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Impeller for a centrifugal pump

- 10 The invention relates to an impeller for a centrifugal pump in accordance with the preamble of claim 1.

Impellers for centrifugal pumps are already known having at least one vane which has an upper side which has at least one kink line in at least
15 one part region. The vanes are in this respect open in a V shape along the kink line in the direction of a surface normal of an upper side, i.e. an opening of the vanes faces in a direction of rotation in which the impeller is rotated in an operation to generate a pump effect.

- 20 It is in particular the underlying object of the invention to provide an impeller by means of which a characteristic of a centrifugal pump can be improved. The object is satisfied by an impeller in accordance with the invention in accordance with claim 1. Further developments of the invention result from the dependent claims.

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The invention starts from an impeller for a centrifugal pump having at least one vane which has a lower side curved concavely in at least one part region and which has at least one kink line in at least one part region, which kink line extends at least substantially along a main
30 direction of extent of the lower side.

It is proposed that the vane is at least open in a V shape along the kink line in at least one part region in the direction of a surface normal of the lower side. Since the vane of the impeller has a V shape which is open
5 exactly conversely in comparison with the prior art, a flow behavior can in particular be improved within the pump wheel, whereby in particular a characteristic of a centrifugal pump can be improved. A "vane" should in this respect in particular be understood as a component of the impeller which forms a wall of a pump space and which has the radially outwardly
10 facing upper side which is provided to generate a pump effect in an operation. A "pump chamber" should in this respect in particular understood as a volume bounded by the impeller which connects a radially inwardly disposed suction region to a radially outwardly disposed pressure region. The pump chamber can in this respect generally be
15 divided into a plurality of part chambers which are disposed axially behind one another and which all connect the same suction region to the same pressure region. It is, however, generally also conceivable that the impeller has a plurality of different pump chambers which are disposed axially behind one another and which each connect different suction
20 regions to a single pressure region. A "lower side" should in this respect in particular be understood as a surface which is formed by the vane and whose surface normal has a component which is directed radially inwardly with respect to an axis of rotation of the impeller. A "kink line" should in this respect in particular be understood as a line defined by a spatially
25 tightly bounded curvature of the vane. A radius of curvature is preferably substantially larger in the region of the kink line than a radius of curvature in adjacent regions. The radius of curvature in the region of the kink line advantageously amount to at most some millimeters. Depending on the rounded portions in the region of the kink line, the radius of
30 curvature can, however, also be in the range of tenths of a millimeter or in

the range of hundredths of a millimeter. The reference indications "axial", "radial" and "in the peripheral direction" should here and in the following relate to the axis of rotation of the impeller, provided nothing explicitly different is stated. "Open in a V shape" should in this respect in particular
5 be understood such that the lower side forms an open V, i.e. such that the surface has two part surfaces which are arranged at both sides of the kink line and which face one another, with the V preferably opening radially inwardly starting from the kink line.

- 10 The at least one vane preferably has an opening angle spanned by the kink line at the lower side which is smaller than 180 degrees in at least one part region. The V-shaped opening can thereby be particularly advantageously realized. An opening angle should in this respect in particular be understood as a clearance angle which the two mutually
15 facing part surfaces include with one another.

It is further proposed that the opening angle has a bisectrix in at least one part region which lies at least substantially in a plane which is oriented perpendicular to an axis of rotation. A symmetrical design of the vane can
20 thereby be achieved, whereby an improved flow behavior can in particular be achieved in the pressure region. A "bisectrix of the opening angle" should in this respect in particular be understood as a line which intersects the kink line and which divides the opening angle into two part angles of equal amounts. "At least substantially" should in this respect in particular be understood such that an angle which is included by the
25 plane perpendicular to the axis of rotation and by the bisectrix is smaller than 5 degrees. The angle between the plane perpendicular to the axis of rotation and the bisectrix is preferably smaller than 3 degrees and particularly preferably smaller than 1 degree.

It is furthermore advantageous if the bisectrix and the kink line span a plane which is oriented perpendicular to an axis of rotation. The vane can thereby be formed symmetrically with respect to a plane perpendicular to the axis of rotation, whereby a particularly advantageous flow behavior
5 can in particular be achieved in the pressure region.

The lower side of the vane preferably has at least two part surfaces which are each arranged on one side of the kink line and which include an acute angle with a plane perpendicular to an axis of rotation. The V-shaped
10 design of the lower side can thereby be achieved particularly easily. An acute angle should in this respect be understood as an angle smaller than 90 degrees, with the angle preferably being determined in a direction parallel to the axis of rotation.

15 It is moreover proposed that the angles between the plane perpendicular to the axis of rotation and the part surfaces are each smaller than 80 degrees. An advantageous opening angle of the lower side can thereby be achieved. The angles are preferably smaller than 75 degrees. The angles are particularly advantageously smaller than 70 degrees.

20 In a particularly advantageous further development, the part surfaces have an at least substantially planar design in the axial direction. A "planar design in the axial direction" should in this respect in particular be understood such that the lower side of the vane can be described by a
25 straight line along at least one longitudinal sectional plane in the region of the part surfaces. The opening angle is preferably defined by a relative alignment of the two part surfaces relative to one another and can be determined in the longitudinal sectional plane. A "longitudinal sectional plane" should in this respect be understood as a section along a plane
30 which has the axis of rotation.

It is further proposed that the impeller has two impeller disks which are laterally adjacent to the at least one vane and with which the part surfaces of the lower side of the vane include an obtuse angle in at least one part region. The pressure chambers bounded by the vanes in the radial direction can thereby also simply be bounded in the axial direction, with the V-shaped configuration of the lower side in such a design extending over a total axial width of the vane in the at least one part region. An "obtuse angle" should be understood as an angle larger than 90 degrees, with the angle preferably being determined in a direction parallel to the axis of rotation. The angles between the impeller disks and the part surfaces can thus in particular be determined at a longitudinal sectional plane. An "impeller disk" should in this respect in particular be understood as a disk which is arranged perpendicular to the axis of rotation and which bounds the pressure chambers of the impeller in the axial direction. The vanes and the chambers can generally be designed at least partly in one piece or in multiple pieces.

The at least one vane preferably has a symmetrical cross-section in at least one longitudinal sectional plane. A particularly advantageous configuration can thereby be achieved, in particular with respect to the characteristic of the centrifugal pump and/or a construction design. A "symmetrical cross-section" should in this respect in particular be understood as a mirror-symmetrical design with respect to a plane perpendicular to the axis of rotation.

It is moreover proposed that the at least one vane has an at least substantially unchanging thickness in at least one sectional plane. The impeller can thereby be further improved. An "unchanging thickness" should in this respect in particular be understood such that the thickness

of the vane, i.e. its dimension perpendicular to the lower side, is at least substantially constant along a line in the sectional plane.

It is furthermore advantageous if the opening angle amounts to at least 60
5 degrees and/or to at most 160 degrees. The lower side can thereby be advantageously configured. The opening angle preferably amounts to at least 80 degrees and/or to at most 130 degrees. The opening angle particularly advantageously amounts to at least 100 degrees and/or to at most 120 degrees.

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In addition, it is proposed as a further development that the impeller has a center wall which is in particular arranged in the region of the kink line. The pump chambers of the impeller can thereby be in a technical flow aspect divided into part volumes axially disposed behind one another,
15 whereby a particularly advantageous flow behavior can be achieved. A "center wall" should in this respect in particular be understood as a wall for dividing pump chambers into two part volumes connected in parallel from a technical flow aspect. A center wall should in particular not be understood as a radially throughgoing impeller disk which is provided to
20 form a multistage or two-pass impeller. A "multistage impeller" should in this respect in particular be understood as an impeller which has a plurality of suction regions connected behind one another in a technical flow aspect. A "two-pass impeller" in particular be understood as an impeller which has two suction regions connected in parallel in a technical
25 flow aspect and which has pump chambers adjoining each of the suction regions, with the suction regions being connected via the pump chamber to a single common pressure region in a technical flow aspect.

The impeller can generally have a single-pass design having a single
30 suction region and having a single pressure region connected to the one

suction region in a technical flow aspect. Alternatively, however, it is also conceivable that the impeller has a two-pass design having two suction regions disposed axially opposite one another, having an impeller disk separating the two suction regions and having a common pressure region
5 connected to the two suction regions in a technical flow aspect. An impeller with a two-pass design is in this respect fed with fluid from both sides, whereas an impeller having a single-pass design is only fed with fluid from one side.

- 10 In addition, a centrifugal pump having an impeller in accordance with the invention is proposed.

Further advantages result from the following description of the Figures. Two embodiments of the invention are shown in the Figures. The Figures,
15 the description of the Figures and the claims contain a number of features in combination. The skilled person will also expediently consider the features individually and combine them to further sensible combinations.

There are shown:

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Fig. 1 a representation on the prior art;

Fig. 2 a perspective representation of an impeller in accordance with the invention of a centrifugal pump;

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Fig. 3 a longitudinal section through the impeller along a longitudinal sectional plane;

Fig. 4 an enlarged representation of a part region of Fig. 3; and

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Fig. 5 an embodiment of an impeller having a center wall.

Figure 1 shows an impeller 110 for a centrifugal pump such as is known as the prior art. The impeller 110 is provided for generating a pump effect.

5 To generate the pump effect, the impeller 110 comprises a plurality of vanes 111 which have a concavely curved lower side 112 and a convexly curved upper side 126. The vanes 111 each have a kink line 113 which extends along a main direction of extent of the vanes 111. The vanes 111 are open in V shape along the kink line 113 in the direction of a surface
10 normal of the upper side 126, i.e. an opening of the vanes 111 faces in a direction of rotation in which the impeller 110 is rotated in an operation for generating the pump effect.

Figure 2 shows a centrifugal pump in a two-pass design and Figures 3
15 and 4 show in partly schematic form a centrifugal pump in a single-pass design having an impeller 10a in accordance with the invention which is provided for generating a pump effect. The centrifugal pump comprises a pump housing, not shown in any more detail, in which the impeller 10a is rotatably supported, and a drive flange 21a, which is rotationally fixedly
20 connected to the impeller 10a and which is provided to connect the impeller 10a to a drive machine not shown in any more detail. The impeller 10a, which is rotatably supported about an axis of rotation 17a, has a radially inwardly disposed suction region 28a and a radially outwardly disposed pressure region 29a.

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To generate the pump effect, the impeller 10a comprises a plurality of vanes 11a. The vanes 11a each have an upper side 26a which is remote from the axis of rotation 17a and a lower side 12a which faces the axis of rotation 17a. The vanes 11a, which are each formed in an analog manner,
30 are uniformly distributed over a periphery of the impeller 10a. The vanes

11a are arranged spirally with respect to the axis of rotation 17a. The upper sides 26a of the vanes 11a are substantially concavely curved. The lower sides 12a of the vanes 11a are substantially convexly curved.

5 In addition, the impeller 10a comprises two impeller disks 22a, 23a, which are adjacent to the vanes 11a at both sides. The impeller disks 22a, 23a are arranged substantially perpendicular to the axis of rotation 17a. Together with the vanes 11a, the impeller disks 22a, 23a form a plurality of pump chambers 30a which effect a pressure difference between the
 10 suction region 28a and the pressure region 29a in an operation. The pump chambers 30a are bounded by the impeller disks 22a, 23a in the axial direction. The pump chambers 30a are bounded radially inwardly by the upper side 26a of a respective one of the vanes 11a. The pump chambers 30a are bounded radially outwardly by the lower side 12a of the
 15 respectively following vane 11a. The vanes 11a and the impeller disks 22a, 23a are formed in one piece in the embodiment shown. A multipart design is, however, generally also conceivable.

In an operation, the upper sides 26a of the vanes 11a act as pressure
 20 surfaces. The pump effect is substantially due to an extent of the upper sides 26a of the vanes 11a. If the impeller 10a rotates about the axis of rotation 17a, the upper sides 26a form pressure surfaces which, in conjunction with a centrifugal force induced by a rotary movement of the impeller 10a, convey a medium to be pumped, in particular liquids,
 25 radially outwardly.

The vanes 11a each have a kink line 13a which substantially extends along a peripheral direction. The kink line 13a extends along a main direction of extent of the vanes 11a and thus along main directions of
 30 extent of the lower side 12a and of the upper side 26a. The vanes 11a

respectively form a kink along the kink line 13a at the upper side 26a and at the lower side 12a and said kink extends axially centrally over the upper side 26a and the lower side 12a at least in an outer part region of the corresponding vane 11a. The kink line 13a lies at the upper side 26a and at the lower side 12a in a plane 16a which is oriented perpendicular to the axis of rotation 17a.

The kink line 13a along which the upper side 26a and the lower side 12 are respectively kinked extends in the embodiment shown only in the outer part regions of the vanes 11a in the peripheral direction. In inner part regions, in particular in the suction region 28a, the kink line 13a is guided in the direction of a margin of the vanes 11a, whereby the kink line 13a extends obliquely to the peripheral direction. The kink line 13a is in this respect in particular guided up to the margin of the vane 11a in the suction region 28a, whereby the vanes 11a in the embodiment shown are inwardly kink-free and only have the kink outwardly.

The impeller 10a can be adapted to different demands made on the centrifugal pump by varying an extent of the kink line 13a. In particular an axial position which the kink line 13a has at different radii can differ from the embodiment shown. For example, the kink line 13a can also be led radially outwardly to a margin of the vanes 11a, for example to provide the vanes 11a with a kink which extends along the main direction of extent of the vanes 11a from the one margin diagonally over the corresponding vanes 11a to the other margin. In this respect, middle part regions which lie between the outer part region of the vanes 11a and an inner part region can generally also be formed kink-free while the inner and outer part regions have a kink.

The vanes 11a are each open in a V shape along their kink line 13a in the direction of a surface normal of the lower side 12a. The vanes 11a have an opening angle 14a at the lower side 12a along the respective kink line 13a, said opening angle being smaller than 180° at least in the part regions in which the corresponding vane 11a is kinked. The opening angle 14a which defines an opening of the vane 11a is directed radially inwardly. In a longitudinal sectional plane, i.e. a sectional plane in which the axis of rotation 17a lies, the lower side 12a has a V-shaped structure (cf. Figure 4). A point at the lower side 12a of the corresponding vane 11a which lies on the kink line 13a has a larger spacing from the axis of rotation 17a than all further points on the lower side 12a of the corresponding vane 11a which lie in the same longitudinal sectional plane. The kink line 13a thus forms a radially outer point of the lower side 12a in the corresponding longitudinal sectional plane in all longitudinal sectional planes at least in the outwardly disposed part regions.

The opening angle 14a has a bisectrix 15a which is directed parallel to the peripheral direction. The bisectrix 15a thus extends in a plane 16a which is oriented perpendicular to the axis of rotation 17a. The kink line 13a extends in the same plane 16a. The bisectrix 15a and the kink line 13a thus span the plane 16a extending perpendicular to the axis of rotation 17a. The bisectrix 15a lies along the total kink line 13a in the plane 16a which is oriented parallel to the axis of rotation 17a.

The lower side 12a of the vane 11a has part surfaces 18a, 19a at both sides of the kink line 13a which include an acute angle 20a, 21a with the plane 16a perpendicular to the axis of rotation 17a which is spanned by the bisectrix 15a and the kink line 13a. The two part surfaces 18a, 19a are inclined toward one another. The part surfaces 18a, 19a each include an angle 20a, 21a of approximately 60-65 degrees with the plane 16a

which extends perpendicular to the axis of rotation 17a. The opening angle 14 thus amounts to approximately 120-130 degrees. The angles 20a, 21a between the part surfaces 18a, 19a and the plane 16a perpendicular to the axis of rotation 17a can generally be between 5
 5 degrees and 70 degrees. It is in this respect in particular also conceivable that the opening angle 14a varies along the kink line 13a, in particular when the lower side 12a is kink-free in a part region. The opening angle 14a can merge successively from a specific value, for example 120 degrees, along the main direction of extent of the vanes 11a into a kink-
 10 free state in such an embodiment.

The part surfaces 18a, 19a have a planar design in the axial direction. The part surfaces 18a, 19a are only curved in the peripheral direction. In a section along the longitudinal sectional planes, the part surfaces 18a, 19a
 15 have a planar extent (cf. Figure 3). In a section in the plane 16a perpendicular to the axis of rotation 17a, the part surfaces 18a, 19a are curved. The part surfaces 18a, 19a at the lower side 12a of the vane 11a include a respective obtuse angle 20a, 21a with the impeller disks 22a, 23a which are laterally adjacent to the vane 11a. The angles 24a, 25a
 20 which the part surfaces 18a, 19a at the lower side 12a respectively include with the impeller disks 22a, 23a each amount to approximately 120-130 degrees. The impeller disks 22a, 23a each include an angle 31a, 32a of approximately 60 degrees with the upper side 26a of the vane 11a. The angles 24a, 25a at the lower side 12a and the angles 31a, 32a at the
 25 upper side 26a are each formed complementary to one another.

The vanes 11a have a substantially unchanging thickness at least in the outer part regions, i.e. in a corresponding longitudinal sectional plane, the radial thickness of the vanes 11a is substantially constant. The upper side
 30 26a thereby has a shape which corresponds to the V-shaped design of the

lower side 12a. At the lower side 12a, the outwardly facing surface of the vane 11a has the V-shaped design which is radially inwardly open. At the upper side 26a, a material of the vane 11 forms the same shape, with the material having the inwardly open V-shaped design.

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The vane 11a has a symmetrical cross-section in the longitudinal sectional plane. The plane 16a perpendicular to the axis of rotation 17a which is spanned by the bisectrix 15a and the kink line 13a forms a plane of symmetry. The vane 11a is formed with mirror symmetry in the outer part region with respect to the plane 16a. The vane 11a is formed asymmetrically in the inner part region, in particular in the suction region 28a.

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A further embodiment of the invention of a centrifugal pump in a double-pass design is shown in Figure 5. The following descriptions are substantially restricted to the differences between the embodiments, with reference being able to be made to the description of the embodiment of Figures 2 to 4 with respect to components, features and functions which remain the same. To distinguish the embodiments, the letter a in the reference numerals of the embodiment in Figures 2 to 4 is replaced with the letter b in the reference numerals of the embodiment of Figure 5. Reference can generally also be made to the drawings and/or the description of the embodiment of Figures 2 to 4 with respect to components of the same name, in particular with respect to components with the same reference numerals.

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Figure 5 shows a detail of an impeller 10b for a centrifugal pump in a double-pass design, said impeller having a plurality of vanes 11b, wherein in the present cross-sectional view only one vane is visible. The vanes 11b each have a concavely curved lower side 12b and a convexly curved upper

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side 26b. In addition, the vane 11b has a kink line 13b which extends along a main direction of extent of the vane 11b. The lower side 12b has a surface normal which is oriented perpendicular to a surface of the vane 11b at every point of the kink line 13b. The vane 11b is open in V shape in the direction of the surface normal of the lower side 12b along the kink line 13b. In addition, the impeller 10b comprises two impeller disks 22b, 23b which adjoin the vanes 11b at both sides and which, together with the vanes 11b, each span pump chambers 30b for conveying a fluid to be pumped.

Unlike the preceding embodiment, the impeller 10b comprises a center wall 33b which divides the respective pump chambers 30b into two part volumes 34b, 35b arranged axially behind one another. The center wall 33b is arranged in the region of the kink line 13b. The center wall 33b extends in a portion substantially parallel parallel to the impeller disks 22b, 23b. The center wall 33b enables advantageously that liquid respectively aspirated through the suction region 28b does not apply directly to each other in the intake for improved pumping action. The center wall 33b fluidically divides the pumping chamber 30b into two part volumes 34b, 35b arranged axially behind one another.

The impeller 10b has a radially inwardly disposed suction region 28b which is connected in a technical flow aspect to the part volumes 34b, 35b disposed axially behind one another. In addition, the impeller 10b has a radially outwardly disposed pressure region 29b which is likewise connected in a technical flow aspect to the part volumes 34b, 35b disposed axially behind one another. Each of the part volumes 34b, 35b thus connects the inwardly disposed suction region 28b to the outwardly disposed pressure region 29b.

The center wall 33b which divides the pump chambers 30b into the part volumes 34b, 35b arranged axially behind one another is formed in the manner of an elevation at the so called hub of the centrifugal pump. The suction region 28b is arranged within the center wall 33b. The pressure
5 region 29b is arranged outside the center wall 33b. The center wall 33b is arranged radially inside in respect of the vane 11b.

The impeller 10b is arranged at a drive shaft 27 for driving the impeller
10b.

Claims

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1. An impeller for a centrifugal pump having at least one vane (11a; 11b) which has a lower side (12a; 12b) concavely curved in at least one part region and which has at least one kink line (13a; 13b) in at
10 least one part region, which kink line extends at least substantially along a main direction of extent of the at least one vane (11a; 11b), characterized in that the vane (11a; 11b) is open in a V shape along the kink line (13a; 13b) in at least one part region in the direction of a surface normal
15 of the lower side (12a; 12b).
2. An impeller in accordance with claim 1, characterized in that the at least one vane (11a; 11b) has at the lower side (12a; 12b) an
20 opening angle (14a) which is spanned by the kink line (13a; 13b) and which is smaller than 180 degrees in at least one part region.
3. An impeller in accordance with claim 2, characterized in that
25 the opening angle (14a) has in at least one part region a bisectrix (15a) which lies at least substantially in a plane (16a) which is oriented perpendicular to an axis of rotation (17a).
4. An impeller in accordance with claim 3,
30 characterized in that

the bisectrix (15a) and the kink line (13a; 13b) span the plane (16a) which is oriented perpendicular to the axis of rotation (17a).

5. An impeller in accordance with any one of the preceding claims,
 5 characterized in that
 the lower side (12a; 12b) of the vane (11a; 11b) has at least two part
 surfaces (18a, 19a) which are arranged on oppositely disposed sides
 of the kink line (13a; 13b) and which include a respective acute
 angle (20a, 21a) at the kink line (13a; 13b) with a plane (16a)
 10 perpendicular to an axis of rotation (17a).
6. An impeller in accordance with claim 5,
 characterized in that
 the angles (20a, 21a) between the plane (16a) perpendicular to the
 15 axis of rotation (17a) and the part surfaces (18a, 19a) are each
 smaller than 80 degrees.
7. An impeller in accordance with claim 5 or claim 6,
 characterized in that
 20 the part surfaces (18a, 19a) have an at least substantially planar
 design in the axial direction.
8. An impeller at least in accordance with claim 5,
 characterized by
 25 two impeller disks (22a, 23a; 22b, 23b) which are laterally adjacent
 to the at least one vane (11a; 11b) and with which the part surfaces
 (18a, 19a) of the lower side (12a; 12b) of the vane (11a; 11b) include
 an obtuse angle (24a, 25a) in at least one part region.
- 30 9. An impeller in accordance with any one of the preceding claims,

characterized in that
the at least one vane (11a; 11b) has a symmetrical cross-section in
at least one longitudinal sectional plane.

5 10. An impeller in accordance with any one of the preceding claims,
characterized in that
the at least one vane (11a; 11b) has a substantially unchanging
thickness in at least one sectional plane.

10 11. An impeller in accordance with any one of the preceding claims,
characterized in that
the opening angle (14a) amounts to at least 60 degrees and/or to at
most 160 degrees.

15 12. An impeller in accordance with any one of the preceding claims,
characterized by
a center wall (33b) which is in particular arranged in the region of
the kink line (13b).

20 13. An impeller in accordance with any one of the preceding claims,
characterized by
a one-pass design.

14. An impeller in accordance with any one of the claims 1 to 12,
25 characterized by
a two-pass design.

15. A centrifugal pump having an impeller (10a; 10b) in accordance
with any one of the preceding claims.