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SEALING GASKET

FIELD OF THE INVENTION

The field of the invention relates to a sealing gasket for a vacuum pump,
5 and a vacuum pump.

BACKGROUND

Rotating machines, such as compressors or pumps, need to be carefully
designed and manufactured in order for the moving parts to cooperate with
10 each other accurately. Providing effective seals to seal the machine tends to be
problematic, particularly when fluid flow is encouraged by a pressure difference
between the machine and ambient environment. It is desired to provide an
improved seal.

15 SUMMARY OF THE INVENTION

In an aspect, there is provided a sealing gasket for a vacuum pump, the
sealing gasket comprising: a first surface; a second surface opposite to the first
surface; opposing side walls disposed between the first and second surfaces;
and one or more protrusions extending from the first surface.

20 The sealing gasket may comprise a plurality of protrusions extending
from the first surface. The protrusions may be spaced apart from one another at
discrete positions across the first surface.

The one or more protrusions may extend substantially perpendicularly
from the first surface.

25 Each of the protrusions may have a cross section, the shape of which is
a rounded polygon, e.g. a rounded square or a rounded rectangle.

Each of the protrusions may comprise a proximal end at which the
protrusion is connected to the first surface, and a distal end opposite to the
proximal end. A length of the protrusion between the proximal end and the distal

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end may be between 1 mm and 6 mm. The proximal end may be spaced apart from one or both of the opposing side walls in a direction from one side wall to another side wall. The proximal end may be spaced apart from a first side wall in the direction from one side wall to another side wall by a distance of less than
5 or equal to 0.4 mm. The proximal end may be spaced apart from a second side wall in the direction from one side wall to another side wall by a distance of less than or equal to 0.4 mm.

The sealing gasket may be a one-piece gasket. The sealing gasket may be a moulded gasket. The sealing gasket may be deformable. The sealing
10 gasket may be an elastomer.

The sealing gasket may comprise: a first sealing member defining a closed shape; a second sealing member defining a closed shape; a first longitudinal sealing member connected between the first sealing member and the second sealing member; and a second longitudinal sealing member
15 connected between the first sealing member and the second sealing member. The first sealing member and/or the second sealing member may define a respective closed shape selected from the group of closed shapes consisting of an annulus, a circle, an oval, an ellipse, a stadium, a rounded polygon, a rounded square, a rounded rectangle, and a squircle. The first sealing member
20 and/or the second sealing member may each comprise a respective plurality of the protrusions which extended outwardly from an outer surface.

In a further aspect, there is provided a vacuum pump, comprising: shell stators defining at least one pumping chamber; end pieces mountable at either end of the shell stator; and the sealing gasket of any preceding claim.

25 The shell stators and/or the end pieces may define one or more seal grooves in which the sealing gasket is located. The one or more seal grooves may comprise one or more voids extending from a side wall of the seal grooves. The one or more protrusions may be received in respective voids. The voids may be slots.

30 For each protrusion and the respective void in which it is received, the length of that void from an open end of the void to a closed end of the void may be greater than the length of the portion of that protrusion that is within the void,

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thereby to allow for expansion of the protrusion within the void in the direction along the length of the protrusion.

For each protrusion and the respective void in which it is received, the width of that void in a direction that is perpendicular to the direction from an open end of the void to a closed end of the void may be less than or equal to
5 the width of the portion of that protrusion that is within the void, thereby to provide an interference fit of the protrusion in the void.

BRIEF DESCRIPTION OF THE DRAWINGS

10 The present invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 is a schematic illustration (not to scale) showing a housing of a vacuum pump;

Figure 2 is a schematic illustration (not to scale) of a sealing gasket;

15 Figure 3 is a further schematic illustration (not to scale) of the sealing gasket;

Figure 4 is a schematic illustration (not to scale) of a cross section of the sealing gasket;

20 Figure 5 is a process flow chart showing certain steps of a method of incorporating the sealing gasket into the housing;

Figure 6 is a schematic illustration (not to scale) showing sealing gasket incorporated into the housing;

Figure 7 is a schematic illustration (not to scale) showing a portion of the sealing gasket in the housing;

25 Figure 8 is a schematic illustration (not to scale) showing a portion of the housing;

Figure 9 is a schematic illustration (not to scale) showing a further sealing gasket incorporated into a housing;

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Figure 10 is a schematic illustration (not to scale) showing an alternative sealing gasket;

Figure 11 is a schematic illustration (not to scale) showing an alternative sealing gasket;

5 Figure 12 is a schematic illustration (not to scale) of a top view of a further sealing gasket;

Figure 13 is a schematic illustration (not to scale) of a perspective view of the further sealing gasket; and

10 Figure 14 is a schematic illustration (not to scale) showing the portion of the further sealing gasket disposed in a seal groove formed in the shell stators of the housing.

DETAILED DESCRIPTION

15 Figure 1 is a schematic illustration (not to scale) showing a housing 10 of a vacuum pump, according to one embodiment. The housing 10 comprises a pair of shell stators 12, 14 and a pair of end plates 16, 18. The shell stators 12, 14 define recesses which receive components of the vacuum pump. The shell stators 12, 14 are brought together to retain the components in those recesses. The end plates 16, 18 are then brought to retain the shell stators 12, 14. This
20 provides for particularly convenient assembly of the vacuum pump.

In other words, the housing 10 of the vacuum pump may be formed from multiple component parts, including shells 12, 14 and end plates 16, 18 which need to be sealed upon assembly. In the arrangement shown in Figure 1, the stator is formed by bringing together the two housing parts or shells 12, 14
25 which are then retained between the pair of end plates 16, 18.

As will be explained in more detail below, in this embodiment, to adequately seal the shell stators 12, 14 together, one or more (e.g. two) longitudinal seals are located along the joining faces of the shell stators 12, 14. Also, to ensure adequate sealing between the shell stators 12, 14 and the

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respective end plates 16, 18, a pair of annular seals is located between the end plates 16, 18 and the shell stators 12, 14.

Figure 2 is a schematic illustration (not to scale) of a sealing gasket 20 for sealing the housing 10, according to one embodiment.

5 The sealing gasket 20 comprises a first sealing member 22, a second sealing member 24, a first longitudinal sealing member 26, and a second longitudinal sealing member 28.

10 In this embodiment, the first and second sealing members 22, 24 are approximately annular sealing members. However, in other embodiments, the first and second sealing members 22, 24 may have or may define different shapes, preferably closed shapes such as an ellipse, an oval, a stadium, a rounded square, a squircle, a rounded rectangle, or a rounded polygon.

15 The first sealing member 22 comprises a first annular surface 30, a second annular surface 32 opposite the first annular surface 30, a first radially inner surface 34, and a first radially outer surface 36 opposite to the first radially inner surface 34. The first radially inner surface 34 and the first radially outer surface 36 are disposed between the first annular surface 30 and the second annular surface 32.

20 The second sealing member 24 comprises a third annular surface 40, a fourth annular surface 42 opposite the third annular surface 40, a second radially inner surface 44, a second radially outer surface 46 opposite to the second radially inner surface 44. The second radially inner surface 44 and the second radially outer surface 46 are disposed between the third annular surface 40 and the fourth annular surface 42.

25 The first longitudinal sealing member 26 is connected or attached between the first radially outer surface 36 (of the first annular sealing member 22) and the second radially outer surface 46 (of the second annular sealing member 24).

30 The second longitudinal sealing member 28 is connected or attached between the first radially outer surface 36 (of the first annular sealing member

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22) and the second radially outer surface 46 (of the second annular sealing member 24).

The second longitudinal sealing member 28 is arranged opposite to the first longitudinal sealing member 26. That is to say, the second longitudinal sealing member 28 is connected to the first and second annular sealing members 22, 24 and at an opposite side of the first and second annular sealing members 22, 24 to the side at which the first longitudinal sealing member 26 is connected to the first and second annular sealing members 22, 24.

The first annular seal member 22 is a ring-shaped sealing member. The first annular seal member 22 has a square or rectangular cross-section.

The second annular seal member 24 is a ring-shaped sealing member. The second annular seal member 24 has a square or rectangular cross-section.

The first longitudinal sealing member 26 may be an O-ring cord. The first longitudinal sealing member 26 has a square or rectangular cross-section.

The second longitudinal sealing member 28 may be an O-ring cord. The second longitudinal sealing member 28 has a square or rectangular cross-section.

In this embodiment, the sealing gasket 20 is a continuous one-piece sealing gasket.

In this embodiment, the sealing gasket 20 comprises a plurality of protrusions 48a, 48b, 48c, 48d. More specifically, the sealing gasket 20 comprises a first plurality of protrusions 48a that extend normally from the first annular surface 30. Also, the sealing gasket 20 comprises a second plurality of protrusions 48b that extend normally from the third annular surface 40. Also, the sealing gasket 20 comprises a third plurality of protrusions 48c that extend normally from an upper surface (in the orientation of Figure 1) of the first longitudinal sealing member 26. Also, the sealing gasket 20 comprises a fourth plurality of protrusions 48d that extend normally from an upper surface (in the orientation of Figure 1) of the second longitudinal sealing member 28.

Preferably, the plurality of protrusions 48a, 48b, 48c, 48d are substantially identical in shape and size.

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The sealing gasket 20 may be made of a deformable or flexible material, such as an elastomer material (e.g. a fluoroelastomers (FKM/FPM) or a perfluoroelastomer (FFKM)) or silicon, such that the sealing gasket 20 is deformable or flexible. Thus, the sealing gasket 20 may be deformed into a
5 desired shape or configuration suitable for use as a seal for the housing 10.

Figure 3 is a schematic illustration (not to scale) showing the sealing gasket 20 that has been deformed into a configuration that may be suitable for sealing the housing 10.

In this configuration, the first and second sealing members 22, 24 are
10 rounded square, i.e. define squares with curved or rounded corners. The configuration has major faces (which are the first radially inner surface 34 and the first radially outer surface 36 of the first sealing member 22, and the second radially inner surface 44 and the second radially outer surface 46 of the second annular sealing member 24) which, in use, abut against major faces of the end
15 plates 16, 18 and the adjacent faces of the shell stators 12, 14. In this example, the first and second sealing members 22, 24 have substantially planar, axially outer faces, provided by the first radially inner surface 34 and the second radially inner surface 44 respectively. The first and second sealing members 22, 24 have substantially planar, axially inner faces, provided by the first radially
20 outer surface 36 and the second radially outer surface 46 respectively. The longitudinal sealing members 26, 28 are connected between the facing axially inner faces of the annular sealing members 22, 24 (i.e., between the first radially outer surface 36 and the second radially outer surface 46). The annular sealing members 22, 24 have substantially constant thicknesses.

25 In this configuration, the first annular surface 30 of the first sealing member 22 has been moved or rotated so that it defines a radially outer wall of the first sealing member 22. Thus, each protrusion 48a in the first plurality of protrusions 48a extends radially outwards from the first annular surface 30.

Similarly, in this configuration, the third surface 40 of the second sealing
30 member 24 has been moved or rotated so that it defines a radially outer wall of the second sealing member 24. Thus, each protrusion 48b in the second plurality of protrusions 48b extends radially outwards from the third surface 30.

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In this configuration, the first longitudinal sealing member 26 has been moved or rotated so that each protrusion 48c in the third plurality of protrusions 48c extends outwards from the sealing gasket 20 in a direction that is substantially perpendicular to a direction along the length of the sealing gasket 20.

Similarly, in this configuration, the second longitudinal sealing member 28 has been moved or rotated so that each protrusion 48d in the fourth plurality of protrusions 48d extends outwards from the sealing gasket 20 in a direction that is substantially perpendicular to a direction along the length of the sealing gasket 20, and in an opposite direction to that in which the protrusions 48c extend.

Figure 4 is a schematic illustration (not to scale) showing a cross section through the seal gasket 20 at the location of a protrusion 48.

In particular, Figure 4 shows a cross section through the first sealing member 22 along the length of a first protrusion 48a. It will be appreciated by those skilled in the art that the protrusions 48b-d in the second, third and fourth pluralities of protrusions 48b-d may be similarly formed.

In this embodiment, the protrusion 48a extends substantially perpendicularly from the first annular surface 30 away from the first seal member 20.

Preferably, the protrusion 48a has a cross-section that has the shape of a rounded polygon. In this embodiment, the shape of the cross-section of the protrusion 48a taken through the plane perpendicular to the page of Figure 4 and indicated by a dotted line 50 is that of a rounded square or a rounded rectangle.

The protrusion 4a comprises a proximal end 52 at which the protrusion 48a is connected to the first annular surface 30, and a distal end 54 opposite to the proximate end 52.

The length l_1 of the protrusion 48a between the proximal end 52 and the distal end 54 may be application dependent. For example, the length l_1 may be

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between about 1 mm and 6 mm, or between about 2 mm and 5 mm, or between about 3 mm and 5 mm, for example a preferred value of l_1 may be about 4 mm.

In this embodiment, the proximal end 52 is spaced apart from the first radially inner surface 34 (in a direction along the first annular surface 30) by a first distance d_1 . The first distance d_1 may be application dependent. For example, the first distance d_1 may be less than or equal to about 0.4 mm, or less than or equal to about 0.3 mm, or less than or equal to about 0.2 mm, or less than or equal to about 0.1 mm, for example the preferred value of d_1 may be about 0.1 mm.

In this embodiment, the proximal end 52 is spaced apart from the first radially outer surface 36 (in a direction along the first annular surface 30) by a second distance d_2 . Preferably, the second distance d_2 is approximately equal to the first distance d_1 . The second distance d_2 may be application dependent. For example, the second distance d_2 may be less than or equal to about 0.4 mm, or less than or equal to about 0.3 mm, or less than or equal to about 0.2 mm, or less than or equal to about 0.1 mm, for example the preferred value of d_2 may be about 0.1 mm.

In this embodiment, the protrusion 48a tapers along its length. In other words, the width w_1 of the protrusion 48a decreases (e.g. linearly) from its proximal end 52 to its distal end 54.

Figure 5 is a process flow chart showing certain steps (s50 – s58) of a method 500 of fitting, installing, or incorporating the sealing gasket 20 into the housing 10.

Figure 6 is a schematic illustration (not to scale) illustrating the incorporation of the sealing gasket 20 into the housing 10, useful in understanding the process of Figure 5.

At step s50, the shell stator 14 is provided, into which components (not shown) of the vacuum pump may be assembled.

At step s52, the sealing gasket 20 is positioned relative to the shell stator 14 such that the first and second longitudinal sealing members 26, 28 are

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located along the joining face of shell stator 14, in seal grooves extending along the joining face of shell stator 14. This may be as depicted in Figure 6.

At step s54, the shell stator 12 is brought into close contact with the longitudinal sealing members 26, 28.

5 Referring to Figure 6, the shell stator 12 may be moved onto the longitudinal sealing members 26, 28 towards the joining face of shell stator 14, as indicated in Figure 6 by an arrow and the reference numeral 60.

At step s56, the shell stators 12, 14 are clamped together, which compresses the longitudinal sealing members 26, 28.

10 Thus, after step s56, the annular sealing members 22, 24 tend to extend or protrude axially from the axial ends of the assembled together shell stators 12, 14.

At step s58, the end plates 16, 18 are brought together to compress the annular seals 22, 24 in the axial (i.e. longitudinal) direction.

15 The annular sealing members 22, 24 are located in annular seal grooves located in the shell stators 12, 14 and/or the end plates 16, 18.

Referring to Figure 6, the end plate 18 is shown having been moved onto the first annular sealing member 22 at a first end of the assembled together shell stators 12, 14. The end plate 16 may be moved onto the second annular
20 sealing member 24 at a second end (opposite to the first end) of the assembled together shell stators 12, 14, as indicated in Figure 6 by an arrow and the reference numeral 62.

Thus, a method of fitting, installing, or incorporating the sealing gasket 20 into the housing 10 is provided.

25 In this embodiment, the sealing gasket 20 is located in seal grooves formed in one or both of the shell stators 12, 14 and/or the end plates 16, 18. The seal grooves comprise a plurality of voids or slots in which respective ones of the protrusions 48a-d are received.

Figure 7 is a schematic illustration (not to scale) showing an example
30 portion of a seal groove 70 in which the first sealing member 22 of the sealing

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gasket 20 is fitted. Other portions of the sealing gasket 20 may be located in other seal grooves in similar or identical fashion.

The seal groove 70 is a closed shape seal groove and may have the shape of, for example, an annulus, a loop, a ring, an ellipse, an oval, a rounded square or rounded rectangle (i.e. a square or rectangle with rounded corners), a squircle, or a rounded polygons.

The seal groove 70 may be formed in an end surface of a shell stator 12, 14 or an end plate 16, 18.

The seal groove 70 comprises a void or slot 72 extending outwardly from a side wall of the seal groove, specifically an outer wall 73 of the seal groove 70. At least a portion of the protrusion 48a of the first sealing member 22 is located in the slot 72.

In this embodiment, the length l_2 of the slot 72 from an opening or open end 74 of the slot 72 to a closed end 76 of the slot 72 is greater than the length l_3 of the portion of the protrusion 48a that is located in the slot 72. Thus, there is a gap 78 between the distal end 54 of the protrusion 48a and the closed end 76 of the slot 72. This advantageously tends to allow for expansion of the protrusion 48a within the slot 72 in the direction along the length of the protrusion, for example due to the heating and/or compression of the sealing gasket 20.

In this embodiment, the width w_2 of the slot 72 (the width w_2 being in a direction that is perpendicular to the length l_2 of the slot 72) is less than or equal to the width of the portion of the protrusion 48a that is within the slot 72. This advantageously tends to provide an interference fit of the protrusion 48a in the slot 72. Thus, during assembly (e.g. during step s52 of the method 500 of Figure 5), the sealing gasket 20 tends to be held in place by the protrusions 48a-d being held or gripped in the slots 72. Twisting or movement of the sealing gasket 20 out of the seal grooves tends to be reduced or eliminated. This tends to reduce the likelihood of the seal gasket 20 being out of position in the assembled system, and thus the likelihood of gas leakage is reduced.

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Preferably, the first sealing member 22 is thinner than the seal groove 70. Also, preferably, proximate the proximal end of the protrusion 48a, the width w_1 of the protrusion 48a is sufficiently larger than the opening 74 of the slot 72 so that that portion of the protrusion 48a cannot be fitted into the slot 72. This advantageously tends to provide that, remote from the protrusion 48a, the first sealing member 22 is within the seal groove 70 but is spaced apart from the outer wall 73 of the seal groove 70, i.e. that there is a gap 80a between the first sealing member 22 and the outer wall 73. Furthermore, in this embodiment, when the first sealing member 22 is fitted into the seal groove 70 and the protrusion 48a is received in the slot 72 (as shown in Figure 7), the first sealing member 22 is spaced apart from the inner wall 82 of the seal groove 70, i.e. there is a gap 80b between the first sealing member 22 and the inner wall 82. (The inner wall of 82 is opposite to the outer wall 73.) This advantageously tends to allow for expansion of the first sealing member 22 within the seal groove 70, for example due to the heating and/or compression of the sealing gasket 20. Also, this advantageously tends to facilitate installation of the sealing gasket into the housing 10.

Figure 8 is a schematic illustration (not to scale) shows the seal groove 70 and slot 72, without the sealing gasket 20 disposed therein.

In this embodiment, there is a step 84 between a bottom surface 86 of the seal groove 70 and the opening 74 of the slot 72. Preferably, the size of the step 84 along the outer wall 73 from the bottom surface 86 of the seal groove 70 to the opening 74 is substantially the same as the first distance d_1 and/or the second distance d_2 .

The sealing gasket tends to be easy to install into a housing or a vacuum pump.

Advantageously, the sealing gasket described herein tends to be relatively easy to produce or manufacture compared to conventional sealing assemblies. For example, the sealing gasket tends to be relatively easy to produce via moulding. For example, the sealing gasket can be moulded, in a mould, as a single-piece, as a substantially planar or flat item (as shown in Figure 2 and described in more detail earlier above), and then deformed or

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manipulated into a desired shape or configuration (e.g., such as that shown in Figure 3 and described in more detail earlier above). Moulding may be performed using a mould tool comprising a first part comprising a recess that is the desired shape of the sealing gasket; a substantially planar second part can
5 be placed over the recess in the first part thereby to define a mould cavity in which the sealing gasket can be formed. Advantageously, the sealing gasket formed in this way tends not to have a parting line (where the two different side of the mould come together). Thus, the potential for separation of the sealing gasket tends to be greatly reduced. Moreover, any mould flash present on the
10 moulded sealing gasket tends to be restricted to non-critical areas of the sealing gasket, such as extending outwards from the upper surface of the sealing gasket when in the orientation of Figure 2). This tends to improve robustness and stability of the sealing gasket.

The sealing gasket can be designed slightly shorter than the longitudinal
15 grooves in the shell stators (i.e. the gasket grooves) so that it has a low tension during assembly. This tends to make the sealing gasket self-positioning regardless of the annular groove depths.

Advantageously, it tends to be possible to mould the sealing gasket on its side in one plane (i.e. in the configuration of Figure 2). This tends to achieve
20 a continuous sealing surface from the side walls of the mould tool, without any split-lines, which ensures a high integrity sealing surface. This one-piece seal shape tends to be reconfigurable to fit the seal housing by using bending only and requiring no twisting of any section of the seal.

It will be appreciated that the cord and the gasket can have different
25 shapes or thicknesses to suit the arrangement of the housing.

In the above embodiments, the sealing gasket is a continuous one-piece sealing gasket. However, in other embodiments, the sealing gasket comprises multiple separate parts that are joined together. The multiple parts may be joined together by any joining means or methods, such as using an adhesive,
30 fusion, or via an interference fit.

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In the above embodiments, the sealing gasket has substantially constant cross-section over its parts. However, in other embodiments, the sealing gasket has non-constant cross-section.

5 In the above embodiments, the sealing gasket has square or rectangular cross-section. However, in other embodiments, some or all of the sealing gasket has an alternative cross-section other than square or rectangular, such as circular, triangular, oval, etc.

10 In the above embodiments, the sealing gasket may be made of an elastomer. In some embodiments, the sealing gasket may be made of a different, deformable material, for example, a metal.

Although the major faces of the sealing gasket in the above embodiments are substantially planar, it will be appreciated that they may be any shape which is suitable for engaging with the major faces of the end plates and the adjacent faces of the shell stators.

15 Although in Figure 2, sixteen protrusions are shown on the sealing gasket, it will be appreciated by those skilled in the art that any appropriate number of protrusions and corresponding slots in the seal groove may be implemented. A greater number of protrusions and slots tends to reduce the likelihood of the sealing gasket moving out of the seal groove.

20 In the above embodiments, the protrusions have a shape as described in more detail earlier above with reference to Figure 4. In particular, the protrusions have rounded square or rounded rectangular cross sections, taper inwardly along their lengths from proximal end to distal end, and extend from the body of the sealing gasket in one direction. However, in other embodiments,
25 the protrusions have different appropriate shapes or configurations.

Figure 9 is a schematic illustration (not to scale) showing a further embodiment of a sealing gasket 90. In this embodiment, the protrusions 92 are substantially L-shaped or hook-shaped protrusions that fit or plug into correspondingly shaped voids 94 in the housing 10.

30 In the above embodiments, the sealing gasket may be manufactured by moulding as a single-piece, as a substantially planar or flat item as shown in

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Figure 2. However, in other embodiments, the sealing gasket may be manufactured in a different way, for example by moulding as a single-piece, as a substantially planar or flat item as shown in Figure 10 (see single-piece, substantially planar or flat gasket 130) or Figure 11 (see single-piece, substantially planar or flat gasket 140).

In some embodiments, the sealing gasket comprises annular sealing members that, in use, seal against the end plates. However, these sealing members may have shape other than strictly annular. The sealing members define closed shapes, and may define closed shapes other than annuluses such as loops, rings, ellipses, ovals, rounded squares or rounded rectangles (i.e. squares or rectangles with rounded corners), squircles, or rounded polygons.

An embodiment in which the sealing members that, in use, seal against the end plates define rounded squares, i.e. substantially squircles, will now be described.

Figures 12 and 13 are schematic illustrations (not to scale) of a further sealing gasket 150 for sealing the housing 10, according to one embodiment.

The sealing gasket 150 comprises a first sealing member 151, a second sealing member 152, a first longitudinal sealing member 153, and a second longitudinal sealing member 154.

The first sealing member 151 defines a closed shape. In particular, in this embodiment, the first sealing member 151 defines a rounded square, i.e. a square with rounded corners, or substantially a squircle,

The first sealing member 151 comprises a first rounded square surface 161, a second rounded square surface 162 opposite the first rounded square surface 161, a first inner surface 163, and a first outer surface 164 opposite to the first inner surface 163. The first inner surface 163 and the first outer surface 164 are disposed between the first rounded square surface 161 and the second rounded square surface 162.

The first sealing member 151 comprises a first curved section 165a, a second curved section 165b, a third curved section 165c, a fourth curved

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section 165d, a first substantially straight section 166a disposed between the first curved section 165a and the second curved section 165b, a second substantially straight section 166b disposed between the second curved section 165b and the third curved section 165c, a third substantially straight section 166c disposed between the third curved section 165c and the fourth curved section 165d, and a fourth substantially straight section 166d disposed between the fourth curved section 165d and the first curved section 165a. The first longitudinal sealing member 153 is connected to the first curved section 165a. The second longitudinal sealing member 154 is connected to the third curved section 165c.

The first sealing member 151 comprises a first plurality of protrusions 178a. The first plurality of protrusions 178a extend normally from the first rounded square surface 161. In this embodiment, there are eight protrusions 178a in the first plurality of protrusions 178a. However, in other embodiments, there may be a different number of protrusions 178a in the first plurality of protrusions 178a.

In this embodiment, the first plurality of protrusions 178a are located at respective boundaries between straight and curved sections of the first sealing member 151. There is a protrusion 178a located at the boundary between the first curved section 165a and the first substantially straight section 166a. Also, there is a protrusion 178a located at the boundary between the first substantially straight section 166a and the second curved section 165b. Also, there is a protrusion 178a located at the boundary between the second curved section 165b and the second substantially straight section 166b. Also, there is a protrusion 178a located at the boundary between the second substantially straight section 166b and the third curved section 165c. Also, there is a protrusion 178a located at the boundary between the third curved section 165c and the third substantially straight section 166c. Also, there is a protrusion 178a located at the boundary between the third substantially straight section 166c and the fourth curved section 165d. Also, there is a protrusion 178a located at the boundary between the fourth curved section 165d and the fourth substantially straight section 166d. Also, there is a protrusion 178a located at

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the boundary between the fourth substantially straight section 166d and the first curved section 165a.

The second sealing member 152 defines a closed shape. In particular, in this embodiment, the second sealing member 152 defines a rounded square, i.e. a square with rounded corners, or substantially a squircle,

The second sealing member 152 comprises a third rounded square surface 171, a fourth rounded square surface 172 opposite the third rounded square surface 171, a second inner surface 173, a second outer surface 174 opposite to the second inner surface 173. The second inner surface 173 and the second outer surface 174 are disposed between the third rounded square surface 171 and the fourth rounded square surface 172.

The second sealing member 152 comprises a fifth curved section 175a, a sixth curved section 175b, a seventh curved section 175c, an eighth curved section 175d, a fifth substantially straight 176a section disposed between the fifth curved section 175a and the sixth curved section 175b, a sixth substantially straight section 176b disposed between the sixth curved section 175b and the seventh curved section 175c, a seventh substantially straight section 176c disposed between the seventh curved section 175c and the eighth curved section 175d, and an eighth substantially straight section 176d disposed between the eighth curved section 175d and the fifth curved section 175a. The first longitudinal sealing member 153 is connected to the fifth curved section 175a. The second longitudinal sealing member 154 is connected to the seventh curved section 175c.

The second sealing member 152 comprises a second plurality of protrusions 178b. The second plurality of protrusions 178b extend normally from the third rounded square surface 171. In this embodiment, there are eight protrusions 178b in the second plurality of protrusions 178b. However, in other embodiments, there may be a different number of protrusions 178b in the second plurality of protrusions 178b.

In this embodiment, the second plurality of protrusions 178b are located at respective boundaries between straight and curved sections of the second sealing member 152. There is a protrusion 178b located at the boundary

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between the fifth curved section 175a and the fifth substantially straight section 176a. Also, there is a protrusion 178b located at the boundary between the fifth substantially straight section 176a and the sixth curved section 175b. Also, there is a protrusion 178b located at the boundary between the sixth curved section 175b and the sixth substantially straight section 176b. Also, there is a protrusion 178b located at the boundary between the sixth substantially straight section 166b and the seventh curved section 175c. Also, there is a protrusion 178b located at the boundary between the seventh curved section 175c and the seventh substantially straight section 176c. Also, there is a protrusion 178b located at the boundary between the seventh substantially straight section 176c and the eighth curved section 175d. Also, there is a protrusion 178b located at the boundary between the eighth curved section 175d and the eighth substantially straight section 176d. Also, there is a protrusion 178b located at the boundary between the eighth substantially straight section 176d and the fifth curved section 175a.

The first longitudinal sealing member 153 is connected or attached between the first outer surface 164 (of the first sealing member 151) and the second outer surface 174 (of the second sealing member 152).

The first longitudinal sealing member 153 comprises a third plurality of protrusions 178c extending normally therefrom. In this embodiment, there are two protrusions 178c in the third plurality of protrusions 178c. However, in other embodiments, there may be a different number of protrusions 178c in the third plurality of protrusions 178c.

The second longitudinal sealing member 154 is connected or attached between the first outer surface 164 (of the first sealing member 151) and the second outer surface 174 (of the second sealing member 152).

The second longitudinal sealing member 154 is arranged opposite to the first longitudinal sealing member 153. That is to say, the second longitudinal sealing member 154 is connected to the first and second sealing members 151, 152 and at an opposite side of the first and second sealing members 151, 152 to the side at which the first longitudinal sealing member 153 is connected to the first and second sealing members 151, 152.

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The second longitudinal sealing member 154 comprises a fourth plurality of protrusions 178d extending normally therefrom. In this embodiment, there are two protrusions 178d in the fourth plurality of protrusions 178d. However, in other embodiments, there may be a different number of protrusions 178d in the fourth plurality of protrusions 178d.

Preferably, the plurality of protrusions 178a-d are substantially identical in shape and size.

The first seal member 151 has a square or rectangular cross-section. The second seal member 152 has a square or rectangular cross-section.

The first longitudinal sealing member 153 may be an O-ring cord. The first longitudinal sealing member 153 may have a square or rectangular cross-section.

The second longitudinal sealing member 154 may be an O-ring cord. The second longitudinal sealing member 154 may have a square or rectangular cross-section.

In this embodiment, the sealing gasket 150 is a continuous one-piece sealing gasket.

The sealing gasket 150 is made of a deformable or flexible material, such as an elastomer material (e.g. a fluoroelastomers (FKM/FPM) or a perfluoroelastomer (FFKM)) or silicon, such that the sealing gasket 150 is deformable or flexible. Thus, the sealing gasket 150 may be deformed into a desired shape or configuration suitable for use as a seal for the housing 10.

The sealing gasket 150 may be installed into the housing 10, for example as described in more detail earlier above with reference to Figure 5. In this way, the first and second longitudinal sealing members 153, 154 may be disposed in sealing engagement with the shell stators 12, 14, which may be clamped together to compress the longitudinal sealing members 153, 154. Also, the rounded square sealing members 151, 152 may be located in closed-shape seal grooves located in the shell stators 12, 14 and/or the end plates 16, 18. A seal groove may have any appropriate closed shape, such as an annulus, a

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circle, an oval, an ellipse, a stadium, a rounded square, a squircle, a rounded rectangle, a rounded polygon, etc.

Figure 14 is a schematic illustration (not to scale) showing the first sealing member 151 fitted into a closed-shape seal groove 177 located in the shell stators 12, 14. In this embodiment, the seal groove 177 defines a rounded square or rounded rectangle. In this embodiment, the second sealing member 152 may be fitted into substantially identical closed-shape seal groove 177 at the opposite end of the shell stators 12, 14.

In this embodiment, the curved sections 165a-d of the first sealing member 151 are located in respective substantially straight portions of the seal groove 177. Also, the substantially straight sections 166a-d of the first sealing member 151 are located in respective curved portions of the seal groove 177.

In particular, the first curved section 165a is disposed in a first substantially straight portion 180a of the seal groove 177, the second curved section 165b is disposed in a second substantially straight portion 180b of the seal groove 177, the third curved section 165c is disposed in a third substantially straight portion 180c of the seal groove 177, the fourth curved section 165d is disposed in a fourth substantially straight portion 180d of the seal groove 177, the first substantially straight section 166a is disposed in a first curved portion 182a of the seal groove 177, the second substantially straight section 166b is disposed in a second curved portion 182b of the seal groove 177, the third substantially straight section 166c is disposed in a third curved portion 182c of the seal groove 177, and the fourth substantially straight section 166d is disposed in a fourth curved portion 182d of the seal groove 177.

As described above, the substantially rounded square sealing members being located in the rounded square seal groove such that the curved sections of the rounded square sealing member are located in substantially straight portions of the seal groove, and such the substantially straight sections of the sealing member are located in curved portions of the seal groove 177. This advantageously tends to reduce stresses in the rounded square sealing members. In particular, compound bending and/or twisting of the sealing member when installing the sealing member in the seal groove tends to be

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reduced compared to other shapes of sealing member. This tends to improve seal life. Furthermore, retention of the sealing member within the seal groove retention tends to be improved. For example, the reduced twisting and/or compound bending of the sealing member tends to reduce the sealing member
5 twisting out of the seal groove.

The protrusions 178a-d are interference fit in respective slots. This advantageously tends to improve retention of the sealing member within the seal groove and reduce the likelihood of leaks.

Although illustrative embodiments of the invention have been disclosed
10 in detail herein, with reference to the accompanying drawings, it is understood that the invention is not limited to the precise embodiment and that various changes and modifications can be effected therein by one skilled in the art without departing from the scope of the invention as defined by the appended claims and their equivalents.

15

Reference numeral list

- 10 – housing
- 12, 14 – shell stators
- 16, 18 – end plates
- 5 20 – sealing gasket
- 22 – first annular sealing member
- 24 – second annular sealing member
- 26 – first longitudinal sealing member
- 28 – second longitudinal sealing member
- 10 30 – first annular surface
- 32 – second annular surface
- 34 – first radially inner surface
- 36 – first radially outer surface
- 40 – third annular surface
- 15 42 – fourth annular surface
- 44 – second radially inner surface
- 46 – second radially outer surface
- 48a-d - protrusions
- 50 – plane
- 20 52 - proximal end
- 54 - distal end
- s50-s58 – method steps
- 60, 62 – directions
- 70 – seal groove
- 25 72 – slot
- 73 - outer wall

- 23 -

- 74 – open end
- 76 – closed end
- 78 – gap
- 80a - gap
- 5 80b – gap
- 82 – inner wall
- 84 – step
- 86 – bottom surface
- 90 – sealing gasket
- 10 92 – protrusions
- 94 – voids
- 130, 140 – sealing gasket
- 150 – sealing gasket
- 151 – first sealing member
- 15 152 – second sealing member
- 153 – first longitudinal sealing member
- 154 – second longitudinal sealing member
- 161 – first rounded square surface
- 162 – second rounded square surface
- 20 163 – first inner surface
- 164 – first outer surface
- 165a-d – curved portions
- 166a-d – straight portions
- 171 – third rounded square surface
- 25 172 – fourth rounded square surface
- 173 – second inner surface

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174 – second outer surface

175a-d – curved portions

176a-d – straight portions

178a-d – protrusions

5 180a-d - curved portions

182a-d - straight portions

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CLAIMS

1. A sealing gasket for a vacuum pump, the sealing gasket comprising:
 - a first surface;
 - 5 a second surface opposite to the first surface;
 - opposing side walls disposed between the first and second surfaces; and
 - one or more protrusions extending from the first surface.
- 10 2. The sealing gasket of claim 1, comprising a plurality of protrusions extending from the first surface spaced apart from one another at discrete positions across the first surface.
3. The sealing gasket of any preceding claim, wherein the one or
15 more protrusions extend perpendicularly from the first surface.
4. The sealing gasket of any preceding claim, wherein each of the protrusions has a cross section, the shape of which is a rounded polygon, for example, a rounded square or a rounded rectangle.
- 20 5. The sealing gasket of any preceding claim, wherein each of the protrusions comprises:
 - a proximal end at which the protrusion is connected to the first surface; and
 - 25 a distal end opposite to the proximal end; and wherein
 - a length of the protrusion between the proximal end and the distal end is between 1 mm and 6 mm.

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6. The sealing gasket of any preceding claim, wherein each of the protrusions comprises:

a proximal end at which the protrusion is connected to the first surface; and

5 a distal end opposite to the proximate end; and wherein

the proximal end is spaced apart from one or both of the opposing side walls in a direction from one side wall to another side wall.

7. The sealing gasket of claim 6, wherein:

10 the proximal end is spaced apart from a first side wall in the direction from one side wall to another side wall by a distance of less than or equal to 0.4 mm; and/or

the proximal end is spaced apart from a second side wall in the direction from one side wall to another side wall by a distance of less than or equal to 0.4
15 mm.

8. The sealing gasket of any preceding claim, wherein the sealing gasket is at least one of: a one-piece gasket, a moulded gasket, deformable and an elastomer.

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9. The sealing gasket of any preceding claim comprising:

a first sealing member defining a closed shape;

a second sealing member defining a closed shape;

a first longitudinal sealing member connected between the first sealing
25 member and the second sealing member; and

a second longitudinal sealing member connected between the first sealing member and the second sealing member.

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10. The sealing gasket of claim 9, wherein the first sealing member and/or the second sealing member define a respective closed shape selected from the group of closed shapes consisting of an annulus, a circle, an oval, an ellipse, a stadium, a rounded polygon, a rounded square, a rounded rectangle,
5 and a squircle.

11. The sealing gasket of claim 9 or 10, wherein the first sealing member and/or the second sealing member each comprise a respective plurality of the protrusions which extend outwardly from an outer surface.

10

12. A vacuum pump, comprising:
shell stators defining at least one pumping chamber;
end pieces mountable at either end of the shell stator; and
the sealing gasket of any preceding claim, wherein
15 the shell stators and/or the end pieces define one or more seal grooves in which the sealing gasket is located;
the one or more seal grooves comprise one or more voids extending from a side wall of the seal grooves; and
the one or more protrusions are received in respective voids.

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13. The vacuum pump of claim 12, wherein the voids are slots.

14. The vacuum pump of claim 12 or 13, wherein for each protrusion and the respective void in which it is received, the length of that void from an open end of the void to a closed end of the void is greater than the length of the
25 portion of that protrusion that is within the void, thereby to allow for expansion of the protrusion within the void in the direction along the length of the protrusion.

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15. The vacuum pump of any of claims 12 to 14, wherein for each protrusion and the respective void in which it is received, the width of that void in a direction that is perpendicular to the direction from an open end of the void to a closed end of the void is less than or equal to the width of the portion of that
- 5 protrusion that is within the void, thereby to provide an interference fit of the protrusion in the void.