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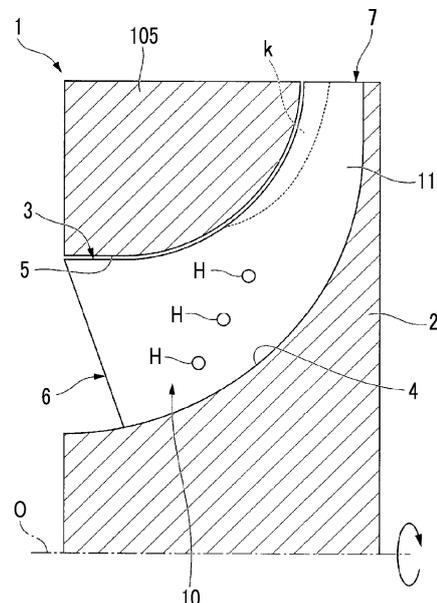
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(54) **IMPELLER AND CENTRIFUGAL COMPRESSOR**

(57) The present invention is provided with: a disk (2) that rotates around an axis (0); and, on the surface of one axial (0) side of the disk (2), a plurality of blades (3) that are provided at intervals in the circumferential direction and demarcate a channel (10) in which a fluid that flows in from one side in the axial (0) direction is discharged toward the outer side in the radial direction. Therein, holes (H) are formed in the blades (3), said holes communicating with a pressure surface (p) that faces the front side in the rotational direction, and with a suction surface (n) that faces the rear side in the rotational direction.

FIG. 7



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## Description

### Technical Field

**[0001]** The present invention relates to an impeller and a centrifugal compressor.

**[0002]** Priority is claimed on Japanese Patent Application No. 2014-009680, filed January 22, 2014, the content of which is incorporated herein by reference.

### Background Art

**[0003]** In general, in a centrifugal compressor or a diagonal compressor which is used in a rotary machine such as an industrial compressor, a turbo chiller, or a small gas turbine, performance improvement is required, and particularly, performance improvement of an impeller which is a key component of the compressors is required. In addition, in recent years, various means for improving the performance of the impeller have been suggested.

**[0004]** PTL 1 discloses that cross bleed holes penetrating both surface of a shroudless blade are provided on the shroudless blade which is used in a fan of a compressor or an axial flow gas turbine. The cross bleed holes are provided in the vicinity of a tip of the blade.

### Citation List

#### Patent Literature

**[0005]** [PTL 1] Specification of US Unexamined Patent Application Publication No. 2010/0329848

#### Summary of Invention

#### Technical Problem

**[0006]** However, in the shroudless blade of PTL 1, since a swirl is formed due to a secondary flow at a region on the outside in a radial direction on a suction surface side of the blade, a low energy fluid stays in the region, and energy loss of an impeller occurs.

**[0007]** The present invention is made to solve the above-described problem and is to provide an impeller in which energy loss decreases and efficiency increases.

#### Solution to Problem

**[0008]** In order to solve the problem, in an impeller and a centrifugal compressor according to a first aspect of the present invention, the following means is adopted.

**[0009]** According to a first aspect of the present invention, there is provided an impeller including: a disk which rotates around an axis; and a plurality of blades which are provided at intervals therebetween in a circumferential direction on one side surface in an axial direction of the disk, and demarcate a channel through which a fluid

flowing in from the one side in the axial direction is discharged toward the outside in a radial direction, in which a hole is formed in the blade, and the hole communicates with a pressure surface facing a front side in a rotational direction and a suction surface facing a rear side in the rotational direction.

**[0010]** According to this configuration, a portion of the fluid flowing into the inner portion of the channel is injected to the inner portion of the channel of the suction surface side as a jet stream via the hole. It is possible to dissipate a secondary flow and a swirl generated in the suction surface side of the blade by the jet stream.

**[0011]** In addition, in the impeller according to a second aspect of the present invention, in the first aspect, the hole may extend toward a downstream side of the channel as the hole is directed from the pressure surface side to the suction surface side.

**[0012]** According to this configuration, since the jet stream injected from the hole flows in approximately the same direction as that of a main stream of the fluid on the suction surface side of the channel, it is possible to dissipate the secondary flow and the swirl without interfering with the flow of the main stream.

**[0013]** Moreover, in the impeller according to a third aspect of the present invention, in the first or second aspect, a plurality of holes may be arranged so as to be separated from each other from the inside in the radial direction of a duct toward the outside in the radial direction.

**[0014]** According to this configuration, since a flow rate of the jet stream injected from the hole increases and the jet stream is injected to a wider region on the suction surface side, it is possible to more effectively dissipate the secondary flow and the swirl generated on the suction surface side.

**[0015]** In addition, in the impeller according to a fourth aspect of the present invention, in any one of the first to third aspects, an opening area of the hole may increase from the pressure surface side toward the suction surface side.

**[0016]** According to this configuration, it is possible to appropriately adjust a pressure of the jet stream injected from the hole so as to be decreased. Accordingly, the jet stream is appropriately adjusted so as not to interfere with the flow of the main stream, and it is possible to effectively dissipate the secondary flow and the swirl.

**[0017]** Moreover, in the impeller according to a fifth aspect of the present invention, in any one of the first to fourth aspects, the opening area of the hole may decrease from the pressure surface side toward the suction surface side.

**[0018]** According to this configuration, it is possible to appropriately adjust a pressure of the jet stream injected from the hole so as to be increased. Accordingly, the jet stream is appropriately adjusted so as not to interfere with the flow of the main stream, and it is possible to effectively dissipate the secondary flow and the swirl.

**[0019]** In addition, in the impeller according to a sixth

aspect of the present invention, in any one of the first to fifth aspects, the hole may have a groove which is spirally formed on an inner peripheral surface of the hole.

**[0020]** According to this configuration, due to the spiral groove, swirling components are applied to the jet stream injected from the hole. Since the fluid including the swirling components collides with the secondary flow and the swirl, it is possible to more effectively dissipate the secondary flow and the swirl.

**[0021]** Moreover, in the impeller according to a seventh aspect of the present invention, in any one of the first to fifth aspects, the hole may have one inflow port which is provided on the pressure surface side, and may have a plurality of injection ports which communicate with the inflow port and are provided on the suction surface side.

**[0022]** According to this configuration, since the plurality of injection ports are provided on the suction surface side while one inflow port is provided on the pressure surface side, the jet stream is injected to a wider region on the suction surface side, and it is possible to more effectively dissipate the secondary flow and the swirl generated on the suction surface side.

**[0023]** In addition, according to an eight aspect of the present invention, there is provided a centrifugal compressor including the impeller according to any one of the first to seventh aspects.

#### Advantageous Effects of Invention

**[0024]** According to the impeller of the present invention, it is possible to provide an impeller in which energy loss decreases and efficiency increases.

#### Brief Description of Drawings

##### **[0025]**

Fig. 1 is a sectional view showing an outline of a centrifugal compressor according to the present invention.

Fig. 2 is a circumferential sectional view of an impeller according to a first embodiment of the present invention.

Fig. 3 is a sectional view taken along line A-A of Fig. 1 in a blade according to the first embodiment of the present invention.

Fig. 4 is a view showing a region in which a hole H according to each embodiment of the present invention is provided.

Fig. 5 is a sectional view of a blade according to a second embodiment of the present invention.

Fig. 6 is a sectional view showing a modification example of the blade according to the second embodiment of the present invention.

Fig. 7 is a sectional view of a blade according to a third embodiment of the present invention.

Fig. 8 is a sectional view showing a modification example of the blade according to the third embodiment

of the present invention.

Fig. 9 is a sectional view of a blade according to a fourth embodiment of the present invention.

Fig. 10 is a sectional view of a blade according to a fifth embodiment of the present invention.

#### Description of Embodiments

**[0026]** Next, an impeller of a rotary machine in embodiments of the present invention will be described with reference to the drawings. In the embodiments, an impeller of a centrifugal compressor which is a rotary machine will be described as an example.

##### (First Embodiment)

**[0027]** As shown in Fig. 1, for example, a centrifugal compressor 100 which is a rotary machine of the present embodiment is mainly configured of a shaft 102 which rotates around an axis O, impellers 1 which are attached to the shaft 102 and compress a process gas (gas) G using centrifugal force, and a casing 105 which rotatably supports the shaft 102 and in which a channel 104 through which the process gas G flows from an upstream side to a downstream side is formed.

**[0028]** The casing 105 is formed so as to have an approximately columnar outline and the shaft 102 is disposed so as to penetrate the center of the casing 105. Journal bearings 105a are provided on both ends of the casing 105 in the axial direction of the shaft 102, and a thrust bearing 105b is provided on one end. The journal bearings 105a and the thrust bearing 105b rotatably support the shaft 102. That is, the shaft 102 is supported by the casing 105 via the journal bearings 105a and the thrust bearing 105b.

**[0029]** Moreover, an intake port 105c through which the process gas G flows in from the outside is provided on one end side of the casing 105 in the axial direction, and an exhaust port 105d through which the process gas G is discharged to the outside is provided on the other end side. An internal space, which communicates with each of the intake port 105c and the exhaust port 105d and in which an increase in a diameter and a decrease in the diameter are repeated, is provided in the casing 105. The internal space functions as a space for accommodating the impellers 1 and functions as the channel 104.

**[0030]** That is, the intake port 105c and the exhaust port 105d communicate with each other via the impellers 1 and the channel 104.

**[0031]** The plurality of impellers 1 are arranged with intervals therebetween in the axial direction of the shaft 102. In addition, in Fig. 1, six impellers 1 are provided. However, at least one or more impeller may be provided.

**[0032]** As shown in Figs. 2 to 4, the impeller 1 is configured so as to include a disk 2 and a plurality of blades 3. The disk 2 is formed in an approximately circular shape in a front view, and is rotatable around the shaft about

the above-described axis O. In the disk 2, a disk surface 4 is curvedly formed from a predetermined position S on the inside in the radial direction slightly separated toward the outside in the radial direction from the axis O toward the outside in the radial direction. In the curvedly formed disk surface 4, the surface positioned on the inside in the radial direction is formed along the axis O, and is formed so as to be gradually concaved in the radial direction toward the outside in the radial direction. That is, the thickness of the disk 2 in the axial direction decreases from one (upstream side) of the end surfaces in the axial direction as the disk 2 is directed from the position S on the inside in the radial direction which is slightly separated from the axis O toward the outside in the radial direction, and a decrease amount in the thickness of the disk 2 in the axial direction becomes larger as the position of the thickness moves inward and the decrease amount becomes smaller as the position of the thickness moves outward.

**[0033]** In the above-described disk surface 4, the plurality of blades 3 are approximately radially disposed and are erected so as to be approximately perpendicular to the disk surface 4. The thickness of each of the blades 3 is approximately uniformly formed from an end portion of the blade of the disk surface 4 side to the end portion of the tip side opposite to the disk surface 4 side.

**[0034]** In addition, when the blade 3 is viewed from the direction of the axis O, the blade 3 has a shape which is curved so as to be a slightly convex surface in a rotational direction of the disk 2 from the end portion on the inside in the radial direction to the end portion on the outside in the radial direction. When the impeller 1 rotates, in blade surfaces of the concave surface side and the convex surface side of the curved blade 3, the blade surface of the concave surface side which is the rear side of the convex surface becomes a suction surface n while the blade surface of the convex surface side becomes a pressure surface p.

**[0035]** Fig. 2 is a view showing a section taken along line A-A of Fig. 1. In addition, line A-A is a line which passes through an intermediate position in a height direction of the blade 3 based on the disk surface 4. As shown in Fig. 2, a tip end t of the blade 3 is formed so as to be curved from the inside in the radial direction of the disk 2 to the outside in the radial direction. More specifically, similarly to the above-described disk surface 4, the tip end is formed along the axis O as it is positioned on the inside in the radial direction, and the tip end is formed so as to be gradually concaved along the radial direction toward the outside in the radial direction. In addition, the height of the blade 3 based on the disk surface 4 becomes high as the position of the height is positioned further on the inside in the radial direction of the disk 2, and the height becomes low as the position of the height is positioned further on the outside in the radial direction.

**[0036]** In the impeller 1, the tip end t side of the blade 3 is covered by the casing 105 (refer to Fig. 1), and an impeller channel 10 of the impeller 1 is configured of a

shroud surface 5 which is configured by the casing 105, the pressure surface p and the suction surface n of the blade 3 which are adjacent to each other, and the disk surface 4 between the pressure surface p and the suction surface n. That is, two impeller channels 10 and 10 are configured so as to be adjacent to each other via one blade 3.

**[0037]** In addition, a hole H which penetrates the blade 3 from the pressure surface p toward the suction surface n is formed in the middle of the extension of the blade 3. The hole H is formed to penetrate the blade 3 so as to have a predetermined angle with respect to the thickness direction of the blade 3. In other words, in the hole H, a position of an inflow port H1 on the pressure surface p side and a position of an injection port H2 on the suction surface n side are formed so as to be deviated from each other when viewed in the circumferential direction of the disk 2, and the inflow port H1 and the injection port H2 are formed so as to linearly communicate with each other. That is, the impeller channels 10 and 10 adjacent to each other via the blade 3 communicate with each other by the hole H.

**[0038]** Moreover, in the present embodiment, when viewed in the circumferential direction of the impeller 1, the penetrating direction of the hole H is set so as to be approximately the same as a line which connects intermediate positions in the height direction of the blade 3 based on the disk surface 4 in the axial direction.

**[0039]** A sectional shape of the hole H when viewed in the penetrating direction of the hole H is circular. Here, an opening size of the hole H is approximately determined according to design. However, in the present embodiment, the opening size of the inflow port H1 of the hole H is the same as that of the injection port H2 of the hole H.

**[0040]** Next, in a case where the blade 3 is viewed from the pressure surface p side, the position at which the hole H (inflow port H1) is provided will be described with reference to Fig. 4. That is, the position at which the hole H is provided is inside a region A in Fig. 4. The region A is a region which is surrounded by a virtual curve L1 along a flow direction of a fluid on the surface of the blade 3, virtual curves L2 and L3 orthogonal to the virtual curve L1, and the disk surface 4.

**[0041]** As described above, the virtual curve L1 is curved along the flow direction of the fluid, and is set so as to pass through approximately 60% of the positions of the height from the disk surface 4 to the tip end t of the blade 3. Moreover, the virtual curve L2 is set so as to pass through approximately 20% of the positions of the dimension from an end edge of an inlet 6 side of the impeller channel 10 to an end edge of an outlet 7 side in the blade 3. Similarly, the virtual curve L3 is set so as to pass through approximately 60% of the positions of the dimension from the end edge of the inlet 6 side to the end edge of the outlet 7 side. That is, the region A is an approximately rectangular region which includes the pair of long sides formed arcuately and the pair of short sides

connecting the long sides, and similarly to the disk surface 4, the region A is formed along the axis 0 as it is positioned on the inside in the radial direction, and the region A is formed so as to be gradually concaved along the radial direction as it is directed the outside in the radial direction. In addition, the height of the blade 3 based on the disk surface 4 becomes higher as the position of the height is positioned on the inside in the radial direction of the disk 2, and the height becomes lower as the position of the height is positioned on the outside in the radial direction.

**[0042]** Moreover, in the above description, the position at which the inflow port H1 is provided on the pressure surface p side is described. However, similarly to the inflow port H1, the injection port H2 is also formed so as to be included inside the region A.

**[0043]** As described above, in the impeller 1, the tip end t side of the blade 3 is covered by the casing 105 (refer to Fig. 1), and the impeller channel 10 of the impeller 1 is configured of the shroud surface 5 which is configured by the casing 105, the pressure surface p and the suction surface n of the blade 3 which are adjacent to each other, and the disk surface 4 between the pressure surface p and the suction surface n. Accordingly, by rotating the impeller 1, a fluid flows in from the inlet 6 of the impeller channel 10 positioned on the inside in the radial direction of the disk 2, and the fluid flows to the outside from the outlet 7 positioned on the outside in the radial direction by centrifugal force. That is, as shown in Fig. 2, the fluid forms a main stream F. Moreover, the main stream F follows the curved direction of the disk surface 4. In addition, the main stream F exists over the entire height direction of the blade 3. However, in Fig. 2, a representative direction of the main stream F is shown by one arrow.

**[0044]** Here, the state of the main stream F in a case where the hole H is not provided in the blade 3 is described. That is, the flow direction is gradually changed from the axial direction to the radial direction as the impeller channel 10 is directed from the inside in the radial direction of the disk 2 to the outside in the radial direction, and as described above, the impeller channel 10 is curvedly formed from the inlet 6 toward the outlet 7. Due to the impeller channel 10 being curvedly formed and centrifugal force toward the outside in the radial direction being generated according to the rotation of the impeller 1, in the impeller channel 10, a secondary flow F2 shown by a dashed arrow in Fig. 2 is formed in addition to the main stream F. In the case where the hole H is not formed in the blade 3, the secondary flow F2 reaches a region k of the shroud surface 5 side close to the suction surface n of a latter half portion 11 of the outlet 7 side of the impeller channel 10, and forms a swirl. That is, the secondary flow F2 stays in the region k as a fluid having low energy.

**[0045]** However, in the present embodiment, the hole H penetrating the blade 3 from the pressure surface p toward the suction surface n is formed in the middle of

the extension of the blade 3. In this case, a portion of the fluid flowing in from the inlet 6 of the impeller channel 10 flows into the hole H from the inflow port H1 of the pressure surface p side, and is injected toward the adjacent impeller channel 10 (the impeller channel 10 positioned on the rear side in the rotational direction of the impeller 1) via the blade 3 from the injection port H2 of the suction surface n. In addition, the fluid injected from the injection port H2 forms a jet stream FJ. As described above, the hole H penetrates the blade 3 in the same direction as the extension direction of the line which connects the intermediate positions in the height direction of the blade 3 based on the disk surface 4. That is, the direction of the hole H is approximately the same as the direction of the main stream F flowing in the vicinity of the hole H. Accordingly, the flow direction of the jet stream FJ injected from the hole H is approximately the same as the direction of the main stream F.

**[0046]** Accordingly, the jet stream FJ having approximately the same directional components as those of the main stream F collides with the secondary flow F2 having directional components different from those of the flow direction of the main stream F. Here, since an opening volume of the hole H is sufficiently smaller than a volume of the impeller channel 10, the jet stream FJ passing through the hole H has a higher pressure than that of the vicinity of the jet stream FJ. In other words, the jet stream FJ has a higher flow rate than that of the secondary flow F2.

**[0047]** Accordingly, the secondary flow F2 is deviated by the jet stream FJ, flows in approximately the same direction as that of the jet stream FJ, that is, in the approximately the same direction as that of the main stream F, and the directional components of the secondary flow F2 directing the region k decrease.

**[0048]** As described above, in the impeller 1 according to the present embodiment, the hole H, which communicates with the pressure surface p facing the front side in the rotational direction and the suction surface n facing the rear side in the rotational direction, is formed in the blade 3.

**[0049]** Accordingly, the swirl generated in the region k due to the secondary flow F2 decreases by the jet stream FJ injected from the hole H, and components staying in the region k as a fluid having low energy decrease. That is, in the impeller 1, pressure loss due to the secondary flow F2 decreases, and it is possible to obtain high efficiency.

**[0050]** In addition, the hole H extends toward the downstream side of the impeller channel 10 as the hole is directed from the pressure surface p side toward the suction surface n side.

**[0051]** Accordingly, with respect to the secondary flow F2 having directional components different from those of the flow direction of the main stream F, it is possible to form the jet stream FJ having approximately the same directional components as those of the main stream F.

(Second Embodiment)

**[0052]** Next, a second embodiment of the present invention will be described with reference to Fig. 5. Moreover, the same reference numerals are assigned to the same components as those of the first embodiment, and detailed descriptions thereof are omitted.

**[0053]** Fig. 5 is a view showing the blade 3 of the impeller 1 according to the present embodiment. As shown in Fig. 5, in the blade 3 according to the present embodiment, the opening area of the injection port H2 provided on the suction surface n side is larger than the opening area of the inflow port H1 provided on the pressure surface p side. That is, the hole H is formed such that the opening area increases from the pressure surface p side toward the suction surface n side.

**[0054]** According to this configuration, unlike the case where the hole H is formed in a linear tube shape, it is possible to adjust the pressure of the jet stream FJ passing through the hole H so as to be decreased. That is, it is possible to decrease the flow rate of the jet stream FJ. Accordingly, it is possible to more effectively decrease the secondary flow F2.

**[0055]** In addition, as shown in Fig. 6, in the blade 3 according to the present embodiment, the hole H may be formed such that opening area of the injection port H2 provided on the suction surface n side is smaller than the opening area of the inflow port H1 provided on the pressure surface p side. That is, the hole H may be formed such that the opening area decreases from the pressure surface p side toward the suction surface n side.

**[0056]** According to this configuration, unlike the case where the hole H is formed in a linear tube shape, it is possible to adjust the pressure of the jet stream FJ passing through the hole H so as to be increased. That is, it is possible to increase the flow rate of the jet stream FJ. Accordingly, it is possible to more effectively decrease the secondary flow F2.

(Third Embodiment)

**[0057]** Next, a third embodiment of the present invention will be described with reference to Fig. 7. Moreover, the same reference numerals are assigned to the same components as those of the above described embodiments, and detailed descriptions thereof are omitted.

**[0058]** As shown in Fig. 7, in the blade 3 according to the present embodiment, the plurality of holes H are provided so as to be separated from each other from the inside in the radial direction of the disk 2 toward the outside in the radial direction. In Fig. 7, three holes H are shown. The three holes H are approximately linearly arranged so as to be separated from the disk surface 4 from the hole H positioned on the inside in the radial direction toward the hole H positioned on the outside in the radial direction. In addition, all three holes are formed inside the region A shown in Fig. 4.

**[0059]** According to this configuration, unlike a case

where only one hole H is provided, it is possible to inject the jet stream FJ in a wider range. Therefore, it is possible to more effectively decrease the secondary flow F2.

**[0060]** In addition, as shown in Fig. 8, three holes H may be arranged along the height direction of the blade 3 based on the disk surface 4. In addition, according to this configuration, it is possible to inject the jet stream FJ in a wider range, and it is possible to more effectively decrease the secondary flow F2.

(Fourth Embodiment)

**[0061]** Next, a fourth embodiment of the present invention will be described with reference to Fig. 9. Moreover, the same reference numerals are assigned to the same components as those of the above described embodiments, and detailed descriptions thereof are omitted.

**[0062]** As shown in Fig. 9, in the blade 3 according to the present embodiment, the hole H has a spiral groove C on the inner peripheral surface of the hole H. The groove C is formed so as to draw a circle along the inner peripheral surface of the hole H from the pressure surface p side toward the suction surface n side. That is, the groove C has a female screw shape. In addition, the circumference direction of the groove C may be the clockwise direction or the counterclockwise direction.

**[0063]** According to this configuration, it is possible to apply swirling components based on the circumference direction of the groove C to the jet stream FJ passing through the hole H. Accordingly, when the jet stream FJ collides with the secondary flow F2, since the flow including the swirling components diffuses the secondary flow F2, it is possible to more effectively decrease the secondary flow F2.

(Fifth Embodiment)

**[0064]** Next, a fifth embodiment of the present invention will be described with reference to Fig. 10. Moreover, the same reference numerals are assigned to the same components as those of the above described embodiments, and detailed descriptions thereof are omitted.

**[0065]** As shown in Fig. 10, in the blade 3 according to the present embodiment, the hole H includes one inflow port H1 which is provided on the pressure surface p side and a plurality of injection ports H2 which are provided on the suction surface n side. Fig. 10 shows a configuration in which three injection ports H2 are provided. Each of the three injection ports H2 communicates with one inflow port H1. In addition, the three injection ports H2 are arranged so as to be separated from each other from the inside in the radial direction of the disk 2 toward the outside in the radial direction. That is, three channels are formed inside the hole H toward the injection ports H2 with the inflow path H1 as the starting point. In addition, the channel which is positioned in the innermost side in the radial direction among the three channels linearly communicates with the inflow port H1.

**[0066]** According to this configuration, after the jet stream FJ introduced from one inflow port H1 is divided into three streams toward the three channels, the divided jet stream is injected from the three injection ports H2 to the suction surface n side. Accordingly, it is possible to supply the jet stream FJ to the suction surface n side in a wide range. Moreover, since only one inflow port H1 is provided on the pressure surface p side, the components of the flow extracted from the main stream F so as to form the jet stream FJ may decrease.

**[0067]** Accordingly, it is possible to more effectively decrease the secondary flow F2, and it is possible to decrease the influence of the jet stream FJ applied to the main stream F.

**[0068]** Hereinbefore, the embodiments of the present invention are described with reference to the drawings. However, specific configurations are not limited to the embodiments, and include design modifications or the like within a scope which does not depart from the gist of the present invention.

**[0069]** For example, in the above-described embodiments, the opening shape of the hole H is circular. However, the opening shape of the hole H is not limited to this, and may be a rectangular slit shape, or a polygon such as a triangular shape. In addition, the opening shape may be an elliptical shape.

#### Industrial Applicability

**[0070]** According to the impeller of the present invention, it is possible to provide an impeller in which energy loss decreases and efficiency increases. It is possible to apply the impeller according to the present invention to a rotary machine such as a centrifugal compressor.

#### Reference Signs List

##### **[0071]**

- 1: impeller
- 2: disk
- 3: blade
- 4: disk surface
- 5: shroud surface
- 6: impeller channel inlet
- 7: impeller channel outlet
- 10: impeller channel
- 100: centrifugal compressor
- 102: shaft
- 104: channel
- 105: casing
- F: main stream
- F2: secondary flow
- FJ: jet stream
- H: hole

#### Claims

##### 1. An impeller comprising:

5 a disk which rotates around an axis; and  
 a plurality of blades which are provided at intervals therebetween in a circumferential direction on one side surface in an axial direction of the disk, and demarcate a channel through which a fluid flowing in from the one side in the axial direction is discharged toward the outside in a radial direction,  
 10 wherein a hole is formed in the blade, and the hole communicates with a pressure surface facing a front side in a rotational direction and a suction surface facing a rear side in the rotational direction.

2. The impeller according to claim 1,  
 20 wherein the hole extends toward a downstream side of the channel as the hole is directed from the pressure surface side to the suction surface side.

3. The impeller according to claim 1 or 2,  
 25 wherein a plurality of holes are arranged so as to be separated from each other from the inside in the radial direction toward the outside in the radial direction.

4. The impeller according to any one of claims 1 to 3,  
 30 wherein an opening area of the hole increases from the pressure surface side toward the suction surface side.

5. The impeller according to any one of claims 1 to 4,  
 35 wherein the opening area of the hole decreases from the pressure surface side toward the suction surface side.

6. The impeller according to any one of claims 1 to 5,  
 40 wherein the hole has a groove which is spirally formed on an inner peripheral surface of the hole.

7. The impeller according to any one of claims 1 to 5,  
 45 wherein the hole includes one inflow port which is provided on the pressure surface side, and a plurality of injection ports which communicate with the inflow port and are provided on the suction surface side.

8. A centrifugal compressor comprising the impeller according to any one of claims 1 to 7.  
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FIG. 3

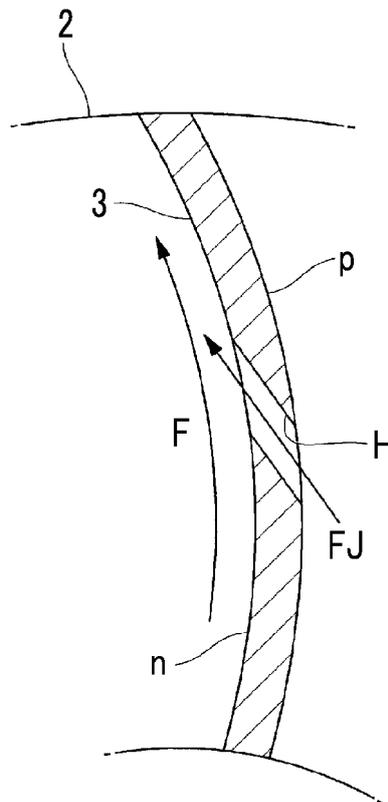


FIG. 4

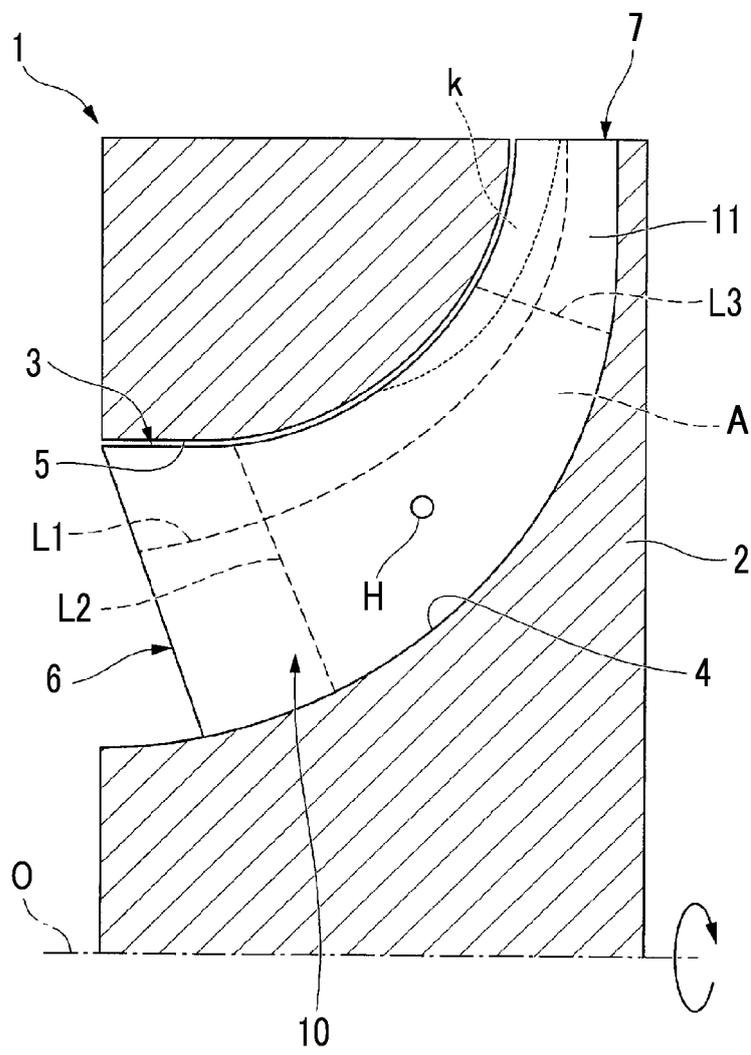


FIG. 5

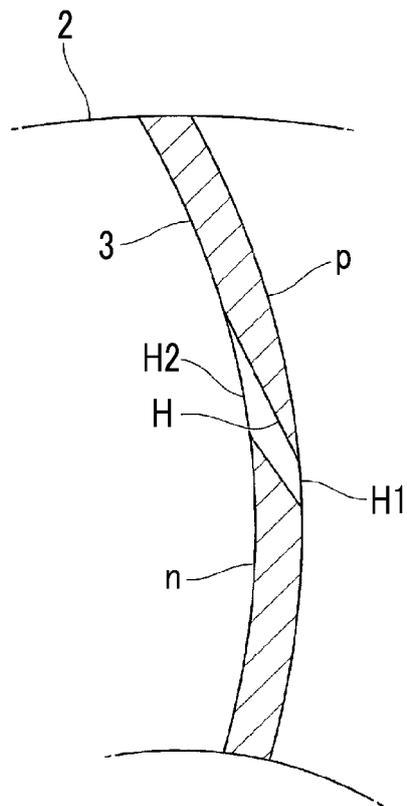


FIG. 6

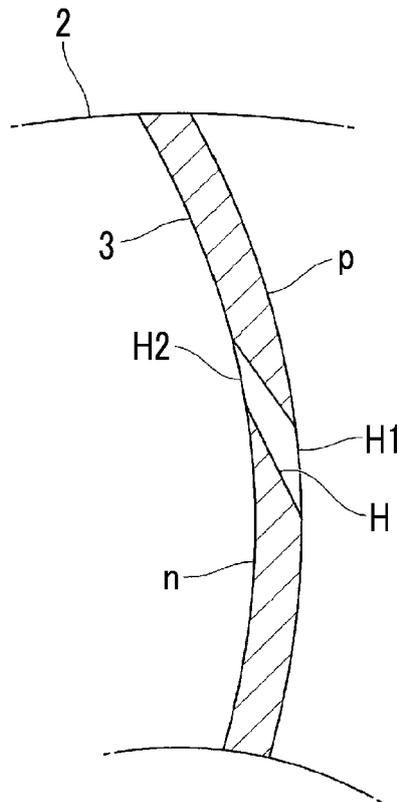


FIG. 7

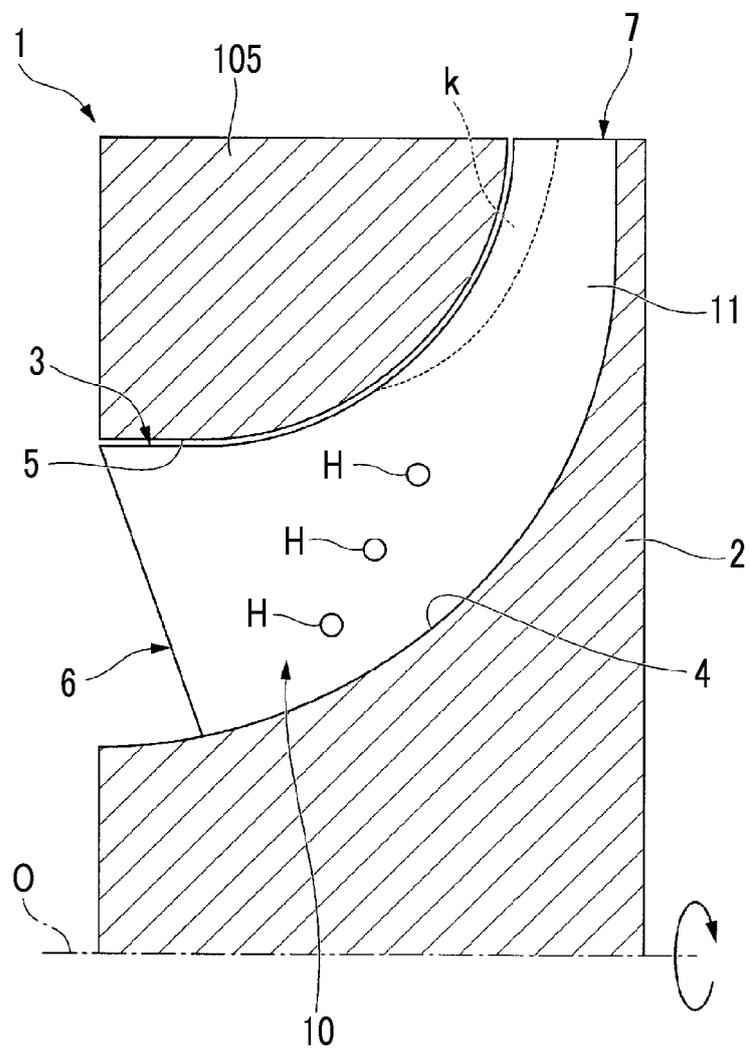


FIG. 8

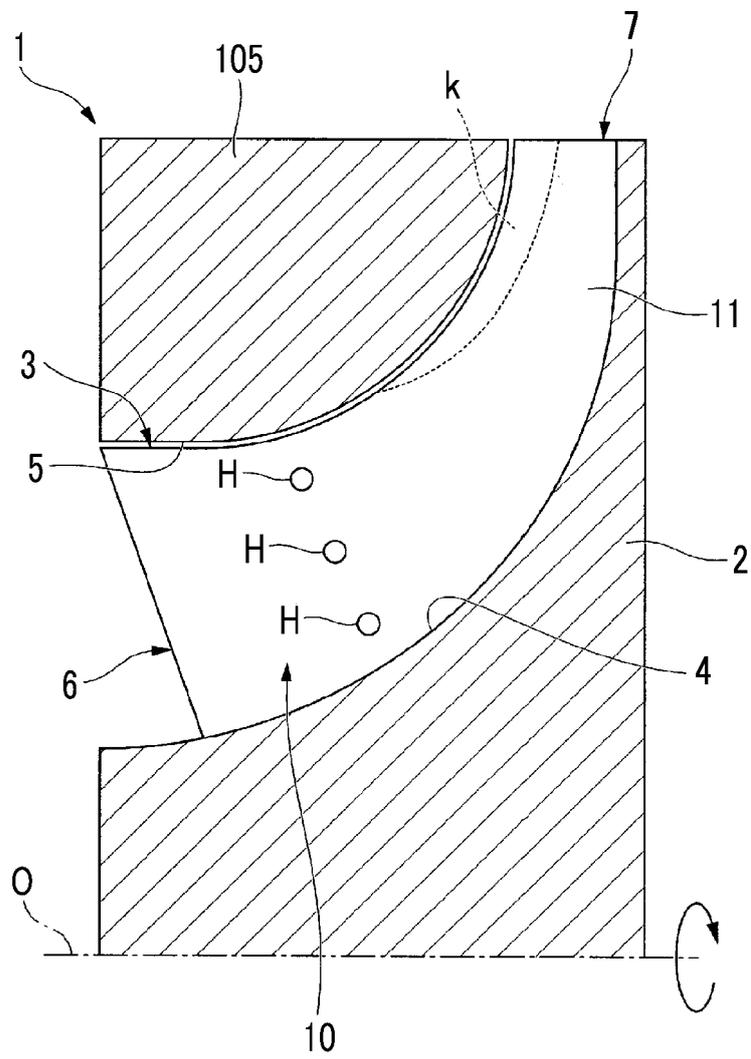


FIG. 9

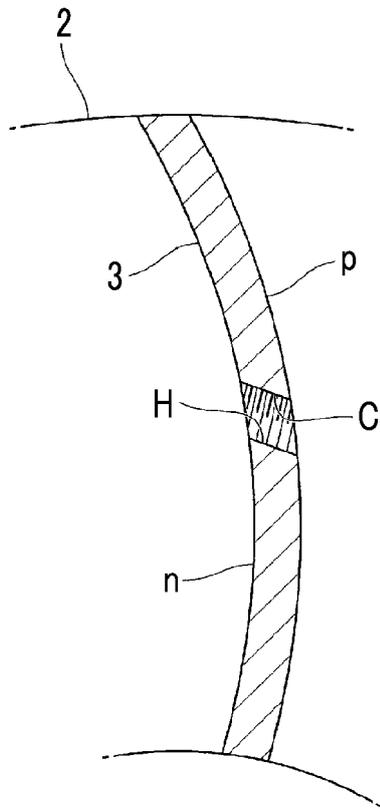
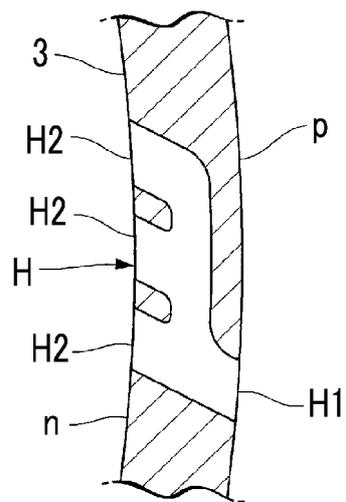


FIG. 10



## INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2014/069451

5	A. CLASSIFICATION OF SUBJECT MATTER F04D29/30(2006.01) i	
	According to International Patent Classification (IPC) or to both national classification and IPC	
10	B. FIELDS SEARCHED	
	Minimum documentation searched (classification system followed by classification symbols) F04D29/30	
15	Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2014 Kokai Jitsuyo Shinan Koho 1971-2014 Toroku Jitsuyo Shinan Koho 1994-2014	
	Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)	
20	C. DOCUMENTS CONSIDERED TO BE RELEVANT	
	Category*	Citation of document, with indication, where appropriate, of the relevant passages
25	X Y	JP 2006-194238 A (Toyota Industries Corp.), 27 July 2006 (27.07.2006), paragraph [0019] & US 2006/0115358 A1
30	Y	JP 10-306796 A (Calsonic Corp.), 17 November 1998 (17.11.1998), fig. 4, 7 & US 006007300 A & EP 000807760 A2
35	A	JP 2012-52439 A (Mitsubishi Heavy Industries, Ltd.), 15 March 2012 (15.03.2012), fig. 2, 4 (Family: none)
40	<input type="checkbox"/> Further documents are listed in the continuation of Box C. <input type="checkbox"/> See patent family annex.	
45	* Special categories of cited documents: "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier application or patent but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family
50	Date of the actual completion of the international search 09 October, 2014 (09.10.14)	Date of mailing of the international search report 21 October, 2014 (21.10.14)
55	Name and mailing address of the ISA/ Japanese Patent Office	Authorized officer
	Facsimile No.	Telephone No.

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**REFERENCES CITED IN THE DESCRIPTION**

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**Patent documents cited in the description**

- JP 2014009680 A [0002]
- US 20100329848 A [0005]