

VACUUM PUMP

This invention relates to a dry vacuum pump.

5 Dry vacuum pumps are widely used in industrial processes to provide a clean and/or low -pressure environment for the manufacture of products. Applications include the pharmaceutical, semiconductor and flat panel manufacturing industries. Such pumps include an essentially dry (or oil free) pumping mechanism, but generally also include some components, such as bearings and
10 transmission gears, for driving the pumping mechanism that require lubrication in order to be effective. Examples of dry pumps include Roots, Northey (or "claw"), screw and scroll pumps. Dry pumps incorporating Roots and/or Northey rotor components are commonly multi-stage positive displacement pumps comprising a stator component defining a plurality of pumping chambers each housing a
15 respective pair of intermeshing rotor components. The rotor components are located on contra-rotating shafts, and may have the same type of profile in each chamber or the profile may change from chamber to chamber.

Iron castings have for a long time been used in the manufacture of stator and rotor
20 components for dry vacuum pumps. However, in the semiconductor industries the increasing use of high flow rates of relatively corrosive gases such as chlorine, boron trichloride, hydrogen bromide, fluorine and chlorine trifluoride has lead to severe corrosion, and therefore relatively short lifetime, of, cast iron stator and rotor components. Such corrosion can lead to equipment failure, leakage of
25 process gases and possible process contamination, in addition to the costs associated with the replacement of the pump or the corroded parts and consequential process downtime.

In view of this, it is known to passively protect these components by the formation
30 of a resin or polymeric coating of a fluoropolymer or polyimide material on the component surfaces which are exposed to the corrosive gases. Such coatings have a tendency to degrade with time, with the resultant peeling or flaking of the

coating exposing the underlying cast iron to the corrosive gases. Another alternative is to form these components from a nickel-rich cast iron, for example ductile Ni-resist, or a stainless steel having superior corrosion resistance. However, Ni-resist cast iron and stainless steel are relatively expensive and
5 difficult to machine, and so do not provide cost-effective options for use in the manufacture of the rotor and stator components.

The present invention provides a dry vacuum pump comprising a stator component and at least one rotor component, wherein the stator component
10 and/or said at least one rotor component are formed from austempered ductile iron.

The stator component may house first and second intermeshing rotor components adapted for counter-rotation within the stator component. In the preferred
15 embodiment, the rotor components have a Roots profile, although they could have a Northey or screw profile as required.

The pump may be in the form of a multi-stage pump in which the stator component defines a plurality of interconnected pumping chambers arranged in series and
20 each housing respective rotor components formed from austempered ductile iron. The intermeshing rotor components may be located on respective shafts, with the pump comprising a gear assembly for transmitting torque from one shaft to another, with at least one gear of the gear assembly preferably being formed from austempered ductile iron.

25 Alternatively, the pump may be in the form of a scroll pump in which the stator component comprises a fixed scroll member having an end plate with a first spiral wrap extending therefrom, and said at least one rotor component comprises an orbital scroll member having an end plate with a second spiral wrap extending
30 therefrom to intermesh with the first spiral wrap. Each of the scroll members is preferably formed from ADI.

The ADI preferably has at least 90% graphite nodularity.

The ADI preferably has a matrix of acicular ferrite and carbon stabilised austenite.

- 5 The austempered ductile iron preferably comprises one or more of the following:
carbon in amount within the range from 3.4 to 3.5 % by mass, silicon in amount
within the range from 2 to 2.3 % by mass, manganese in amount within the range
from 0.2 to 0.22 % by mass, molybdenum in amount within the range from 0.075
to 0.15% by mass, nickel in amount within the range from 1.2 to 1.4 % by mass,
10 and copper in amount within the range from 0.75 to 0.95 % by mass.

Preferred features of the present invention will now be described, by way of
example only, with reference to the following drawings, in which:

- 15 Figure 1 is a cross-section through a multi-stage dry vacuum pump; and

Figure 2 is a view along line A-A in Figure 1.

- With reference to Figures 1 and 2, a multi-stage dry vacuum pump 10 comprises a
20 stator component 12, preferably formed from austempered ductile iron (ADI),
having a series of walls that define a plurality of pumping chambers 14, 16, 18, 20,
22. An inlet conduit 24 for conveying gas to be pumped to the inlet pumping
chamber 14, and an exhaust conduit 26 for exhausting pumped gas from the
exhaust pumping chamber 22, are also formed in the stator 12. Circumferential
25 passages 28, 30, 32 and 34 formed in the stator 12 connect the pumping
chambers 14, 16, 18, 20, 22 in series.

- The stator 12 houses a first shaft 36 and, spaced therefrom and parallel thereto, a
second shaft 38. Bearings 40 for supporting the shafts 36, 38 are provided in the
30 end plates 42, 44 of the stator 12. One of the shafts 36 is connected to a drive
motor 46, the shafts being coupled together by means of timing gears 47 so that in
use the shafts 36,38 rotate at the same speed but in opposite directions, as

indicated by arrows 48 and 50 in Figure 2. A gear box 52 attached to the side of the pump 10 contains oil 54 for lubricating the timing gears 47. The timing gears 47 may be formed from ADI.

5 Within each pumping chamber, the shafts 36, 38 support respective rotor components 56, 58, which may also be formed from ADI. In this embodiment, the rotors 56, 58 have a Roots-type profile within each pumping chamber, although a mixture of Roots and Northey-type profiles may be provided within the pump 10. The rotors 56, 58 are located in each pumping chamber relative to an internal
10 surface of the stator 12 such that the rotors 56, 58 can act in an intermeshing manner known per se.

In use, gas is urged into the pump 10 through the inlet conduit 24 and passes into the inlet pumping chamber 14. The gas is compressed by the rotors 56, 58
15 located within the inlet pumping chamber 14, and is fed by passage 28 into the next pumping chamber 16. The gas fed in the pumping chamber 16 is similarly compressed by the rotors 56, 58 therein, and fed by the passage 30 to the next pumping chamber 18. Similar gas compressions take place in the pumping chambers 18, 20 and 22, with the pumped gas finally being exhaust from the
20 pump 10 through exhaust conduit 26.

The use of austempered ductile iron (ADI) to manufacture the stator component 12 and/or the rotor components 56, 58 of the pump 10 makes the pump 10 particularly suitable for pumping corrosive gases such as chlorine, boron
25 trichloride, hydrogen bromide, fluorine and chlorine trifluoride. In comparison to the more expensive Ni-resist material, which are currently around four to five times more expensive than ADI, ADI has superior hardness, higher specific strength ratio and comparable F_2 corrosion susceptibility. This can enable the stator and rotor components, and the timing gears, to have relatively high wear and corrosion
30 resistance with reduced component weight and costs for equivalent or improved performances.

As an example, the austempered ductile iron (ADI) used to manufacture the stator component 12 and/or rotor components 56, 58 and/or timing gears 47 may include the following (by mass):

Element	%
carbon	3.4 – 3.5
silicon	2.0 – 2.3
manganese	0.2 – 0.22
molybdenum	0.075 – 0.15
nickel	1.2 – 1.4
copper	0.75 – 0.95

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The ADI preferably has a graphite nodularity of at least 90 %, and preferably has a nodule count in the range from 150 to 300 /mm². The ADI preferably has a predominant matrix of acicular ferrite and carbon stabilised austenite, with substantially no carbides, inclusions or porosity. These features of the ADI enable the material to meet the performance requirements for semiconductor processing equipment, notably adequate tribological and mechanical properties at elevated temperatures, and corrosion resistance.

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CLAIMS

1. A dry vacuum pump for pumping chlorine, boron trichloride, hydrogen bromide, fluorine and chlorine trifluoride comprising a stator component and at least one rotor component, wherein that stator component and/or at least one rotor component are formed from austempered ductile iron.
2. A pump according to Claim 1, wherein said at least one rotor component has one of a screw, Roots or Northey profile.
3. A pump according to Claim 2, comprising first and second intermeshing rotor components adapted for counter-rotation within the stator component.
4. A pump according to Claim 3, in the form of a multi-stage dry vacuum pump in which the stator component defines a plurality of interconnected pumping chambers arranged in series and each housing a respective pair of rotor components each formed from austempered ductile iron.
5. A pump according to Claim 3 or Claim 4, wherein intermeshing rotor components are located on respective shafts, the pump comprising a gear assembly for transmitting torque from one shaft to another, at least one gear of the gear assembly being formed from austempered ductile iron.
6. A pump according to Claim 1, in the form of a scroll pump in which the stator component comprises a fixed scroll member having an end plate with a first spiral wrap extending therefrom, and said at least one rotor component comprises an orbital scroll member having an end plate with a second spiral wrap extending therefrom to intermesh with the first spiral wrap.

7. A pump according to any preceding claim, wherein the austempered ductile iron has at least 90% graphite nodularity.
 8. A pump according to any preceding claim, wherein the austempered ductile iron has a matrix of acicular ferrite and carbon stabilised austenite.
 9. A pump according to any preceding claim, wherein the austempered ductile iron comprises carbon in amount within the range from 3.4 to 3.5 % by mass.
 10. A pump according to any preceding claim, wherein the austempered ductile iron comprises silicon in amount within the range from 2 to 2.3 % by mass.
 11. A pump according to any preceding claim, wherein the austempered ductile iron comprises manganese in amount within the range from 0.2 to 0.22 % by mass.
 12. A pump according to any preceding claim, wherein the austempered ductile iron comprises molybdenum in amount within the range from 0.075 to 0.15% by mass.
 13. A pump according to any preceding claim, wherein the austempered ductile iron comprises nickel in amount within the range from 1.2 to 1.4 % by mass.
 14. A vacuum pump rotor or stator component formed from austempered ductile iron.
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