A pump side part for use with a shrouded pump impeller, comprising a side wall section rear face including an outer region with an outer edge in a plane which is substantially at right angles to the rotation axis, an inner region with an inner edge and an intermediate region between the outer and inner regions which is inclined inwardly from the said plane in a direction towards the inlet section, the inner region extending from the intermediate region in a direction away from the front face of the side wall section, wherein the outer face of the impeller front shroud and the side part rear face are arranged to be facing one another with a gap therebetween, the rear face being configured so that the cross-sectional dimension of the gap increases in a direction toward the impeller rotation axis in the intermediate region.
PUMPS AND COMPONENTS THEREFOR

TECHNICAL FIELD

[0001] This disclosure relates generally to pumps and more particularly, though not exclusively, to centrifugal slurry pumps which are suitable for pumping slurries.

BACKGROUND OF THE DISCLOSURE

[0002] Centrifugal slurry pumps generally include a pump casing comprising a main casing part and one or more side parts. One of the side parts forms a pump intake which is often referred to as a front liner, suction plate or throat bush. The pump may also comprise an outer housing which encases the pump casing. In this latter arrangement, the pump casing is configured as a pump liner which is typically formed from hard metals or elastomers.

[0003] An impeller is mounted for rotation within the casing about a rotation axis. The main casing part has an outer peripheral wall section with an internal surface which may be of volute form, a discharge outlet and an inlet which is at one side of the casing and coaxial with the impeller rotation axis. The impeller typically includes a hub to which a drive shaft is operatively connected and at least one shroud. Pumping vanes are provided on one side of the shroud with discharge passageways between adjacent pumping vanes. In one form of impeller, two shrouds are provided with pumping vanes being disposed therebetween. The pumping vanes include opposed main side faces one of which is a pumping or pressure side face. The pumping vanes further include a leading edge portion in the region of the inlet and a trailing edge portion in the region of the outer peripheral edge of the or each shroud. The leading edge portion is inclined with respect to the inlet at a vane inlet angle.

[0004] Centrifugal slurry pumps, which may typically comprise hard metal or elastomer liners and/or casing that resist wear, are widely used in the mining industry. Normally, the higher the slurry density, or the larger or harder the slurry particles, will result in higher wear rates and reduced pump life.

[0005] Centrifugal slurry pumps are widely used in minerals processing plants from the start of the process where the size is very fine down to the end of the process where the slurry is very much finer and the wear rates greatly reduce (for example, when flotation tailings are produced). As an example, slurry pumps dealing with a coarse particulate feed duty may only have a life of wear parts measured in weeks or months, compared to pumps at the end of the process which have wear parts which can last from one to two years in operation.

[0006] The wear in centrifugal slurry pumps that are used for handling coarse particulate slurries typically is worst at the impeller inlet, because the solids have to turn through a right angle (from axial flow in the inlet pipe to radial flow in the pump impeller) and, in so doing, the particle inertia and size results in more impacts and sliding motion against the impeller walls and the leading edge of the impeller vanes.

[0007] The impeller wear occurs mainly on the vanes and the front and rear shrouds at the impeller inlet. High wear in these regions can also influence the wear on the front liner of the pump. The small gap that exists between the rotating impeller and the stationary front liner will also have an effect on the life and performance of the pump wear parts. This gap is normally quite small, but typically increases due to wear on the impeller front, impeller shroud or due to wear on both the impeller and the front liner.

[0008] One way to reduce the flow that escapes from the high pressure casing region of the pump (through the gap between the front of the impeller and the front liner into the pump inlet) is by incorporating a raised and angled lip on the stationary front liner at the impeller inlet. The impeller has a profile to match this lip. The flow through the gap can also be reduced by the use of expelling vanes on the front of the impeller.

[0009] The various aspects disclosed herein may be applicable to all centrifugal slurry pumps and particularly to those that experience high wear rates at the impeller inlet or to those that are used in applications with high slurry temperatures.

SUMMARY OF THE DISCLOSURE

[0010] In a first aspect, embodiments are disclosed of a pump side part for use with a pump impeller, the impeller comprising a front shroud, a back shroud and a plurality of pumping vanes therebetween, the front shroud having an outer face and an impeller inlet extending through the front shroud, the impeller inlet being coaxial with an impeller rotation axis; the pump side part comprising a side wall section having a front face and a rear face, the pump side part further comprising an inlet section extending from the front face and arranged when in use to be coaxial with the impeller rotation axis, the rear face including an outer region with an outer edge in a plane which is substantially at right angles to the rotation axis, an inner region with an inner edge and an intermediate region between the outer and inner regions which is inclined inwardly from the said plane in a direction towards the inlet section, the inner region extending from the intermediate region in a direction away from the front face of the side wall section, wherein the outer face of the impeller front shroud and the rear face of the pump side part are arranged in use to be facing one another with a gap therebetween, the rear face of the side wall section being configured so that the cross-sectional dimension of the gap increases in a direction toward the impeller rotation axis in the intermediate region.

[0011] In certain embodiments the dimension of the gap between the outer face of the impeller front shroud and the inner region of the rear face of the pump side part decreases in the direction from the intermediate region towards the inner edge.

[0012] In certain embodiments the inner region comprises a continuous substantially uninterrupted inclined face.

[0013] In certain embodiments the intermediate region comprises a continuous substantial uninterrupted inclined face.

[0014] In certain embodiments the inclined face of one or both of the intermediate and inner regions is substantially linear.

[0015] In certain embodiments one or both of the intermediate and inner regions is generally frusto conical in shape.

[0016] In certain embodiments there is, a transition region between the intermediate and inner regions, the transition region being curved. In certain embodiments the transition region is generally frusto conical in shape.

[0017] In certain embodiments the rear face has a profile viewed in cross-section in which the profile of the outer region, inner region and intermediate region are substantially linear; the outer region profile being substantially at right
angles to the central axis, the intermediate region profile being inclined from the outer region profile outwardly with respect to the plane and the inner region profile being inclined inwardly from the intermediate profile with respect to the plane.

[0018] In a second aspect, embodiments are disclosed of a pump impeller in combination with a pump side part in accordance with the first aspect of the present disclosure, in certain embodiments the impeller comprising a front shroud, a back shroud and a plurality of pumping vanes therebetween, the front shroud having an outer face and an impeller inlet extending through the front shroud, the impeller inlet being coaxial with an impeller rotation axis; wherein the outer face of the impeller front shroud and the rear face of the pump side part are arranged to be facing one another with a gap therebetween, one or both of the outer faces of the impeller front shroud and the rear face of the side wall section being configured so that the cross-sectional dimension of the gap is increased in a direction toward the impeller rotation axis in the intermediate region.

[0019] In certain embodiments the gap size in the transition region is determined by a constructed circle C generated in the transition region where the intermediate region and the inner region terminates at respective tangential points on the circumference of the circle, and the plane of the outer face of the impeller front shroud is tangential to another point on the circumference of the circle C, the diameter D of the circle C being in the range from 0.02 to 0.10 of the radial distance L between the outer diameter Z of the front shroud and an inner diameter Y of an innermost end of the inlet section of the pump side part.

[0020] In certain embodiments the diameter D of the circle C is in the range from 0.04 to 0.05 of the radial distance L between the outer diameter Z of the front shroud and an inner diameter Y of an innermost end of the inlet section of the pump side part.

[0021] In certain embodiments the distance M from the centre of the circle C to the rotation axis X-X is from 1.0 to 1.8 of the diameter Y of the innermost end of the inlet section of the pump side part.

[0022] In certain embodiments the distance M from the centre of the circle C to the rotation axis X-X is from 1.2 to 1.8 of the diameter Y of the innermost end of the inlet section of the pump side part.

[0023] In certain embodiments the distance M from the centre of the circle C to the rotation axis X-X is from 1.2 to 1.5 of the diameter Y of the innermost end of the inlet section of the pump side part.

[0024] In certain embodiments the impeller comprises a plurality of auxiliary vanes on the outer face of the front shroud, the auxiliary vanes being of a depth T, the diameter D of the circle C being in the range from 0.5 to 1.5 of the depth of the auxiliary vanes.

[0025] In certain embodiments the impeller comprises a plurality of auxiliary vanes on the outer face of the front shroud, the auxiliary vanes being of a depth T, the diameter D of the circle C being in the range from 0.5 to 1.0 of the depth of the auxiliary vanes.

[0026] In a third aspect, embodiments are disclosed of a pump side part for use with a pump impeller, the impeller comprising a front shroud, a back shroud and a plurality of pumping vanes therebetween, the front shroud having an outer face and an impeller inlet extending through the front shroud, the impeller inlet being coaxial with an impeller rotation axis; the pump side part comprising a side wall section, having a front face and a rear face, the pump side part further comprising an inlet section extending from the front face and arranged when in use to be coaxial with the impeller rotation axis, wherein the outer face of the impeller front shroud and the rear face of the pump side part are arranged in use to be facing one another with a gap therebetween, the rear face of the side wall section being configured so that the cross-sectional dimension of the gap increases in a direction toward the impeller rotation axis.

[0027] In certain embodiments the rear face has an outer region with an outer edge in a plane which is substantially at right angles to the central axis and an inner region with an inner edge and the rear face further having an intermediate region between the outer and inner regions which is laterally displaced or recessed from the plane.

[0028] In certain embodiments the lateral displacement is inclined inwardly from the said plane in a direction towards the inlet section.

[0029] In certain embodiments the intermediate region extends from the outer region towards and terminating at the inner region.

[0030] In certain embodiments the intermediate portion comprises a continuous inclined face. In certain embodiments the inclined face is substantially linear.

[0031] In certain embodiments the intermediate region is generally frusto conical in shape.

[0032] In certain embodiments the inner region extends from the intermediate region in a direction away from said front face of said side wall section.

[0033] In certain embodiments the pump side part further includes a transition region between the intermediate and inner region, the transition region being curved.

[0034] In certain embodiments the inner region is generally frusto conical in shape.

[0035] In a fourth aspect, embodiments are disclosed of a pump impeller for use with a pump side part, the pump side part comprising a side wall section, a front face and a rear face, an inlet section extending from the front face and arranged when in use to be coaxial with an impeller rotation axis; the impeller comprising a front shroud, a back shroud and a plurality of pumping vanes therebetween, the front shroud having an outer face and an impeller inlet extending through the front shroud, the impeller inlet being coaxial with the impeller rotation axis; wherein the outer face of the impeller front shroud and the rear face of the pump side part are arranged to be facing one another with a gap therebetween, the outer face of the impeller front shroud being configured so that the cross-sectional dimension of the gap increases in a direction toward the impeller rotation axis.

[0036] In certain embodiments the outer face of the front shroud includes an outer region which has an outer edge in a plane which is substantially at right angles to the impeller rotation axis and an inner region with an inner edge; and the outer face further having an intermediate region between the outer and inner regions which is laterally displaced or recessed from the plane.

[0037] In certain embodiments the lateral displacement is inclined inwardly from the said plane in a direction towards the pumping vanes.

[0038] In certain embodiments the intermediate region extends from the outer edge portion towards and terminating at the inner region.
[0039] In certain embodiments the intermediate region comprises a continuous inclined face. In certain embodiments the inclined face is substantially linear.

[0040] In certain embodiments the intermediate region is generally frusto conical in shape.

[0041] In certain embodiments the pump impeller further includes a plurality of pump-out (or expeller) vanes on the outer face of the front shroud.

[0042] In a fifth aspect, embodiments are disclosed of a pump impeller in combination with a pump side part, the impeller comprising a front shroud, a back shroud and a plurality of pumping vanes therebetween, the front shroud having an outer face and an impeller inlet extending through the front shroud, the impeller inlet being coaxial with an impeller rotation axis; a pump side part comprising a side wall section, a front face and a rear face, an inlet section extending from the front face and arranged when in use to be coaxial with the impeller rotation axis, wherein the outer face of the impeller front shroud and the rear face of the pump side part are arranged to be facing one another with a gap therebetween, one or both of the outer faces of the impeller front shroud and the rear face of the side wall section being configured so that the cross-sectional dimension of the gap is increased when moving in a direction toward the impeller rotation axis.

[0043] In certain embodiments the gap is a lateral recess located at a rear face of the side wall section of the pump side part.

[0044] In certain embodiments of the combination, the pump side part is as described in the third and fourth aspects.

[0045] In certain embodiments, the gap size in the transition region when viewed in cross-section is determined by a constructed circle C generated in the transition region where the intermediate region and the inner region terminates at respective tangential points on the circumference of the circle C, and the plane of the outer face of the impeller front shroud is tangential to another point on the circumference of the circle C, the diameter D of the circle C being in the range from 0.02 to 0.10 of the radial distance L between the outer diameter Z of the front shroud and an inner diameter Y of an innermost end of the inlet section of the pump side part (or the inner diameter of the inlet section of the impeller).

[0046] In certain embodiments the distance M from the centre of the circle C to the rotation axis X-X is from 1.2 to 1.8 of the diameter Y of the innermost end of the inlet section of the pump side part. These various parameters are shown in FIGS. 8 and 9.

[0047] In certain embodiments the impeller comprises a plurality of auxiliary vanes on the outer face of the front shroud, the auxiliary vanes being of a depth T, the diameter of the circle C being in the range from 0.5 to 1.0 of the depth of the auxiliary vanes.

[0048] In certain embodiments, the gap size in the transition region when viewed in cross-section is determined by a constructed circle C generated in the transition region where the intermediate region and the inner region terminates at respective tangential points on the circumference of the circle C, and the plane of the outer face of the impeller front shroud is tangential to another point on the circumference of the circle C, the diameter D of the circle C being in the range from 0.02 to 0.10 of the radial distance L between the outer diameter Z of the front shroud and an inner diameter Y of the inlet section of the impeller at the front shroud.

[0049] In certain embodiments the distance M from the centre of the circle C to the rotation axis X-X is from 1.2 to 1.8 of the diameter Y of the inlet section of the impeller at the front shroud.

[0050] In a sixth aspect, embodiments are disclosed of a pump impeller in combination with a pump side part, the impeller comprising a front shroud, a back shroud and a plurality of pumping vanes therebetween, the front shroud having an outer face and in impeller inlet extending through the front shroud, the impeller inlet being coaxial with an impeller rotation axis; a pump side part comprising a side wall section, a front face and a rear face, an inlet section extending from the front face and arranged when in use to be coaxial with the impeller rotation axis, wherein the outer face of the impeller front shroud and the rear face of the pump side part are arranged to be facing one another with a gap therebetween, wherein the gap is configured so that in use material entering thereinto in a direction toward the impeller rotation axis is caused to decelerate as it passes along the gap, thereby reducing erosive wear of the side wall rear face and of the impeller front face.

[0051] Other aspects, features, and advantages will become apparent from the following detailed description when taken in conjunction with the accompanying drawings, which are a part of this disclosure and which illustrate, by way of example, principles of inventions disclosed.

DESCRIPTION OF THE FIGURES

[0052] The accompanying drawings facilitate an understanding of the various embodiments.

[0053] FIG. 1 illustrates an exemplary, schematic, partial cross-sectional elevation of a pump incorporating an impeller and an impeller and liner combination, in accordance with one embodiment;

[0054] FIGS. 2 to 7 illustrate various exemplary, schematic, partial cross-sectional views of an impeller and pump side part according to certain embodiments;

[0055] FIGS. 8 and 9 are cross-sectional views of an impeller and pump side part illustration various parameters of the components according to certain embodiments; and

[0056] FIGS. 10 and 11 are exemplary, schematic, partial cross-sectional views of an impeller and pump side part according to a further embodiment, FIG. 11 being a more detailed view of that shown in FIG. 10.

DETAILED DESCRIPTION

[0057] Referring to FIG. 1 there is illustrated an exemplary pump 10 in accordance with certain embodiments including a pump casing 12, a back liner or side part 14, a front liner or side part 30 and a pump outlet 18. An internal chamber 20 is adapted to receive an impeller 40 for rotation about a rotational axis X-X.

[0058] The front liner or side part 30 includes a cylindrically-shaped delivery or inlet section 32 through which slurry enters the pump chamber 20. The inlet or delivery section 32 has a passage 33 therein with a first, outermost end 34 operatively connectable to a feed pipe (not shown) and a second, innermost end 35 adjacent the chamber 20. The front liner or side part 30 further includes a side wall section 15 which mates with the pump casing 12 to form and enclose the chamber 20, the side wall section 15 having a front face 36 and a rear face 37. The second end 35 of the front liner or side
part 30 has a raised lip 38 thereat, with a curvature which is
arranged to mate with the impeller 40 at an impeller inlet 52.
[0059] The impeller 40 includes a hub 41 from which a
plurality of circumferentially spaced pumping vanes 42 extend.
An eye portion 47 extends forwardly from the hub
towards the passage 33 in the front liner. The pumping vanes
42 include a leading edge 43 located at the region of the
impeller inlet 48, and a trailing edge 44 located at the region
of the impeller outlet 49. The impeller further includes a front
shroud 50 with the impeller inlet 52 in the front shroud and a
back shroud 51, the vanes 42 being disposed therebetween.

[0060] As best illustrated in FIGS. 2 to 7 and also in the
similar embodiment shown in FIGS. 10 and 11, the rear face
37 of the side wall section 15 of the pump side part 30
comprises an outer region 60 with an outer edge 61, an inner
region 62 with an inner edge 63 and an intermediate region 64
between the inner and outer regions 62 and 60. It is to be
understood that the outer region 60 may comprise only by the
outer edge 61 or it may extend inwardly from the outer edge
61 some distance along the face 37. The side wall section 15
includes an outer face 36 with a rim 69 extending between the
inner and outer faces. The outer face may comprise an outer
edge 65 of greater diameter than the outer edge 61 of the inner
face 37 so that the rim 69 is inclined.

[0061] In each embodiment the pump side part 30 is
arranged to cooperate with an impeller 40 having a front
shroud 50 having an inner face 55 and an outer face 54. The
outer face 54 comprises an outer region 70, an inner region 72
with an intermediate region 74 therebetween. The outer
region 70 has an outer edge 71 and the inner region has an
inner edge 73. As is the case for the pump side part 30, the
outer and inner regions of the impeller front shroud 50 may be
comprised by only the outer and inner edges. The impeller
may further include auxiliary vanes or expeller vanes or
pump-out vanes 56 which extend from the outer edge along
the outer face terminating in the intermediate region. The
expeller vanes 56 may be of any suitable shape and configura-
tion.

[0062] In an assembled or operative position the impeller
40 and side part 30 are disposed side by side with the outer
face 54 of the impeller 40 facing the rear face 37 of the side
part 30 with a gap or space 80 therebetween. The rotation axis
of the impeller 40 and the central axis of the pump side part 30
are coaxial. The gap or space 80 provides for an outer opening
82 and an inner opening 83.

[0063] In the embodiment of FIG. 2, the outer region 70 of
the outer face 54 of the impeller front shroud 50 is comprised
by outer edge 71, the intermediate region 74 extends from the
outer region 70 or outer edge 71, to the inner region 72. In this
particular embodiment, the outer face 64 of the intermediate
region 74 is in a plane which is generally at right angles to the
impeller rotation axis X-X and the central axis of the side part.
The inner region 72 is inclined in a direction away from the
front face 36 of the side part 30 and towards the pumping
vanes 42.

[0064] The outer region 60 of the inner face of the side part
extends from outer edge 61 to the outer edge 71 of the impel-
ler front shroud 50. The outer region 60 is in a plane at right
angles to the axis X-X. The intermediate region 64 extends at
an inclined angle from the outer region 60 towards the inner
region 62 so that the gap 80 in this region gradually increases
in its cross-sectional dimension. The inner region 62 follows
generally the inner region of the impeller front shroud 50,
there being a transition region 86 between the intermediate 64
and inner 62 regions.

[0065] In the embodiment of FIG. 3 the various regions of
the impeller front shroud 50 and the side wall section 15 of the
pump side part 30 are generally the same as shown in FIG. 2
except in this embodiment the intermediate region of the
impeller front shroud 50 is inclined, and the intermediate
region of the side wall section 15 is in a plane at right angles
to the axis X-X. In this particular embodiment it can be seen
that the expeller vanes 56 are also tapered.

[0066] The embodiment of FIG. 4 is similar to that of FIG.
2 except that the inner region of the impeller front shroud is in
the same plane as the intermediate region; that is, the inter-
mediate region, in effect, continues through to the inner edge
74.

[0067] The embodiment of FIG. 5 is similar to that of FIG.
3 except that the inner region of the impeller front shroud is in
the same plane as the intermediate region; that is the interme-
diate region continues through to the inner edge 63.

[0068] In the embodiment of FIG. 2, both the intermediate
and inner regions of the front shroud and the side wall section
are in the same plane, the impeller being in a plane at right
angles to the axis X-X and the opposing face of the side wall
section being inclined with respect to the shroud.

[0069] The embodiment of FIG. 7 is the same as FIG. 6
except that the intermediate and inner regions of the front
shroud are inclined and these regions in the pump side part are
at right angles to the axis X-X.

[0070] In the embodiment of FIGS. 10 and 11, the part of
the gap between the inner (rear) face 37 of the pump side part
30 and the outer face 54 of the impeller 40 is relatively narrow
at the outer radius region of the impeller and of the pump side
part, and both of the inner face 37 and the outer face 54 are
generally at right angles to the impeller rotation axis X-X.
This narrow gap region 70 where the faces 37 and 54 are in
close alignment extends about one third of the distance
between the outer edge 61 and the inner edge 63.

[0071] Various parameters of the pump impeller and side
part are illustrated in FIGS. 8 and 9. These parameters are
used in determining the optimum gap size in the region of the
transition region.

[0072] In order to determine the optimum gap size in the
transition region when viewed in cross-section a constructed
circle C is generated. The intermediate and inner regions are
configured so that they terminate at tangential points 81 and
82 on the circumference of the circle C, and the plane of the
outer face of the impeller front shroud is tangential to another
point 83 on the circumference of the circle C. FIGS. 8 and 9
identify the following parameters:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>D</td>
<td>Diameter of the constructed circle C</td>
</tr>
<tr>
<td>Z</td>
<td>Outer diameter of the front shroud</td>
</tr>
<tr>
<td>Y</td>
<td>Inner diameter of innermost end of the inlet section of the pump side part; also being the diameter of the inlet section of the front shroud of the impeller</td>
</tr>
<tr>
<td>R</td>
<td>Radial distance between Z and Y</td>
</tr>
<tr>
<td>T</td>
<td>Radial distance from the impeller rotation axis X-X and the centre of circle C</td>
</tr>
<tr>
<td>0.02 L to 0.10 L</td>
<td>More preferably 0.04 L to 0.05 L</td>
</tr>
</tbody>
</table>

[0073] The optimum gap size may be determined as follows:

1. Determine the parameters D, Z, Y, R, and T as specified in the above table.
2. Calculate the gap size using the following formula:

\[ \text{Gap Size} = D - \text{Z} \]

3. Adjust the gap size to ensure a smooth transition between the impeller and the front shroud.

[0074] D = Diameter of the constructed circle C

[0075] Z = Outer diameter of the front shroud

[0076] Y = Inner diameter of innermost end of the inlet section of the pump side part; also being the diameter of the inlet section of the front shroud of the impeller

[0077] R = Radial distance between Z and Y

[0078] T = Radial distance from the impeller rotation axis X-X and the centre of circle C

[0079] The optimum gap size may be determined as follows:

1. \( D = 0.02 \text{ L to 0.10 L} \), more preferably \( 0.04 \text{ L to 0.05 L} \).
The optimum position of circle C is as follows:

M = 1.0Y to 1.8Y, or preferably 1.2Y to 1.8Y, or preferably 1.2Y to 1.5Y.

In further certain embodiments

D = 0.5 T to 1.5 T, more preferably 0.5 T to 1.0 T.

In the assembled position the intermediate regions 64 and 74, jointly with the gap or space therebetween, the gap or space 80 gradually increasing as it extends inwardly. In use, the increase in the dimension of the gap gives a greater cross-sectional area in this region which tends to lower the velocity of fluid including the particles flowing therein, and therefore lowers the abrasive wear on the pump components. The smoothly increasing width configuration of the gap and resultant incremental increase in the flow area moving along the intermediate regions yields an optimum reduction in turbulence and abrasive wear of the pump components. Furthermore, in particular with reference to the embodiment shown in FIGS. 10 and 11, the narrow gap portion between the impeller and the outer region of the pump side part improves the sealing performance and wear life of these components.

In the foregoing description of preferred embodiments, specific terminology has been resorted to for the sake of clarity. However, the invention is not intended to be limited to the specific terms so selected, and it is to be understood that each specific term includes all technical equivalents which operate in a similar manner to accomplish a similar technical purpose. Terms such as "front" and "rear", "inner" and "outer", "upper" and "lower" and the like are used as words of convenience to provide reference points and are not to be construed as limiting terms.

The reference in this specification to any prior publication (or information derived from it), or to any matter which is known, is not, and should not be taken as, an acknowledgement or admission or any form of suggestion that prior publication (or information derived from it) or known matter forms part of the common general knowledge in the field of endeavour to which this specification relates.

In this specification, the word "comprising" is to be understood in its "open" sense, that is, in the sense of "including", and thus not limited to its "closed" sense, that is the sense of "consisting only of". A corresponding meaning is to be attributed to the corresponding words "comprise", "comprised" and "comprises" where they appear.

In addition, the foregoing describes only some embodiments of the invention(s), and alterations, modifications, additions and/or changes can be made thereto without departing from the scope and spirit of the disclosed embodiments, the embodiments being illustrative and not restrictive.

Furthermore, invention(s) have been described in connection with what are presently considered to be the most practical and preferred embodiments, it is to be understood that the invention is not to be limited to the disclosed embodiments, but on the contrary, is intended to cover various modifications and equivalent arrangements included within the spirit and scope of the invention(s). Also, the various embodiments described above may be implemented in conjunction with other embodiments, e.g., aspects of one embodiment may be combined with aspects of another embodiment to realize yet other embodiments. Further, each independent feature or component of any given assembly may constitute an additional embodiment.

1. In combination, a pump side part and a pump impeller, the impeller comprising a front shroud, a back shroud and a plurality of pumping vanes therebetween, the front shroud having an outer face and an impeller inlet extending through the front shroud, the impeller inlet being coaxial with an impeller rotation axis, the pump side part comprising a side wall section having a front face and a rear face, the pump side part further comprising an inlet section extending from the front face and arranged when in use to be coaxial with the impeller rotation axis, the rear face including an outer region with an inner edge and an intermediate region between the outer and inner regions the rear face cross-sectional profile in the intermediate region being inclined from the outer region outwardly with respect to the plane, and the rear face cross-sectional profile in the inner region being inclined inwardly from the intermediate region with respect to the plane, wherein the outer face of the impeller front shroud and the rear face of the pump side part are arranged in use to be facing one another with a gap therebetween the gap having an outer opening and an inner opening, the rear face of the side wall section being configured so that the cross-sectional dimension of the gap increases in a direction toward the impeller rotation axis in the intermediate region, and the inner region terminating at the inner opening.

2. The combination according to claim 1, wherein the dimension of the gap between the outer face of the impeller front shroud and the inner region of the rear face of the pump side part decreases in the direction from the intermediate region towards the inner edge.

3. The combination according to claim 2, wherein the profile of said inner region comprises a continuous substantially uninterrupted inclined face.

4. The combination according to claim 2, wherein the profile of said intermediate region comprises a continuous substantially uninterrupted inclined face.

5. The combination according to claim 4, wherein the inclined face of one or both of the intermediate and inner regions is substantially linear.

6. The combination according to claim 4, wherein one or both of the intermediate and inner regions is generally frosted conical in shape.

7. The combination according to claim 2, further including a transition region between the intermediate and inner regions, the transition region being curved.

8. (canceled)

9. The combination according to claim 1, wherein the profile of the outer region, inner region and intermediate region are substantially linear, the outer region profile being substantially at right angles to the central axis.

10. In combination, a pump side part and a pump impeller, the impeller comprising a front shroud, a back shroud and a plurality of pumping vanes therebetween, the front shroud having an outer face and an impeller inlet extending through the front shroud, the impeller inlet being coaxial with an impeller rotation axis, the pump side part comprising a side wall section having a front face and a rear face, the pump side part further comprising an inlet section extending from the front face and arranged when in use to be coaxial with the impeller rotation axis, the rear face including an outer region with
an outer edge in a plane which is substantially at right angles to the rotation axis, an inner region with an inner edge, and an intermediate region between the outer and inner regions which is inclined outwardly from the said plane in a direction towards the inlet section, the inner region being inclined and extending from the intermediate region in a direction away from the front face of the side wall section and a curved transition region between the inner and intermediate regions,

wherein the outer face of the impeller front shroud and the rear face of the pump side part are arranged in use to be facing one another with a gap therebetween the gap having an outer opening and an inner opening, the rear face of the side wall section being configured so that the cross-sectional dimension of the gap increases in a direction toward the impeller rotation axis in the intermediate region and wherein the dimension of the gap between the outer face of the impeller front shroud and the inner region of the rear face of the pump side part decreases in the direction from the intermediate region towards the inner edge, terminating at the inner opening.

11. The combination according to claim 10, wherein the gap size in the transition region is determined by a constructed circle C generated in the transition region where the intermediate region and the inner region terminates at respective tangential points on the circumference of the circle, and the plane of the outer face of the impeller front shroud is tangential to another point on the circumference of the circle C, the diameter D of the circle C being in the range from 0.02 to 0.10 of the radial distance L between the outer diameter Z of the front shroud and an inner diameter Y of an innermost end of the inlet section of the pump side part.

12. The combination according to claim 11, the diameter D of the circle C being in the range from 0.04 to 0.05 of the radial distance L between the outer diameter Z of the front shroud and an inner diameter Y of an innermost end of the inlet section of the pump side part.

13. The combination according to claim 11, wherein the distance M from the centre of the circle C to the rotation axis X-X is from 1.0 to 1.8 of the diameter Y of the innermost end of the inlet section of the pump side part.

14. The combination according to claim 11, wherein the distance M from the centre of the circle C to the rotation axis X-X is from 1.2 to 1.8 of the diameter Y of the innermost end of the inlet section of the pump side part.

15. The combination according to claim 11, wherein the distance M from the centre of the circle C to the rotation axis X-X is from 1.2 to 1.5 of the diameter Y of the innermost end of the inlet section of the pump side part.

16. The combination according to claim 11, wherein the impeller comprises a plurality of auxiliary vanes on the outer face of the front shroud, the auxiliary vanes being of a depth T, the diameter D of the circle C being in the range from 0.5 to 1.5 of the depth of the auxiliary vanes.

17. The combination according to claim 11, wherein the impeller comprises a plurality of auxiliary vanes on the outer face of the front shroud, the auxiliary vanes being of a depth T, the diameter D of the circle C being in the range from 0.5 to 1.0 of the depth of the auxiliary vanes.

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