A valve assembly is mounted on a compressor mechanism and controls the passage of fluid from a compression chamber to a discharge chamber. The valve assembly includes a flexible valve member, a rigid valve retainer and a dampening element. The valve member has a first portion secured to the compressor mechanism and a second portion freely extending from the first portion. The second portion has a closed position sealingly engageable with a discharge port to prevent passage of fluid from the compression chamber to the discharge chamber. The second portion is flexible outwardly away from the discharge port thereby allowing passage of fluid from the compression chamber to the discharge chamber. The at least one dampening element is non-movingly affixed to the retainer and projects from the retainer toward the valve member. The valve member strikes the dampening element when the valve member is biased away from the discharge port.
DISCHARGE VALVE WITH DAMPENING

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] The present invention relates to discharge valve assemblies used in compressors, and, more particularly, to valve retainers in such discharge valve assemblies.

[0003] 2. Description of the Related Art

[0004] Compressor assemblies, such as those used to compress refrigerants, e.g., carbon dioxide, commonly include a compressor mechanism having a compression chamber in which the fluid is compressed, a suction inlet by which the compressible fluid enters the chamber, and a discharge outlet by which the compressed fluid exits the chamber. A discharge valve assembly is often mounted at the outlet and controls the flow of compressed fluid exiting the chamber.

[0005] The discharge valve assemblies typically include a flexible valve that is sealingly positioned over the outlet to close outlet and prevent refrigerant from reentering the compression chamber. The flexible valve is capable of flexing away from the outlet when the fluid pressure within the chamber reaches a certain level, thereby opening the outlet and allowing the compressed fluid to be discharged from the chamber. To secure the valve member and limit the flexing of the valve, discharge valve assemblies commonly include a valve stop or valve retainer. The valve retainer is positioned adjacent the valve such that the valve is between the retainer and the outlet. The valve retainer is spaced apart from the valve to allow the valve to flex a certain distance away from outlet. Once the valve reaches the retainer, it strikes the retainer and is prevented from further deflection. However, the repeated striking of the valve against the retainer may subject the valve to a significant amount of impact stress. In addition, the striking of the valve against the retainer can result in undesirable noise.

SUMMARY OF THE INVENTION

[0006] The present invention provides a compressor assembly having a discharge valve with dampening. By utilizing one or more dampening elements on a valve retainer to dampen the impact of the valve member against the valve retainer during operation of the compressor, the impact stress created in the valve member and the noise generated by the impact can both be reduced.

[0007] The present invention comprises, in one form, a compressor assembly including a compressor mechanism defining at least one compression chamber and having at least one discharge port defining at least one discharge passage. A discharge chamber is defined by the assembly, and the at least one discharge passage provides fluid communication between the at least one compression chamber and the discharge chamber. A valve assembly is mounted on the compressor mechanism and controls the passage of compressed fluid from the at least one compression chamber to the discharge chamber. The valve assembly includes a flexible valve member, a rigid valve retainer and at least one dampening element. The flexible valve member has a first portion secured to the compressor mechanism and a second portion freely extending from the first portion. The second portion has a closed position sealingly engageable with the at least one discharge port to thereby prevent passage of fluid from the compression chamber to the discharge chamber through the at least one discharge passage. The second portion is flexible outwardly away from the at least one discharge port thereby allowing passage of fluid from the compression chamber to the discharge chamber through the at least one discharge passage. The rigid valve retainer has a first surface defining a first surface area facing the valve member and disposed to limit the outward flexing of the second portion of the valve member. The at least one dampening element is non-movingly affixed to the valve retainer and projects from the first surface toward the valve member substantially opposite the discharge port. The valve member strikes the dampening element before the first surface proximate the dampening element when the valve member is biased away from said discharge port. The dampening element defines a second surface area facing the valve member and being less than the first surface area.

[0008] The present invention also provides a method of dampening a valve impact in a compressor assembly. The method, in one form, comprises the steps of compressing a fluid in the compression chamber of a compressor mechanism; discharging the compressed fluid from the compression chamber to a discharge chamber through at least one discharge port; securing a valve member to the compressor mechanism wherein the valve member has a freely extending portion sealingly engageable with the discharge port to close the discharge port and is flexible outwardly away from the at least one discharge port; providing a rigid valve retainer having a first surface defining a first surface area; securing the valve retainer to the compressor mechanism wherein the first surface faces the valve member and is positioned to limit the outward flexing of the valve member; affixing a dampening element to the valve retainer substantially opposite the discharge port wherein the dampening element projects outwardly from the first surface towards the valve member and defines a second surface area facing the valve member, the second surface area being less than the first surface area; biasing the valve member into an open position away from the discharge port towards the valve retainer; and dampening the impact of the valve member against the valve retainer with the dampening element.

[0009] An advantage of the present invention is that the dampening element dampens the impact at which the discharge valve strikes the valve retainer, thereby facilitating the reduction of noise and reducing the impact stress generated within the valve member.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] The above mentioned and other features and objects of this invention, and the manner of attaining them, will become more apparent and the invention itself will be better understood by reference to the following description of an embodiment of the invention taken in conjunction with the accompanying drawings, wherein:

[0011] FIG. 1 is a sectional view of a compressor assembly having a discharge valve assembly in accordance with one embodiment of the present invention;

[0012] FIG. 2 is an enlarged view of the circled region of FIG. 1;

[0013] FIG. 3 is an exploded view of the cylinder region of the compressor assembly of FIG. 1;
FIG. 4 is a perspective view of the discharge valve retainer of the cylinder valve assembly of FIG. 3;

FIG. 4A is a sectional view of the discharge valve retainer of FIG. 4 taken along lines 4A-4A;

FIG. 5 is a perspective view of a discharge valve retainer of a cylinder valve assembly in accordance with another embodiment of the present invention; and

FIG. 5A is a sectional view of the discharge valve retainer of FIG. 5 taken along lines 5A-5A.

Corresponding reference characters indicate corresponding parts throughout the several views. Although the exemplification set out herein illustrates embodiments of the invention, in several forms, the embodiments disclosed below are not intended to be exhaustive or to be construed as limiting the scope of the invention to the precise forms disclosed.

DESCRIPTION OF THE PRESENT INVENTION

In accordance with the present invention, compressor assembly 10, illustrated in FIG. 1, includes a housing 12 comprised of upper housing member 14 and lower housing member 16. Housing members, 14 and 16 are hermetically sealed to one another to define interior volume 20. A portion of interior volume 20 bordered by lower housing member 16 forms oil sump 22. Housing 12 includes suction inlet 24 by which a compressible fluid, e.g., carbon dioxide or other suitable refrigerant, enters interior volume 20 at suction pressure. Housing 12 also includes discharge outlet 26 through which the compressed refrigerant is discharged from compressor 10. Motor assembly 28 is disposed within interior volume 20 and includes stator 30 and rotor 32. Motor assembly 28 is a conventional electric motor and is connected to an electrical power source (not shown). Shaft 34 is secured to rotor 32 whereby motor 28 rotationally drives shaft 34.

Compressor 10 includes a reciprocating piston compressor mechanism 35, which is disposed in interior volume 20 and is operatively engaged to motor assembly 28. Compressor mechanism 35 includes cylinder block 36 which defines a pair of compression chambers or bores 38. A piston 40 is reciprocatingly disposed within each chamber 38 to create a variable volume compression space. Piston rod 40 is coupled at one end to piston 40 and at the opposite end to journal portion 44 defined in shaft 34 to thereby operatively couple piston 40 to motor assembly 28.

Referring to FIGS. 1-3, a cylinder head assembly is mounted on cylinder block 36 adjacent compression chambers 38 and includes cylinder head 46 and cylinder valve assembly 48. Cylinder head 46 defines suction plenum 46a and discharge plenum 46b. Cylinder valve assembly 48 is positioned between cylinder block 36 and cylinder head 46 and includes the flow of refrigerant between compression chamber 38 and plenums 46a, 46b. Cylinder valve assembly 48 includes valve plate 50, suction valve 60 and discharge valve assembly 61. Valve plate 50 defines bore holes 58 and is mounted to cylinder block 36 and cylinder head 46 via bolts (not shown), which extend through bore holes 58. Referring particularly to FIG. 3, valve plate 50 defines inlet ports 52, through which the compressible fluid is communicated from suction plenum 46a to compression chambers 38. Valve plate 50 also defines discharge ports 54, through which compressed fluid is communicated from compression chambers 38 to discharge plenum 46b. Valve plate 50 also defines fastener receiving holes 56 adapted to receive fasteners 80 which, in the illustrated embodiment, are rivets.

Referring still to FIG. 3, suction valve 60 is disposed over inlet ports 52 and is secured to the compression chamber side of valve plate 50 by fasteners 80, which extend through notches 60a defined in suction valve 60. Suction valve 60 is constructed of a resilient, flexible material and is adapted to flex away from inlet ports 52 to allow compressible fluid to flow from suction plenum 46a into compression chambers 38. In its natural state, suction valve 60 lies flat against valve plate 50 and sealingly closes inlet ports 52.

Turning now to FIGS. 2 and 3, discharge valve assembly 61 is secured to the cylinder head side of valve plate 50 and includes two discharge valves 62 and a valve retainer 68. Discharge valves 62 are disposed between valve plate 50 and valve retainer 68. As shown in FIGS. 3 and 4, each discharge valve 62 has a generally circular shape and includes two diametrically opposed first portions or secured portions 64 and two diametrically opposed second portions or freely extending portions 66. Each of secured portions 64 defines fastener receiving holes 67 and is secured to valve plate 50 by fasteners 80, which extend through fastener receiving holes 67 and through openings 78 in valve retainer 68 to thereby secure portions 64 tightly between valve plate 50 and valve retainer 68. Freely extending portions 66 are configured to cover discharge ports 54 in valve plate 50. Discharge valves 62 are constructed of a resilient flexible material, such as spring steel or other suitable material. In the illustrated embodiment, valves 62 are a spring steel material and have a thickness of about 0.012 in. (0.03 mm). High pressure within discharge ports 54 causes the deflection of freely extending portions 66 away from discharge ports 54, thus allowing compressed refrigerant to flow from compression chambers 38 to discharge plenum 46b. In its natural state, freely extending portions 66 of discharge valves 62 lie against valve plate 50 and sealingly close discharge ports 54.

Referring now to FIGS. 3, 4 and 4A, valve retainer 68 defines a first surface or valve limiting surface 70 and is positioned adjacent discharge valve 62 such that valve limiting surface 70 faces discharge valve 62. Valve retainer 68 includes valve limiting portions 68a and securing portions 68b. Each of securing portions 68b defines fastener receiving holes 78, which align with fastener receiving holes 67 of discharge valve 62 and receive fasteners 80 to thereby secure valve retainer 68 to valve 62 and valve plate 50. Valve retainer 68 is configured such that the valve limiting portions 68a are bent away from valve plate 50. In the illustrated embodiment, valve retainer 68 is constructed of a cold rolled steel material having a thickness of approximately 0.072 inches (0.183 cm). Valve retainer 68 may, however, be constructed of other suitable metallic or other materials in alternative embodiments.

Turning back to FIG. 1, suction muffler 88 is disposed in interior volume 20 and is adapted to communicate compressible refrigerant from interior volume 20 to suction plenum 46a of cylinder head 46. Discharge tube 90 is disposed in interior volume 20 and is adapted to communicate compressed refrigerant from discharge plenum 46b of cylinder 46 to discharge outlet 26 of housing 12.
In general operation, the rotation of rotor 30 induces the rotation of shaft 34. The rotational movement of shaft 34 is translated by journal portion 44 and piston rod 42 into the reciprocating movement of piston 40 within compression chamber 38. As piston 40 enlarges compression chamber 38 during an intake stroke, suction valve 60 flexes away from inlet ports 52 due to the pressure differential between compression chamber 38 and suction plenum 46a. As a result, compressible refrigerant enters interior volume 20 through suction inlet 24, and is drawn through suction muffler 88, suction plenum 46a, inlet ports 52, and into compression chamber 38. As piston 40 reduces the size of compression chamber 38 during a compression stroke, suction valve 60 sealingly closes inlet ports 52 and piston 40 compresses the refrigerant within compression chamber 38. When the refrigerant within the compression chamber 38 reaches a sufficient pressure, freely extending portions 66 of discharge valve 62 flex away from discharge ports 54 and the refrigerant is discharged from compression chamber 38, through discharge ports 54, and into discharge plenum 46b. From discharge plenum 46b the refrigerant flows through discharge tube 90 and exits compressor 10 through discharge outlet 26.

The deflection of valve 62 away from outlet opening 54 is limited by valve retainer 68. Valve 62 flexes away from outlet opening 54 only until it reaches valve retainer 68, at which point discharge valve 62 strikes valve retainer 68 and is prevented from further deflection. In the illustrated embodiment, the maximum valve lift is approximately 0.100 in. (2.54 mm).

To facilitate the reduction of noise and stress within discharge valve 62 caused by the striking of valve 62 against retainer 68, valve retainer 68 includes one or more dampening elements 72, as shown in FIGS. 2-4 and 4A. In one embodiment shown in FIGS. 3, 4 and 4A, valve retainer 68 includes a plurality of discretely placed mounted apertures or ports 76 defined in valve limiting surface 70 and positioned substantially opposite discharge ports 54. Dampening elements 72 are at least partially mounted within mounting apertures 76 and project from valve limiting surface 70 by distance D. Dampening element 72 defines valve striking surface 74 against which discharge valve 62 strikes. Striking surface 74 defines a surface area that is less than the surface area of valve limiting surface 70. In the illustrated embodiments, that portion of surface 70 which permanently engages discharge valve 62 proximate fastener holes 78 to secure valve 62 to valve plate 50 does not include dampening elements. Dampening elements 72 may be constructed of any material that demonstrates good shock dampening capacity and suitable durability. The material is also preferably capable of withstanding high temperatures. Acceptable materials include thermosetting materials such as polyetherimide (PEI) resins. In the illustrated embodiment, the material used to form dampening elements is a PEI resin sold under the tradename Ultem 2400 by GE Plastics, a part of the General Electric Company which has a place of business located in Southfield, Mich. A significant advantage of this material is its relatively low coefficient of thermal expansion (1.5 e-5/deg. C) which is substantially equivalent to that of steel and thereby facilitates its use with a cold rolled steel valve retainer.

In the disclosed embodiment, the refrigerant may be R22 and enter the suction tube at a pressure substantially equivalent to its evaporating pressure (45 psig) and at a suction temperature of about 25 deg. C. During the compression process the refrigerant is compressed to a pressure of about 300 psig and attains a discharge temperature of about 105 deg. C. Polyetherimides have a relatively high glass transition temperature, i.e., about 217 deg. C, and have a relatively high resistance to flammability and, thus, are well suited for use as a valve damping material in such an application.

Dampening elements 72 may be formed using any conventional molding techniques, such as injection molding, and may be molded directly into mounting aperture 76. Alternatively, dampening elements 72 may be pre-formed and snap-fit into the mounting apertures. The size and shape of dampening elements 72 may vary depending upon the desired impact surface area. In the embodiment illustrated in FIG. 3, dampening elements 72 have a surface area facing valve 62 that is substantially equivalent to the area of discharge ports 54 and elements 72 are positioned directly opposite discharge ports 54. The extent to which the dampening elements 72 project outwardly from retainer 68 toward valve member 62 may also vary. For example, in the embodiment of FIG. 3, dampening elements 72 project outwardly from valve limiting surface 70 by a distance D of between about 0.004 in. (0.1 mm) and 0.008 in. (0.2 mm), and more advantageously between 0.004 in. (0.1 mm) and 0.005 in. (0.127 mm).

The size of mounting aperture 76 may vary depending on the size and depth of dampening element 72. The depth d of mounting aperture 76 is selected so that it will be sufficient to anchor dampening element 72. In the embodiment of FIG. 3, the depth d of mounting aperture 76 is approximately 0.08 in. (2.032 mm). Apertures 76 define an opening that is approximately 0.5 in. by 0.3 in. (1.27 cm by 0.76 cm). The illustrated apertures 76 further include a centrally located cylindrical bore having a diameter of approximately 0.08 in. (2.032 mm) and which may be up to about 0.1 in. (2.54 mm) in diameter. Although FIG. 4A does not illustrate this cylindrical bore as being filled with material, when injecting molding the dampening elements 72, this bore may be either partially or completely filled with the material used to form the dampening elements 72 and which is an integral part of element 72 and thereby more firmly secure element 72 within aperture 76.

Alternative securing methods may also be employed to affix the plurality of discretely placed dampening elements to valve retainer 68. Further, as shown in FIGS. 5 and 5A, rather than discretely positioning a dampening element opposite each of the discharge ports 54, a single dampening element may cover a greater amount of valve limiting surface 70 such that one dampening element corresponds to multiple discharge ports 54. For example, the embodiment illustrated in FIGS. 5 and 5A includes dampening elements 72a which cover a relatively large area and correspond to multiple discharge ports 54. The dampening elements 72a provided in this embodiment may be secured to the valve retainer by having an integral portion of the elements being formed within apertures 76 during the molding of elements 72a. Alternatively, the valve retainer may not include mounting apertures for the dampening elements with the dampening elements 72a having a constant thickness throughout their length and being secured to the valve retainer with an adhesive.
While this invention has been described as having an exemplary design, the present invention may be further modified within the spirit and scope of this disclosure. This application is therefore intended to cover any variations, uses, or adaptations of the invention using its general principles.

What is claimed is:

1. A compressor assembly comprising:
   a compressor mechanism defining at least one compression chamber and having at least one discharge port defining at least one discharge passage;
   a discharge chamber defined by said assembly, said at least one discharge passage providing fluid communication between said at least one compression chamber and said discharge chamber; and
   a valve assembly mounted on said compressor mechanism and controlling the passage of compressed fluid from said at least one compression chamber to said discharge chamber, said valve assembly including a flexible valve member, a rigid valve retainer and at least one dampening element, said flexible valve member having a first portion secured to said compressor mechanism and a second portion freely extending from said first portion, said second portion having a closed position sealingly engageable with said at least one discharge port to thereby prevent passage of fluid from said compression chamber to said discharge chamber through said at least one discharge passage, said second portion being flexible outwardly away from said at least one discharge port thereby allowing passage of fluid from said compression chamber to said discharge chamber through said at least one discharge passage, said rigid valve retainer having a first surface defining a first surface area, said first surface facing said valve member and being disposed to limit the outward flexing of said second portion of said valve member, said at least one dampening element non-movingly affixed to said valve retainer and projecting from said first surface toward said valve member substantially opposite said discharge port wherein said valve member strikes said dampening element before said first surface proximate said dampening element when said valve member is biased away from said discharge port, said dampening element defining a second surface area facing said valve member, said second surface area being less than said first surface area.

2. The compressor assembly of claim 1 wherein said valve retainer comprises a metallic material and said at least one dampening element comprises a thermostetting material.

3. The compressor assembly of claim 2 wherein said valve retainer includes at least one mounting aperture, said at least one dampening element being partially disposed within said at least one mounting aperture.

4. The compressor assembly of claim 1 wherein said at least one dampening element comprises a polyetherimide material.

5. The compressor assembly of claim 4 wherein said valve retainer comprises a cold rolled steel material.

6. The compressor assembly of claim 4 wherein said at least one dampening element projects outwardly from said first surface by a distance between approximately 0.004 inches and 0.008 inches.

7. The compressor assembly of claim 4 wherein said at least one dampening element projects outwardly from said first surface by a distance between approximately 0.004 inches and 0.005 inches.

8. The compressor assembly of claim 4 wherein said valve retainer includes at least one mounting aperture, said at least one dampening element being partially disposed within said at least one mounting aperture.

9. The compressor assembly of claim 1 wherein said at least one discharge port includes a plurality of discharge ports defining a plurality of discharge passages providing fluid communication between said at least one compression chamber and said discharge chamber wherein said second portion of the said valve member is sealingly engageable with said plurality of discharge ports and wherein said at least one dampening element comprises a plurality of discrete dampening elements non-movingly affixed to said valve retainer, said dampening elements being spaced apart and each of said dampening elements projecting from said first surface toward said valve member and disposed substantially opposite a respective one of said plurality of discharge ports wherein said second portion of said valve member strikes said plurality of dampening elements before said first surface proximate said dampening elements when said valve member is biased away from said discharge port.

10. The compressor assembly of claim 9 wherein said compressor mechanism is a reciprocating compressor mechanism.

11. A method of dampening a valve impact in a compressor assembly, said method comprising:

compressing a fluid in the compression chamber of a compressor mechanism;

discharging the compressed fluid from the compression chamber to a discharge chamber through at least one discharge port;

securing a valve member to the compressor mechanism wherein said valve member has a freely extending portion sealingly engageable with the discharge port to close the discharge port and being flexible outwardly away from the at least one discharge port;

providing a rigid valve retainer having a first surface defining a first surface area;

securing the valve retainer to the compressor mechanism wherein the first surface faces the valve member and is positioned to limit the outward flexing of the valve member;

affixing a dampening element to the valve retainer substantially opposite the discharge port wherein the dampening element projects outwardly from the first surface towards the valve member and defines a second surface area facing the valve member, the second surface area being less than the first surface area;

biasing the valve member into an open position away from the discharge port towards the valve retainer; and

dampening the impact of the valve member against the valve retainer with the dampening element.

12. The method of claim 11 further comprising providing the valve retainer with at least one mounting aperture and affixing the at least one dampening element to the valve
retainer by partially disposing the at least one dampening element in the at least one mounting aperture.

13. The method of claim 12 wherein the dampening element is snap-fit into the mounting aperture.

14. The method of claim 12 wherein the compressed fluid is discharged from the compression chamber to the discharge chamber through a plurality of discharge ports and the freely extending portion of the valve member sealingly engages each of the plurality of discharge ports and is flexible outwardly away from each of the discharge ports; the at least one mounting aperture comprising a plurality of mounting apertures and the at least one dampening element comprising a plurality of discrete dampening elements wherein each of the dampening elements is secured in a mounting aperture substantially opposite one of the plurality of discharge ports, each of the plurality of dampening elements projecting outwardly from the first surface towards the valve member.

15. The method of claim 14 wherein the valve member has a generally circular shape and is secured to the compressor mechanism at two diametrically opposite locations, the freely extending portion of the valve member comprising two separate freely extending sections.

16. The method of claim 11 wherein the valve retainer is formed of a metallic material and the at least one dampening element is formed of a thermostetting material.

17. The method of claim 11 wherein the at least one dampening element is formed of polyetherimide material.

18. The method of claim 17 wherein the valve retainer is formed of cold rolled steel.

19. The method of claim 17 wherein the at least one dampening element projects outwardly from the first surface by a distance between approximately 0.004 inches and 0.008 inches.

20. The method of claim 17 wherein the at least one dampening element projects outwardly from the first surface by a distance between approximately 0.004 inches and 0.005 inches.