

SYSTEM AND METHOD TO REDUCE NOISE IN A RECIPROCATING COMPRESSOR

5 FIELD OF INVENTION

Embodiments of the present invention provide a system and method to reduce the noise produced in reciprocating compressors during operation.

10 BACKGROUND

Reciprocating compressors are used, for example, in the refrigeration industry, to compress a gas. This compressed gas is then used to cool a space, such as the inside of a refrigerator. Reciprocating compressors contain various moving parts, such as a crankshaft and a piston, that are driven to provide the compression of the
15 gas.

One problem with reciprocating compressors is that they tend to produce a great deal of noise when in operation. This can be particularly troublesome when the compressor is used in a confined space, such as a kitchen.

20

Current methods used to reduce this noise include putting various types of mufflers on the reciprocating compressor. While these muffler systems help to reduce the noise produced by the compressors, consumers continually demand that the compressors run even more quietly.

25

It would therefore be a great improvement in the art if a system and method could be developed to further reduce the amount of noise produced during the operation of reciprocating compressors.

30

SUMMARY

Embodiments of the present invention provide a system and method to reduce the noise emanating from a cylinder head in a reciprocating compressor. One aspect of

the present invention provides a system to reduce noise produced by a reciprocating compressor. The system includes a cylinder head located within the reciprocating compressor; and a material coupled to the cylinder head to form a sound barrier capable of reducing noise associated with operation of the compressor.

5

In alternate embodiments, the system may further include a gap between the cylinder head and the material, the gap capable of receiving an oil located within the compressor to reduce the noise. The cylinder head may include a plurality of grooves that provide the gap and/or the material may further include a plurality of
10 ridges that provide the gap. The gap may be between 0.2 mm and 0.4 mm, and the oil may be drawn into the gap via capillary action.

In some embodiments, the cylinder head may be made from aluminum, and the material is integrally formed with the aluminum cylinder head to effect the coupling.

15

In alternate embodiments, the system may further include a damping material between the cylinder head and the material to reduce the noise. The damping material may be an elastomer.

20 In other embodiments, the cylinder head may include a plurality of projections along a perimeter thereof, and the material may also include a plurality of channels configured to mate with the projections to couple the material to the cylinder head. The material may be coupled to the cylinder head using at least one of an adhesive and a plurality of mechanical fasteners.

25

In alternate embodiments, the material may be a polymer. The polymer may be selected from a group consisting of polybutylene terephthalate (PBT), polyphenylene sulphide (PPS) and liquid crystal polymer (LCP).

30 An alternate aspect of the present invention provides a reciprocating compressor including: a sealed housing; a motor located within the housing; a crankshaft driven by the motor; a connecting rod connected at a first end to the crankshaft and at a second end to a piston, the piston capable of moving within a cylinder block, capped with a valve plate and a cylinder head to compress a gas; and a material coupled to the cylinder

head to form a sound barrier capable of reducing noise associated with operation of the compressor. The compressor may further include a gap between the cylinder head and the material, the gap capable of receiving an oil located within the compressor to reduce the noise. The cylinder head may include a plurality of
5 grooves that provide the gap and/or the material may further include a plurality of ridges that provide the gap. The gap may be between 0.2 mm and 0.4 mm, and the oil may be drawn into the gap via capillary action.

10 In some embodiments of the compressor, the cylinder head may be made from aluminum, and the material is integrally formed with the aluminum cylinder head to effect the coupling.

In alternate embodiments, the compressor may further include a damping material between the cylinder head and the material to reduce the noise. The damping
15 material may be an elastomer.

In other embodiments of the compressor, the cylinder head may include a plurality of projections along a perimeter thereof, and the material may also include a plurality of channels configured to mate with the projections to couple the material to
20 the cylinder head. The material may be coupled to the cylinder head using at least one of an adhesive and a plurality of mechanical fasteners.

In alternate embodiments of the compressor, the material may be a polymer. The polymer may be selected from a group consisting of polybutylene terephthalate
25 (PBT), polyphenylene sulphide (PPS) and liquid crystal polymer (LCP).

A further aspect of the present invention provides a method to reduce noise produced by a reciprocating compressor, the method including the steps of: providing a cylinder head located within the reciprocating compressor; and coupling
30 a material to the cylinder head such that the material reduces noise associated with operation of the compressor.

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 illustrates a cross-sectional view of one embodiment of a reciprocating compressor capable of using the noise reducing system of the present invention;

10 Figure 2a illustrates an exploded perspective view of one embodiment of a noise reduction system according to the present invention;

Figure 2b illustrates a perspective view of the noise reduction system of Figure 2a;

15 Figure 2c illustrates a cross-sectional perspective view of the noise reduction system of Figures 2a and 2b;

Figure 2d illustrates an enhanced side view of the cross-section shown in Figure 2c;

20 Figure 3a illustrates an exploded perspective view of an alternate embodiment of a noise reduction system according to the present invention;

Figure 3b illustrates a perspective view of the noise reduction system of Figure 3a;

25 Figure 3c illustrates a cross-sectional perspective view of the noise reduction system of Figures 3a and 3b;

Figure 3d illustrates an enhanced side view of the cross-section shown in Figure 3c;

30 Figure 4a illustrates an exploded perspective view of another alternate embodiment of a noise reduction system according to the present invention;

Figure 4b illustrates a perspective view of the noise reduction system of Figure 4a;

Figure 4c illustrates a cross-sectional perspective view of the noise reduction system of Figures 4a and 4b;

Figure 4d illustrates an enhanced side view of the cross-section shown in Figure 4c;

Figure 5 illustrates a perspective view of another alternate embodiment of the present invention; and

Figure 6 illustrates a graph showing cumulative noise reduction properties for embodiments of the present invention.

DETAILED DESCRIPTION

Embodiments of the present invention provide a system for reducing the noise emanating from a reciprocating compressor. One example of a reciprocating compressor 100 capable of using the system of the present invention is shown in Figure 1. The compressor 100 includes a housing 102 containing a gas 104 capable of being compressed. The compressor 100 further includes a motor 106. The motor 106 drives a crankshaft 108. The crankshaft 108 is connected on a first end to a connecting rod 110, and on an opposite end to a piston 112. The piston 112 slides within a cylinder block 114 capped with a valve plate 117 and a cylinder head 118. Cylinder head 118 forms part of a noise reduction system of the present invention, embodiments of which are described below with reference to Figures 2-5. A quantity of oil 116 is contained within the housing 102 to lubricate the various moving parts. Optionally, a muffler 120 may also be included within the compressor 100.

The reciprocating compressor 100 illustrated in Figure 1 is one example of a refrigerant compressor typically used in home appliances. However, it is understood that the various embodiments of the noise reduction system of the present invention that are discussed herein may be used with any type of reciprocating compressor. It is further understood that references in the description to various orientations of the components described below, such as upper, lower, right, left, etc., are provided by

way of example only. Different orientational terms may be used to describe the embodiments depending on the specific view.

Figure 2a illustrates an exploded perspective view of one embodiment of a noise reduction system 200 according to the present invention. Figure 2b illustrates a perspective view of the noise reduction system 200 of Figure 2a. Figure 2c illustrates a cross-sectional perspective view of the noise reduction system 200 of Figures 2a and 2b. Figure 2d illustrates an enhanced side view of the cross-section shown in Figure 2c.

With continuing reference to Figures 2a-2d, the noise reduction system 200 includes a cylinder head 202. A material 220 having a top surface 222 is coupled to the cylinder head 202 to form a sound barrier capable of reducing the noise emanating from the compressor 100. In some embodiments, there may be a gap 204 (Figure 2d) between the cylinder head 202 and the material 220. This will be discussed in more detail below. The cylinder head 202 may also include one or more openings 206 that may be used to secure the cylinder head 202 to the valve plate 117 and cylinder block 114.

Figure 3a illustrates an exploded perspective view of an alternate embodiment of a noise reduction system 300 according to the present invention. Figure 3b illustrates a perspective view of the noise reduction system 300 of Figure 3a. Figure 3c illustrates a cross-sectional perspective view of the noise reduction system 300 of Figures 3a and 3b. Figure 3d illustrates an enhanced side view of the cross-section shown in Figure 3c.

With continuing reference to Figures 3a-3d, the noise reduction system 300 includes a cylinder head 302. A material 320 is coupled to the cylinder head 302 to reduce the noise emanating from the compressor 100. In this embodiment, the cylinder head 302 may include one or more grooves 308 that provide a gap 304 between the cylinder head 302 and the material 320. In alternate embodiments, the material 320 may include one or more ridges 310 that provide the gap 304 between the cylinder head 302 and the material 320. In other alternate embodiments, the ridges 310 on the material 320 may be configured to correspond to the grooves 308 on the

cylinder head 302. In each of these embodiments, a small gap 304 may also be provided between the grooves 308 and the ridges 310. The cylinder head 302 may also include one or more openings 306 that may be used to secure the cylinder head 302 to the valve plate 117 and cylinder block 114.

5

It is understood that the grooves 308 may extend completely across a top portion of the cylinder head 302, or may extend only partially across the top portion of the cylinder head 302. Similarly, it is understood that the ridges 310 may extend completely across a lower portion of the material 320, or may extend only partially across the lower portion of the material 320.

10

Additionally, it is understood that the gap 304 may be provided between the cylinder head 302 and the material 320 using many other means known to those of skill in the art. Such means may include, but are not limited to, the use of small bumps or projections on either the cylinder head 302, the material 320, or both, to provide a gap of a desired height.

15

With reference to Figures 2 and 3, the gap 204, 304 may allow the oil 116 (Figure 1) located within the compressor 100 to flow between the cylinder head 302 and the material 320. In some embodiments, this oil 116 may flow into the gaps 204, 304 by way of capillary action. In order for capillary action to effectively draw the oil 116 into the gap 204, 304, both the viscosity of the oil and the gap measurement may be taken into account. In a preferred embodiment, using standard types of oil found in refrigerant compressors, the gap 204, 304 may be between 0.2 millimeters (mm) to 0.4 mm.

20

25

Figure 4a illustrates an exploded perspective view of an alternate embodiment of a noise reduction system 400 according to the present invention. Figure 4b illustrates a perspective view of the noise reduction system 400 of Figure 4a. Figure 4c illustrates a cross-sectional perspective view of the noise reduction system 400 of Figures 4a and 4b. Figure 4d illustrates an enhanced side view of the cross-section shown in Figure 4c.

30

With continuing reference to Figures 4a-4d, the noise reduction system 400 includes a cylinder head 402. A material 420 having a top surface 421 may be coupled to the cylinder head 402 to reduce the noise emanating from the compressor 100. In this embodiment, an additional noise damping material 416 may be inserted between
5 the material 420 and the cylinder head 402 to increase the noise damping effect of the system 400. The cylinder head 402 may also include one or more openings 406 that may be used to secure the cylinder head 402 to the valve plate 117 and cylinder block 114.

10 In this embodiment, the noise damping material 416 may be made from an elastomeric material capable of both withstanding the heat generated within the compressor 100 and of providing a sound dampening effect. By way of example and not limitation, such elastomeric material may include nitrile rubber and/or fluoroelastomers. Other materials may also be used.

15 Figure 5 illustrates a perspective assembled view of another alternate embodiment of a noise reductions system 500 according to the present invention. A material 520 may be coupled to a cylinder head 502 to reduce the noise emanating from the compressor 100. In this embodiment, the material 520 may be configured to cover
20 the holes (hidden by the mechanical fasteners 518 in this view) in the cylinder head 502. A plurality of mechanical fasteners 518 may then be used to secure the system 500 to the valve plate 117 and cylinder block 114 shown in Figure 1.

In the embodiment illustrated in Figure 5, the mechanical fasteners 518 are shown
25 as bolts. However, it is understood that other types of mechanical fasteners may also be used to secure the system 500 to the valve plate 117 and cylinder block 114.

30 The cylinder heads 202, 302, 402, and 502 may be made from any material known to those of skill in the art to be satisfactory for that purpose. In some embodiments, the cylinder heads 202, 302, 402, and 502 are made from aluminum or an aluminum alloy. It is understood that various materials may be used for the cylinder heads 202, 302, 402, and 502 without departing from the scope of the embodiments.

The material 220, 320, 420, and 520 may be made from a polymer capable of both withstanding the heat generated within the compressor 100 and of providing a sound dampening effect. In some embodiments, this polymer material may be polybutylene terephthalate (PBT). Alternately, and by way of example and not
5 limitation, the polymer material may be polyphenylene sulphide (PPS), liquid crystal polymer (LCP), or other polymers.

As shown in Figures 2-4, the material 220, 320, 420 may be coupled to the respective cylinder heads 202, 302, 402 using various means. For example, as best
10 shown in Figure 2, the material 220 may be secured to the cylinder head 202 using any type of adhesive capable of withstanding the temperatures that may be reached within the compressor 100. These temperatures may reach as high as 150 degrees Celsius.

In alternate embodiments, as best shown with reference to Figures 4a and 4c, the material 420 may be coupled to the cylinder head 402 using a snap fit arrangement. For example, a plurality of protrusions 405 may be formed along an outside surface of the cylinder head 420 402. Corresponding channels 422 may be formed on an inside surface a lower portion 424 of the material 420. The material 420 may have
20 sufficient flexibility to then snap over the protrusions 405 such that the protrusions 405 fit within the channels 422 to couple the material 420 to the cylinder head 402. It is understood that the arrangement listed above may be reversed such that the protrusions are found on the material 420 and the channels are formed within the cylinder head 402.

In other alternate embodiments, as shown in Figure 5, the material 520 may be coupled to the cylinder head 502 using, for example, one or more mechanical fasteners 518. While the embodiment shown in Figure 5 illustrates the mechanical fasteners 518 being used to both couple the material 520 to the cylinder head 502,
30 and to secure the system 500 to the valve plate 117 and cylinder block 114, it is understood that different types/locations of mechanical fasteners may be used to couple the material 520 to the cylinder head 502, while the fasteners 518 provide the attachment of the system to the cylinder block 114 of the compressor 100. Similarly, any of the methods for coupling the material to the cylinder head may be

used in conjunction with the use of mechanical fasteners to attach the system(s) to the cylinder block of a compressor. All such alternatives are deemed to fall within the scope of the embodiments as represented by the claims.

- 5 In another alternate embodiment, as best illustrated with respect to Figures 2a-2d, the material 220 may be integrally formed with the cylinder head 202. For example, there are various processes known in the art to integrate aluminum castings and various types of plastic into a single component.
- 10 In one process, a special coating may be applied to a metal top surface of the cylinder head, and the material is then molded directly onto the cylinder head. In an alternate process using an aluminum cylinder head, micro-porous holes having a diameter of between 5 micrometers and 100 micrometers are formed on the surface of the cylinder head. Various types of plastics, such as those discussed above, may
- 15 then be injected onto the cylinder head. The plastic fills the micro-porous holes, thus integrating the two pieces.

It is understood that the specific configurations provided for the cylinder head and material in the embodiments discussed above are by way of example only. Various

20 physical configurations for the cylinder head may be used. Similarly, various physical configurations for the material may also be used. In a preferred embodiment, the material should cover at least 60% of the surface area of the cylinder head to provide for adequate noise reduction capabilities. However, as shown in Figure 5, the material 520 may cover the entire top surface of the cylinder

25 head 502.

Various combinations of the specific embodiments illustrated in Figures 2-5 may also be used to produce a noise reducing system according to the present invention. For example, various combinations and types of grooves, additional noise damping

30 material, coupling systems, and materials as described above may be used to produce a noise reducing system. All such combinations are deemed to fall within the scope of the described embodiments.

The various systems 200, 300, 400, and 500 described above provide measurable noise reduction as compared to using standard cylinder heads. Figure 6 illustrates a graph, designated generally as reference numeral 600, showing cumulative noise reduction properties for embodiments of the present invention. The graph 600 shows cylinder head noise in decibels on a y-axis 602, and various frequencies on the x-axis 604. A first plot 606 shows the noise levels of a cylinder head in a regular compressor, while a second plot 608 shows the noise levels of a cylinder head that has been modified according to the present embodiments. As can be seen from the graph 600, embodiments of the system provide an average of about 2 decibels of noise reduction across a range of audible frequencies.

It will be appreciated by a person skilled in the art that numerous variations 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 system to reduce noise produced by a reciprocating compressor, the system comprising:
 - 5 a cylinder head located within the reciprocating compressor; and
 - a material coupled to the cylinder head to form a sound barrier capable of reducing noise associated with operation of the compressor.
2. The system of claim 1, further comprising a gap between said cylinder head
10 and said material, said gap capable of receiving an oil located within said compressor to reduce said noise.
3. The system of claim 2, wherein said cylinder head further comprises a plurality of grooves that provide said gap and/or said material further comprises a
15 plurality of ridges that provide said gap.
4. The system of claims 2 or 3, wherein said gap is between 0.2 mm and 0.4 mm, and said oil is drawn into said gap via capillary action.
- 20 5. The system of claim 1, wherein said cylinder head comprises aluminum, and said material is integrally formed with said aluminum cylinder head to effect said coupling.
6. The system of claim 1, further comprising a damping material between said
25 cylinder head and said material to reduce said noise.
7. The system of claim 6, wherein said damping material comprises an elastomer.
- 30 8. The system of any one of the previous claims, wherein said cylinder head further comprises a plurality of projections along a perimeter thereof, and said material comprises a plurality of channels configured to mate with said projections to couple said material to said cylinder head.

9. The system of any one of claims 1-7, wherein said material is coupled to said cylinder head using at least one of an adhesive and a plurality of mechanical fasteners.

5 10. The system of any one of the previous claims, wherein said material comprises a polymer.

11. The system of claim 10, wherein said polymer is selected from a group consisting of polybutylene terephthalate (PBT), polyphenylene sulphide (PPS) and
10 liquid crystal polymer (LCP).

12. A reciprocating compressor comprising:
a sealed housing;
a motor located within said housing;
15 a crankshaft driven by said motor;
a connecting rod connected at a first end to said crankshaft and at a second end to a piston, said piston capable of moving within a cylinder block capped with a valve plate and a cylinder head to compress a gas; and
a material coupled to said cylinder head to form a sound barrier capable of
20 reducing noise associated with operation of the compressor.

13. The compressor of claim 12, further comprising a gap between said cylinder head and said material, said gap capable of receiving an oil located within said compressor to reduce said noise.

25

14. The compressor of claim 13, wherein said cylinder head further comprises a plurality of grooves that provide said gap and/or said material further comprises a plurality of ridges that provide said gap.

30 15. The compressor of claims 13 or 14, wherein said gap is between 0.2 mm and 0.4 mm, and said oil is drawn into said gap via capillary action.

16. The compressor of claim 12, wherein said cylinder head comprises aluminum, and said material is integrally formed with said aluminum cylinder head to effect said coupling.

5 17. The compressor of claim 12, further comprising a damping material between said cylinder head and said material to reduce said noise.

18. The compressor of claim 17, wherein said damping material comprises an elastomer.

10

19. The compressor of any one of claims 12-18, wherein said cylinder head further comprises a plurality of projections, and said material comprises a plurality of channels configured to mate with said projections to couple said material to said cylinder head.

15

20. The compressor of any one of claims 12-18, wherein said material is coupled to said cylinder head using at least one of an adhesive and a plurality of mechanical fasteners.

20 21. The compressor of any one of claims 12-20, wherein said material comprises a polymer.

22. The compressor of claim 21, wherein said polymer is selected from a group consisting of polybutylene terephthalate (PBT), polyphenylene sulphide (PPS) and
25 liquid crystal polymer (LCP).

23. A method to reduce noise produced by a reciprocating compressor, the method comprising the steps of:

providing a cylinder head located within the reciprocating compressor; and

30 coupling a material to the cylinder head such that said material reduces noise associated with operation of the compressor.