

TURBOMOLECULAR PUMP

FIELD OF THE INVENTION

- 5 The present invention relates to turbomolecular pumps.

BACKGROUND

- A turbomolecular pump is a type of pump which operates by pushing gas
10 molecules in a desired pumping direction using rotating blades in one or more
bladed pumping stages.

SUMMARY OF INVENTION

- 15 In an aspect, there is provided a support structure for a rotor shaft of a
turbomolecular pump, comprising a central section for coupling to the rotor shaft
of the turbomolecular pump, the central section having a centre point through
which a rotation axis of the rotor shaft passes when the rotor shaft is coupled to
the central section, and a leg extending from the central section, wherein the leg
20 is for coupling the central section to a housing of the turbomolecular pump,
wherein the leg extends tangentially relative to the central section.

The central section may be integrally formed with the leg.

- 25 The central section may have a circular profile.

The leg may comprise a substantially straight section and a curved section.

The leg may be entirely curved.

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The support structure may comprise a plurality of legs which are evenly
angularly spaced around the central section, wherein each of the plurality of
legs extends from the central section, wherein each of the plurality of legs is for
coupling the central section to a housing of the turbomolecular pump, and

wherein each of the plurality of legs extends tangentially relative to the central section.

The support structure may further comprise an additional strip of material
5 connecting one of the plurality of legs to another of the plurality of legs.

The support structure may comprise exactly three legs.

The tangential extension of the leg relative to the central section may act to
10 direct rotational forces on the central section down the leg.

In another aspect, there is provided an apparatus for a turbomolecular pump,
comprising a housing for the turbomolecular pump, and the support structure of
the above aspect.

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The support structure may be integrally formed with the housing.

The leg may extend between the housing and the central section to couple the
central section to the housing.

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The housing may comprise an opening defining an inlet of the turbomolecular
pump, and wherein the support structure is located at the opening.

The rotor shaft may be coupled to the central section by way of a bearing,
25 preferably a permanent magnetic bearing.

In yet another aspect, there is provided a turbomolecular pump comprising the
support structure of the above aspect or the apparatus of the above aspect.

30 In yet another aspect, there is provided use of the turbomolecular pump of the
above aspect to pump gas.

BRIEF DESCRIPTION OF DRAWINGS

Figure 1 is an illustration (not to scale) showing a schematic diagram of a turbomolecular pump;

- 5 Figure 2A and Figure 2B are illustrations (not necessarily to scale) showing perspective and top-down views of a rotor support structure of the turbomolecular pump;

Figure 3 is an illustration (not necessarily to scale) showing a perspective view of another rotor support structure usable by the turbomolecular pump;

- 10 Figure 4 is an illustration (not necessarily to scale) showing a perspective view of yet another rotor support structure usable by the turbomolecular pump; and Figure 5 is an illustration (not necessarily to scale) showing a perspective view of yet another rotor support structure usable by the turbomolecular pump.

15 DETAILED DESCRIPTION

- Figure 1 is a schematic illustration (not to scale) showing a turbomolecular pump 100. The turbomolecular pump 100 comprises an inlet 105, a housing 110, a plurality of stator blades 120, a plurality of rotor blades 130, a rotor shaft 140, and a rotor support structure 200. The turbomolecular pump 100 is configured to receive gas at the inlet 105 and pump the received gas out of an outlet (not shown) using rotation of the rotor blades 130 relative to the stator blades 120. The physical mechanism used by the turbomolecular pumps to pump gas is well understood and will not be described here in detail. However, briefly, the rotor blades 130 are angled relative to the stator blades 20 such that rotation of the rotor blades 130 pushes gas through the spaces between the rotor and stator blades 120, 130 in a desired pumping direction to pump gas through the turbomolecular pump 100. The direction of travel of the pumped gas through the turbomolecular pump 100 is shown with dashed arrows in Figure 1.

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The housing 110 defines a substantially cylindrical space within which the stator blades 120, rotor blades 130, rotor shaft 140 and rotor support structure 200 are located. The inlet 105 is defined by an opening in the housing 110 at an end of the substantially cylindrical space defined by the housing 110. The stator blades

120 are stationary within the housing 110. The rotor blades 130 are attached to the rotor shaft 140 such that rotation of the rotor shaft 140 rotates the rotor blades 130 about a central longitudinal axis of the rotor shaft 140. The rotor shaft 140 is coupled to and supported by the rotor support structure 200. The
5 rotor support structure 200 is attached to the housing 110 and is arranged to hold the rotor shaft 140 in place in the housing 110. Various different structures/geometries for the rotor support structure 200 will now be described.

Figures 2A and 2B illustrate perspective and top-down views of the rotor
10 support structure 200 according to an embodiment. The rotor support structure 200 comprises a central section 200a and a plurality of legs 200b extending from the central section 200a. In this embodiment, the rotor support structure 200 comprises three legs 200b. In this embodiment, the central section 200a has a circular profile. The central section 200a is coupled to the shaft 140 (the
15 shaft 140 is not shown in full in Figure 2A) such that the shaft 140 is able to rotate relative to the central section 200a. The central section 200a comprises bearings (not shown) for facilitating rotation of the rotor shaft 140 relative to the central section 200a. Thus, the central section 200a may be referred to as a bearing hub. Each of the plurality of legs 200b extends from the central section
20 200a to a location on the housing 110. The central section 200a and plurality of legs 200b are located in the opening defining the inlet 105.

Each of the plurality of legs 200b comprises a substantially straight elongate section 200b-1 and a curved section 200b-2. The substantially straight elongate
25 section 200b-1 is attached to the central section 200a via the curved section 200b-2. The substantially straight elongate section 200b-1 has a central longitudinal axis (shown as a dotted line in Figs. 2A and 2B) which is offset from a centre point of the central section 200a. The centre point of the central section 200a is a point through which the rotation axis of the rotor shaft 140 extends.
30 Thus, the central longitudinal axis of the substantially straight elongate section 200b-1 is perpendicular to the rotation axis of the rotor shaft 140 and offset from the rotation axis of the rotor shaft 140 in a radial direction. In this embodiment, the offset between the central longitudinal axis of the substantially straight elongate section 200b-1 and the rotation axis of the rotor shaft 140 is

approximately 6mm. This offset means that each of the legs 200b extends tangentially relative to the central section 200a. In other words, the legs 200b do not extend perpendicularly from the central section 200a. It will be appreciated that, in general, the precise offset distance is not limited to 6mm and any offset
5 distance which enables the functionality described herein may be used.

In this embodiment, the legs 200b are evenly angularly spaced around the central section 200a. In this embodiment, for each of the plurality of legs 200b, the substantially straight elongate section 200b-1 and the curved section 200b-2
10 are integrally formed with each other. In this embodiment, each of the plurality of legs 200b is integrally formed with the central section 200a. In this embodiment, each of the plurality of legs 200b is also integrally formed with the housing 110.

15 In a situation where a rotational force is imparted on the central section 200a by the rotation of the rotor shaft 140, e.g. if the rotor shaft seizes or fails during operation of the turbomolecular pump 100, the above-described tangential extension and offset of the legs 200b helps to direct the force down the legs 200b as a compressive force, rather than as a shearing force across the legs
20 200b. This is illustrated by the arrows in Fig. 2B. Thus, the legs 200b are less likely to break or suffer damage compared to designs where the offset is absent, as compressive forces down the legs 200b are less likely to damage the legs 200b compared to shearing forces across the legs 200b.

25 Figure 3 is an illustration (not necessarily to scale) showing a perspective view of another rotor support structure 300 usable by the turbomolecular pump 100 according to an embodiment. The rotor support structure 300 comprises a central section 300a and a plurality of legs 300b. Each of the plurality of legs 300b comprises a substantially straight elongate section 300b-1 and a curved
30 section 300b-2. The rotor support structure 300 shown in Figure 3 is the same as the rotor support structure 200 shown in Figs. 2A and 2B, except that the curved section 300b-2 is thicker. This embodiment tends to provide a greater overall stiffness for the rotor support structure 300. As in the embodiment of

Figs 2A and 2B, in this embodiment each of the legs 300b extends tangentially relative to the central section 300a.

Figure 4 is an illustration (not necessarily to scale) showing a perspective view of yet another rotor support structure 400 usable by the turbomolecular pump 100. The rotor support structure 400 comprises a central section 400a and a plurality of legs 400b. The rotor support structure 400 shown in Figure 4 is the same as the rotor support structure 200 shown in Figs. 2A and 2B except that each of the legs 400b is entirely curved. Similar to the embodiment of Figs 2A and 2B, in this embodiment each of the legs 400b can be considered to extend tangentially relative to the central section 400a, as the curvature of the legs 400b means that the legs 400b do not perpendicularly extend from the central section.

Figure 5 is an illustration (not necessarily to scale) showing a perspective view of yet another rotor support structure 500 usable by the turbomolecular pump 100. The rotor support structure 500 comprises a central section 500a and a plurality of legs 500b. Each of the plurality of legs 500b comprises a substantially straight elongate section 500b-1 and a curved section 500b-2. The rotor support structure 500 shown in Figure 5 is the same as the rotor support structure 200 shown in Figs. 2A and 2B except that the curved sections 500b-2 of the legs 500b are connected by additional strips 500c of material. In this embodiment, each strip 500c is curved and extends between two curved sections 500b-2 which are adjacent to each other around the circumference of the central section 500a. Similar to the embodiment of Figure 3, the presence of the strips 500c tends to provide a greater overall stiffness for the rotor support structure 500. As in the embodiment of Figs 2A and 2B, in this embodiment each of the legs 500b extends tangentially relative to the central section 500a.

In each of the embodiments of Figures 3 to 5, each of the legs 300b, 400b, 500b extends from the central section 300a, 400a, 500a such that a rotational force on the central section 300a, 400a, 500a tends to be directed compressively down the legs 300b, 400b, 500b. As such, in a similar way to the embodiment of Figs. 2A and 2B, the rotor support structure 300, 400, 500 of the

embodiments of Figures 3 to 5 are less likely to break or suffer damage if the rotor shaft 140 seizes or fails during operation.

Thus, a rotor support structure for a turbomolecular pump is provided. The
5 above-described rotor support structure advantageously tends to provide improved resistance to rotational forces without significantly blocking the inlet of the turbomolecular pump. Advantageously, the use of three legs tends provide a good balance between using fewer components to avoid blocking the inlet and providing enough stiffness to the rotor support structure. Advantageously,
10 integrally forming the legs with the housing means that the connection point between each of the legs and the housing tends to be not flexible so all the rotational forces are transmitted through the legs, thereby making the structure strong without blocking the inlet of the turbomolecular pump. Furthermore, advantageously, the above-described rotor support structure reduces the
15 tolerance stack up in the pump due to fewer parts to influence misalignment to the central section.

In the above embodiments, the rotor support structure comprises three legs. However, in other embodiments, a different number of legs is used, e.g. 1, 2, 4,
20 5.

In the above embodiments, the central section of the rotor support structure has a circular profile. However, in other embodiments, a differently shaped profile may be used, e.g. triangular or oval.

25 In the above embodiments, the legs extend tangentially from the central section and/or are offset from a centre point of the central section on a side of the central section such that the above-described rotation force compresses the legs. However, in other embodiments, the legs extend tangentially from the
30 central section and/or are offset from a centre point of the central section on a side of the central section such that the above-described rotation force applies a tensile force to the legs. For example, in one such embodiment, the turbomolecular pump is the same as the one described with reference to Figures 2A and 2B, except each of the legs is offset from the central point of the

central section on the opposite side of the central point. In these embodiments, the legs may be formed from a material which is ductile.

It will be appreciated that various modifications/deviations may be made to the
5 above-described embodiments without departing from the scope of the
invention.

REFERENCE NUMERAL LIST

- 100: turbomolecular pump
- 105: inlet
- 5 110: housing
- 120: stator blades
- 130: rotor blades
- 140: rotor shaft
- 200: rotor support structure
- 10 200a, 300a, 400a, 500a: central section
- 200b, 300b, 400b, 500b: leg
- 200b-1, 300b-1, 500b-1: elongate section
- 200b-2, 300b-2, 500b-2: curved section
- 500c: strip
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CLAIMS

1. A support structure for a rotor shaft of a turbomolecular pump,
comprising:
 - 5 a central section for coupling to the rotor shaft of the turbomolecular pump, the central section having a centre point through which a rotation axis of the rotor shaft passes when the rotor shaft is coupled to the central section; and
a leg extending from the central section, wherein the leg is for coupling the central section to a housing of the turbomolecular pump;
 - 10 wherein the leg extends tangentially relative to the central section.
2. The support structure of claim 1, wherein the central section is integrally formed with the leg.
- 15 3. The support structure of claim 1 or 2, wherein the central section has a circular profile.
4. The support structure of any preceding claim, wherein the leg comprises a substantially straight section and a curved section.
- 20 5. The support structure of any of claims 1 to 3, wherein the leg is entirely curved.
6. The support structure of any preceding claim, wherein the support
25 structure comprises a plurality of legs which are evenly angularly spaced around the central section, wherein each of the plurality of legs extends from the central section, wherein each of the plurality of legs is for coupling the central section to a housing of the turbomolecular pump, and wherein each of the plurality of legs extends tangentially relative to the central section.
- 30 7. The support structure of claim 6, further comprising an additional strip of material connecting one of the plurality of legs to another of the plurality of legs.

8. The support structure of any preceding claim, wherein the support structure comprises exactly three legs.
9. The support structure of any preceding claim, wherein the tangential extension of the leg relative to the central section acts to direct rotational forces on the central section down the leg.
10. Apparatus for a turbomolecular pump, comprising:
a housing for the turbomolecular pump; and
the support structure of any preceding claim.
11. The apparatus of claim 9, wherein the support structure is integrally formed with the housing.
12. The apparatus of claim 9 or 10, wherein the leg extends between the housing and the central section to couple the central section to the housing.
13. The apparatus of any of claims 9 to 11, wherein the housing comprises an opening defining an inlet of the turbomolecular pump, and wherein the support structure is located at the opening.
14. A turbomolecular pump comprising the support structure of any of claims 1 to 9 or the apparatus of any of claims 10 to 13.
15. Use of the turbomolecular pump of claim 14 to pump gas.