

A VALVE PLATE FOR A COMPRESSOR

FIELD OF INVENTION

5 The present invention relates generally to valve plate for a compressor, a compressor, and to a method of thermal insulation applied in a compressor.

BACKGROUND

10 Gas-compression refrigeration has been and still is the most widely used method for fridges and air-conditioning of large public buildings, private residences, hotels, hospitals, theatres, restaurants and automobiles etc. The gas-compression refrigeration system uses a circulating refrigerant as a medium, which absorbs and removes heat from a location or space to be cooled and subsequently dissipates the
15 heat elsewhere.

 A typical gas-compression system has four components: a compressor, a condenser, an expansion valve (also called a throttle valve), and an evaporator. The compressor sucks low-temperature and low-pressure saturated gas from the evaporator and compresses the gas to high-pressure, resulting in higher
20 temperature as well. To improve the volumetric and energetic efficiencies of the compressor, which is to draw larger volume of the gas within a compressor's single compression cycle, it is desired to thermally insulate the drawn low-temperature gas in the suction line from hotter parts of the compressor so that the low-temperature
25 gas from the evaporator can be pumped in larger volume when its temperature is kept low. One of the major causes responsible for heating the internal components of the compressor is its discharge system, as the refrigerant gas reaches its highest temperature levels during the compression cycle. The heat generated by the compression is dissipated to other components of the compressor.

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 There are many components along the suction line. These components include a muffler, a cylinder head, and some pipelines, etc. Inside a commonly adopted reciprocating compressor for a refrigeration system, the muffler is usually provided inside

the compressor shell at a gas suction side for conducting the received gas to a suction valve of the compressor. The valve, with its valve plate, is the interface between the suction and discharge gas.

5 However, it is difficult to prevent heat exchange between the low-temperature gas and other hotter parts of the compressor because the drawn gas is present in the compressor within a narrow space and short distances from the hotter parts of the compressor. One approach is to improve thermal insulation for the storage or interface medium of the suction gas. These mediums can be manufactured from
10 materials of low thermal conductivity, such as resins or plastics. Recently, there are also some structural approaches to improve thermal insulation of the muffler.

 One suction muffler suggested in WO02/101239A1 has designed two acoustic chambers for refrigerant gas communication inside a muffler. In particular,
15 a first acoustic chamber of the muffler, which directly receives low-temperature gas outside the compressor, is surrounded by a second acoustic chamber of the muffler. This structure provides additional thermal insulation to the received low-temperature gas in the first acoustic chamber because heat flow from the exterior has to cross surrounding walls of the second acoustic chamber to reach the low-temperature gas
20 inside the first acoustic chamber. However, the design of two acoustic chambers complicates the internal structure of the muffler and increases the muffler's size which also adversely affects the manufacturing cost of the muffler. Furthermore, the structural strength and reliability of the muffler may be compromised.

25 A need therefore exists to provide solution for a refrigeration system that seeks to address at least one of the above problems.

SUMMARY

In accordance with a first aspect of the present invention there is provided a valve plate for a compressor, the valve plate having a thermally insulating capability for thermally insulating a suction muffler of the compressor from a discharge plenum in a cylinder head of the compressor, wherein the valve plate comprises a first plate element and a second plate element, the first plate element and the second plate element assembled to be joined together, and the first plate element is made from a thermally insulating material.

The second plate element may be made from metal.

The first and second plate elements may be joint by one or more of a group consisting of press-fitting, injection molding, induction heating, bonding adhesive, and ultrasonic welding.

The first plate element may be disposed to face the discharge plenum.

The valve plate may further comprise a third plate element made from metal, and the first plate element is sandwiched between the first and second plate elements.

The first, second and third plate elements may be joint by one or more of a group consisting of press-fitting, injection molding, induction heating, bonding adhesive, and ultrasonic welding.

The first plate element may be configured to be received in a recess formed in the second plate element.

The recess may be formed around a suction orifice in the second plate element.

The second plate element may comprise a raised portion around a discharge orifice in the second plate element, and the first plate element comprises an opening for receiving the raised portion.

The valve plate may comprise a metal coating on one or both sides of the first plate.

In accordance with a second aspect of the present invention there is provided a compressor comprising a valve plate as defined in the first aspect.

In accordance with a third aspect of the present invention there is provided a method of thermal insulation applied in a compressor, comprising using a valve plate having a thermally insulating capability for thermally insulating a suction muffler of the compressor from a discharge plenum in a cylinder head of the compressor, wherein the valve plate comprises a first plate element and a second plate element, the first plate element and the second plate element assembled to be joined together, and the first plate element is made from a thermally insulating material.

BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments of the invention will be better understood and readily apparent to one of ordinary skill in the art from the following written description, by way of example only, and in conjunction with the drawings, in which:

Figure 1 shows a schematic diagram illustrating a temperature profile of a refrigerant gas path inside a reciprocating compressor;

Figure 2 shows schematic drawings illustrating heat flow from high temperature discharge gas to the suction path at the suction and discharge interface, using (a) a conventional valve plate and (b) an valve plate structure according to an example embodiment.

Figure 3 shows a schematic drawing of a compressor according to an example embodiment.

Figure 4 shows a schematic drawing illustrating a valve plate structure according to an example embodiment.

Figure 5 shows a schematic drawing illustrating a valve plate structure according to an example embodiment.

Figure 6 shows a schematic drawing illustrating a valve plate structure according to an example embodiment.

Figure 7 shows a schematic drawing illustrating a valve plate structure according to an example embodiment.

Figure 8 shows a schematic drawing illustrating a valve plate structure according to an example embodiment.

Figure 9 shows a schematic drawing illustrating a valve plate structure according to an example embodiment.

DETAILED DESCRIPTION

Referring to Figure 1, the interior of a compressor 100 for hermetic gas-compression refrigeration is exposed for indicating a temperature profile of a refrigerant gas along its travelling path inside the compressor 100. The present invention is applicable to both Hermetic and semi-hermetic compressors. As will be appreciated by a person skilled in the art, the difference between the hermetic and semi-hermetic compressors is that the hermetic compressors use a one-piece welded steel casing that cannot be opened for repair. A semi-hermetic compressor uses a large cast metal shell with gasketed covers that can be opened to replace motor and pump components.

The compressor 100 comprises a suction inlet pipeline 102, a suction muffler 104, and a cylinder head 108. The suction muffler 104 is disposed inside the shell 106 of the compressor 100. The suction muffler 104 connects to the cylinder head 108 which has a suction plenum 116 and a discharge plenum 114 at its interior. The suction plenum 116 receives the gas with lower temperature while the discharge plenum 114 receives the compressed gas from the cylinder chamber (hidden) at higher temperature. The suction plenum 116 and the discharge plenum 114 are connected to a cylinder chamber (hidden) via a suction valve and a discharge valve (not shown) respectively. The discharge plenum 114 is further connected to the discharge pipeline 118 of the compressor 100 via muffler cover discharge 110 and discharge line 112 for discharging compressed gas at high temperature for the refrigeration system.

Along the travelling passage inside the compressor 100, initially, the low-temperature refrigerant gas is drawn into the suction muffler 104 via the suction inlet pipeline 102, either directly or indirectly. At the entrance of the inlet pipeline 102

going into the shell 106 (point 1), the gas has the lowest temperature inside the compressor shell 106, typically at about 40.5 degree Celsius. When the gas is drawn further towards the muffler 104, it is heated up by the surroundings to typically about 47.9 degree Celsius at the entrance (point 2) of the muffler 104.

5 Inside the muffler 104, the gas temperature is typically further raised to about 60.3 degree Celsius (point 3) before reaching the cylinder head 108. Further down the travelling path where the gas arrives at the suction plenum 116 of the cylinder head 108, the temperature of the gas has typically reached about 66.9degree Celsius (point 4). The gas is then drawn via the suction valve (not shown) to be compressed
10 in the cylinder chamber (hidden). The compressed gas leaves via the discharge valve (not shown) and enters the discharge plenum 114 of the cylinder head 108. Inside the discharge plenum 114, the temperature of the compressed gas is typically about 117.9 degree Celsius (point 5). On leaving the cylinder head 108, the gas starts to cool down. Along the down stream path via muffler cover discharge 110
15 and discharge line 112, and discharge pipeline 118 of the compressor 100, the high temperature and high pressure gas typically cools to about 82.8degree Celsius at the point (point 7) where the discharge pipeline exits the shell 106.

It is evident that the gas has a large temperature difference between the
20 adjacent suction 116 and discharge plenums 114. It has been recognised by the applicant that the high temperature gas contained in the discharge plenum 114 constitutes a heat source which can significantly contribute to the temperature increase in the low temperature suction refrigerant gas in the suction plenum 116 prior to compression. The increase in the suction refrigerant gas temperature
25 causes an increase in its specific volume and reduces the mass flow rate of the refrigerant gas, which in turn leads to a drop in the compressor's efficiency due to a reduction in cooling performance. It is noted that the high temperature compressed gas in the discharge plenum 114, as well as other heat sources within the compressor structure 100, also contributes to the overall temperature increase in the
30 suction gas as the gas travels from the inlet pipe 102 via the muffler 104 into the suction plenum 116, which can further contribute to an overall increase in the suction refrigerant gas temperature.

Figure 2a shows the cross sectional view of a cylinder head 202 bolted to the cylinder body 203. The inventors have recognized that significant heat transmission takes place between the hot gas in the discharge plenum 204 and the gas in suction muffler 205 through the valve plate 201, which is typically made from a metal.

5 Through this the inventors have in particular recognized that, by creating a barrier for heat transfer between the suction and discharge gas at the valve plate 201, such a valve plate structure can significantly contribute to prevent the suction gas from being heated up. Figure 2b shows the resultant heat flow diagram when a valve plate structure 210 comprising first and second metal plate elements 212, 214 and
10 an inlet 215 made from an insulating material in the plate element 212 is provided, according to an example embodiment. The inlet 215 functions as a thermal barrier to hinder heat transmission from the gas in the discharge plenum 216 to the gas in the suction muffler 218. This advantageously improves the overall thermal efficiency of the compressor.

15 Valve plate structure 210 acts as a seal between different pressure zones within the compressor. It contains both a suction orifice 220 and a discharge orifice 222, and thus provides fluid communication of the refrigerant. It is positioned between suction reed 224 and discharge reed 226, which open when differential pressures between
20 zones are reached and allow gases to flow from high to low pressure regions during the compression cycle. Due to its functional attributes, valve plate structure 210 preferably is corrosion, chemical and wear resistant, as well as preferably being able to withstand high temperature. It also provides the seal to prevent leakage of refrigerant. Preferably, the valve plate structure 210 also allows run-time low noise and smooth movement.

25 In Figure 3, a schematic drawings of a compressor according to an example embodiment is shown. More particular, a cylinder head 300 is exposed to show its interior structure and assembly. The cylinder head 300 is generally rectangular in shape with its four corners rounded off. At the four corners, four equal sized apertures 308a-d are provided for bolting, using part 309a-d, the cylinder head 300
30 to the cylinder body 307. Other components in the cylinder head assembly include valve plate structure 301, comprising valve plate 301a and an insulating material inlet 301b, a discharge reed 302, a suction reed 303, and sealing gaskets 304, 305. A suction muffler 306 fits into the suction plenum (hidden) in the cylinder head 300.

There are 2 alignment holes 310a-b at the rim of the valve plate 301a to provide reference guide during assembly of the cylinder head 300 to the cylinder body 307.

Figures 4 to 8 show different types of valve plate structures according to different embodiments.

Figure 4 shows a valve plate structure 400, comprising two plates 401 and 402. Plate 401 is made of thermally insulating material, while plate 402 is made of metal to provide strength. When assembled, the thermally insulating material plate 401 will be located towards the discharge reed (not shown). During the compression cycle, the surface of the valve plate structure 400 facing the cylinder bore (not shown) is made of metal, i.e. metal plate 402. This preferably prevents deformation under high pressure. A flat surface finish of the thermally insulating material plate 401 is preferably ensured to prevent leakage. The flatness of the thermally insulated valve plate can be ensured through flatness control methods such as, but not limited to, lapping. For example, the valve plate may be rubbed on a flat surface with an abrasive such as sandpaper there between, by hand movement or by machine. There are protrusions 403-07 formed on plate 401 and corresponding holes 408-12 formed on plate 402 to facilitate press fitting of plates 401 and 402 during assembly. The cross sectional view 414 shows the protrusions from plate 401 inserted in the corresponding holes in plate 402 so that plate 401 can be aligned and press fitted with plate 402.

Figure 5 shows a valve plate structure 500, comprising two plates 501 and 502. Plate 501 is made of thermally insulating material, while plate 502 is made of metal to provide strength. When assembled, the thermally insulating material plate 501 will be located towards the discharge reed (not shown). During the compression cycle, the surface of the valve plate structure 500 facing the cylinder bore (not shown) is made of metal, i.e. metal plate 502. This preferably prevents deformation under high pressure. A flat surface finish of the thermally insulating material plate 501 is preferably ensured to prevent leakage. Compared to the embodiment shown in Figure 4, there are no protrusions/corresponding holes formed the plates 501, 502, for press fitting. In this embodiment, plates 501, 502 can be assembled by for example, but not limited to, injection molding, inductionheating, bonding adhesive, press fitting, ultrasonic welding etc.

Figure 6 shows a valve plate structure 600, comprising three plates 601, 602, 603. Plate 602 is made of thermally insulating material, while plates 601, 603 are made of metal to provide strength. During the compression cycle, the surface of the valve plate structure 600 facing the cylinder bore (not shown) is made of metal, i.e. metal plate 603. This preferably prevents deformation under high pressure. A flat surface finish of the thermally insulating material plate 601 is preferably ensured to prevent leakage. In use, the metal plates 601, 603 are thus in contact with the discharge reed (not shown) and the suction reed (not shown) respectively. This preferably ensures good surface contact and prevents leakage. Also, having the surfaces adjacent the discharge and suction reeds respectively made from metal preferably increases reliability, for example due to the metal surface better withstanding the reciprocating reed movements. Plates 601, 602 and 603 can be assembled by for example, but not limited to, press fitting, injection molding, induction heating, bonding adhesive, ultrasonic welding etc.

Figure 7 shows a valve plate structure 700, comprising one plate 701 and an inlet 702. Inlet 702 is made of thermally insulating material, while plate 701 is made of metal to provide strength. During the compression cycle, the surface of the valve plate structure 700 facing the cylinder bore (not shown) is made of metal, i.e. metal plate 701. This preferably prevents deformation under high pressure. When assembled, the thermally insulating material inlet 702 is inserted in a corresponding recess 704 and will be located towards the discharge reed (not shown). While a flat surface finish of the thermally insulating material inlet 702 is again preferably ensured to prevent leakage, it will be appreciated that the majority of the surface facing the discharge reed (not shown) is made up by the surface of the metal plate 701, which preferably ensures good surface contact and prevents leakage. Plate 701 and inlet 702 can be assembled by for example, but not limited to, press fitting, injection molding, induction heating, bonding adhesive, ultrasonic welding etc. In this embodiment, because the regions where the screws are inserted are made of metal, deformation under high torque, e.g. when screws (not shown) are being tightened, is preferably prevented. Also, in use, the metal plate 701 is thus in contact with both the discharge reed (not shown) and the suction reed (not shown). This preferably ensures good surface contact and prevents leakage. Also, having the surfaces adjacent the discharge and suction reeds respectively made from

metal preferably increases reliability, for example due to the metal surface better withstanding the reciprocating reed movements

Figure 8 shows a valve plate structure 800, comprising two plates 801 and 802.

5 Plate 801 is made of thermally insulating material, while plate 802 is made of metal to provide strength. During the compression cycle, the surface of the valve plate structure 800 facing the cylinder bore (not shown) is made of metal, i.e. metal plate 802. This preferably prevents deformation under high pressure. The metal plate 802 in this embodiment comprises a raised region 803 around discharge orifice 804. When
10 assembled, the raised region 803 is received in a corresponding opening 805 formed in the insulating material plate 801. This preferably enhances the reliability, for example due to the metal surface of the raised region 803 better withstanding the reciprocating reed movements. A flat surface finish of the thermally insulating material inlet 802 is again preferably ensured. It will be appreciated that by having the metal surface of the
15 raised region 803, in use, adjacent the discharge reed (not shown) preferably ensures good surface contact and prevents leakage and may provide improved reliability. Plates 801 and 802 can be assembled by for example, but not limited to, press fitting, injection molding, induction heating, bonding adhesive, ultrasonic welding etc. Also, in use, the metal plate 802 and the raised region 803 are thus in contact with the suction reed (not
20 shown) and the discharge reed (not shown) respectively. This preferably ensures good surface contact and prevents leakage. Also, having the surfaces adjacent the discharge and suction reeds respectively made from metal preferably increases reliability, for example due to the metal surface better withstanding the reciprocating reed movements

25 Figure 9 shows a valve plate structure 900, with metal coatings 902, 904 on both surfaces of a thermally insulating material plate 906. This preferably ensures good surface contact and prevents leakage. Also, having the surfaces adjacent the discharge and suction reeds respectively made from metal preferably increases reliability, for example due to the metal surface better withstanding the reciprocating reed movements.
30 Alternatively, the coating could be done on either side of the thermally insulated valve plate. The metal coating may be formed using various techniques understood in the art, including, but not limited to, vapor deposition, spray coating, electroless plating.

In the example embodiments described, the thermally insulating material may include, but is not limited to, engineering plastics such as Polybutylene terephthalate (PBT) and Polyetherimide (PEI), Liquid Crystal Polymer (LCP), Polyether ether ketone (PEEK), Polyphenylene Sulphide (PPS) etc. The metal used in the example
5 embodiments described may include, but is not limited to cast/sintered iron.

The embodiments described can provide a hybrid valve plate structure in which a thermal barrier provided by respective materials, of thermally insulating characteristics, can improve the thermal insulation such that the suction gas temperature in the
10 compressor may be reduced. Since a reduction in the suction gas temperature decreases its specific volume and increases the mass flow rate of the refrigerant, this can lead to improved compressor efficiency due to an increase in cooling performance.

It will be appreciated by a person skilled in the art that numerous variations
15 and/or modifications may be made to the present invention as shown in the specific embodiments without departing from the spirit or scope of the invention as broadly described. The present embodiments are, therefore, to be considered in all respects to be illustrative and not restrictive.

CLAIMS

1. A valve plate for a compressor, the valve plate having a thermally insulating capability for thermally insulating a suction muffler of the compressor from a discharge plenum in a cylinder head of the compressor, wherein the valve plate comprises a first plate element and a second plate element, the first plate element and the second plate element assembled to be joined together, and the first plate element is made from a thermally insulating material.
2. The valve plate as claimed in claim 1, wherein the second plate element is made from metal.
3. The valve plate as claimed in claim 2, wherein the first and second plate elements are joined by one or more of a group consisting of press-fitting, injection molding, induction heating, bonding adhesive, and ultrasonic welding.
4. The valve plate as claimed in claims 2 or 3, wherein the first plate element is disposed to face the discharge plenum.
5. The valve plate as claimed in claim 2, further comprising a third plate element made from metal, wherein the first plate element is sandwiched between the second and third plate elements.
6. The valve plate as claimed in claim 5, wherein the first, second and third plate elements are joined by one or more of a group consisting of press-fitting, injection molding, induction heating, bonding adhesive, and ultrasonic welding.
7. The valve plate as claimed in claim 2, wherein the first plate element is configured to be received in a recess formed in the second plate element.
8. The valve plate as claimed in claim 7, wherein the recess is formed around a suction orifice in the second plate element.

9. The valve plate as claimed in claim 2, wherein the second plate element comprises a raised portion around a discharge orifice in the second plate element, and the first plate element comprises an opening for receiving the raised portion.

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10. A compressor comprising a valve plate as claimed in any one of the preceding claims.

11. A method of thermal insulation applied in a compressor, comprising using a
10 valve plate having a thermally insulating capability for thermally insulating a suction muffler of the compressor from a discharge plenum in a cylinder head of the compressor, wherein the valve plate comprises a first plate element and a second plate element, the first plate element and the second plate element assembled to be joined together, and the first plate element is made from a thermally insulating
15 material.