) turns off.
2. A refrigeration circuit arrangement, as in claim 1, characterized in that said valve (20) comprises a sealing means (25), which is operatively associated to the refrigerant fluid passage (22) and which is directly and simultaneously submitted to condensation pressure upstream the valve (20) and to suction pressure downstream the valve (20), said sealing means (25) being displaced, as a function of the force resulting from said pressures, in order to allow said cross-section variation of the refrigerant fluid passage (22) between the full closing condition of the



latter and the condition of achieving the nominal condensation temperature of the condensed refrigerant fluid.

3. A refrigeration circuit arrangement, as in claim 2,
5 characterized in that the refrigerant fluid passage (22) is defined by an annular space formed between a valve seat (24) and the sealing means (25).

4. A refrigeration circuit arrangement, as in claim 3,
10 characterized in that the valve (20) comprises a valve body (21) defining therein a chamber (27) for the passage of refrigerant fluid, communicating with the outlet of the condenser (4) through the valve seat (24) and being provided with an opening (23) in constant fluid communication with the inlet of the
15 evaporator 8.

5. A refrigeration circuit arrangement, as in claim 4,
20 characterized in that the sealing means (25) comprises a sealing portion located upstream the valve seat (24) and an impelling portion located downstream the valve seat, said impelling portion being connected to the valve body (21) by a spring element (26) constantly forcing the sealing means (25) to the closing condition of the refrigerant fluid passage (22), said spring element (26) having a sealing position, which
25 is achieved when the hermetic compressor (1) turns off, and at least a plurality of fluid passage positions, which are achieved by elastic deformation of the spring element (26) when there is suction in the chamber (27) for the passage of refrigerant fluid.

30 6. A refrigeration circuit arrangement, as in claim 5, characterized in that the spring element (26) is in the form of a diaphragm defining a wall of said chamber (27) opposite to the valve seat (24).

7. A refrigeration circuit arrangement, as in claim 6,
35 characterized in that the spring element (26) is



placed inside the valve body (21), in order to divide the latter in the chamber (27) for the passage of refrigerant fluid and in a hermetic chamber (28) containing a fluid which is sensitive to temperature variation of the evaporator (8).

8. A refrigeration circuit arrangement, as in claim 7, characterized in that the thermically sensitive fluid acts in the spring element (26), in order to force the latter towards the sealing position, when the temperature of the evaporator (8) decreases, and to conduct the spring element (26) to each fluid passage position, when the temperature of the evaporator (8) increases.

9. A refrigeration circuit arrangement, as in claim 7, characterized in that the valve body (21) is hermetic and provided in the evaporator (8) adjacently to the condensed fluid inlet thereof.

10. A refrigeration circuit arrangement, as in claim 9, characterized in that the impelling portion of the sealing means (25) is adjustably connected to the spring element (26).