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(54) **CENTRIFUGAL COMPRESSOR IMPELLER**

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(57) **ABSTRACT**

Provided is a centrifugal compressor impeller capable of improving machine operation efficiency, by making the total pressure distribution of a fluid that flowed into a vaneless diffuser constant. To this end, the provided centrifugal compressor impeller has a plurality of vanes radially provided around a rotating shaft, uses centrifugal force produced by rotating along with the rotating shaft, pumps a fluid (G) taken in from the leading edge side of the vanes to the outside in the radial direction of the rotating shaft from the trailing edge side of the vanes, and thereafter, discharges the fluid (G) into a vaneless diffuser. Furthermore, the edge front end and the edge rear end of the trailing edge are positioned to the outside in the radial direction of the rotating shaft relative to the edge center section of the trailing edge.

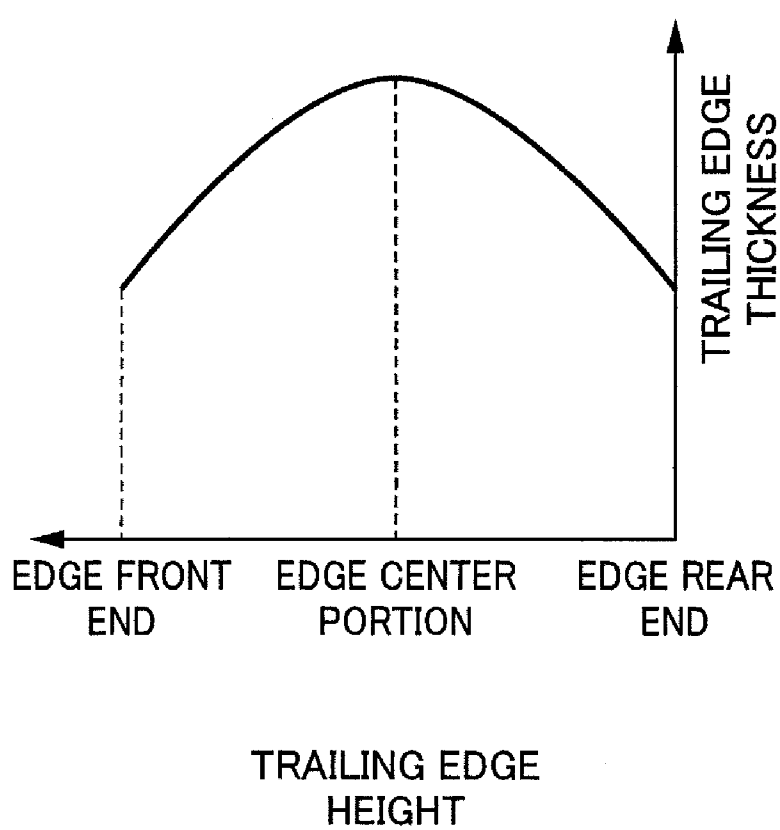


Fig.1

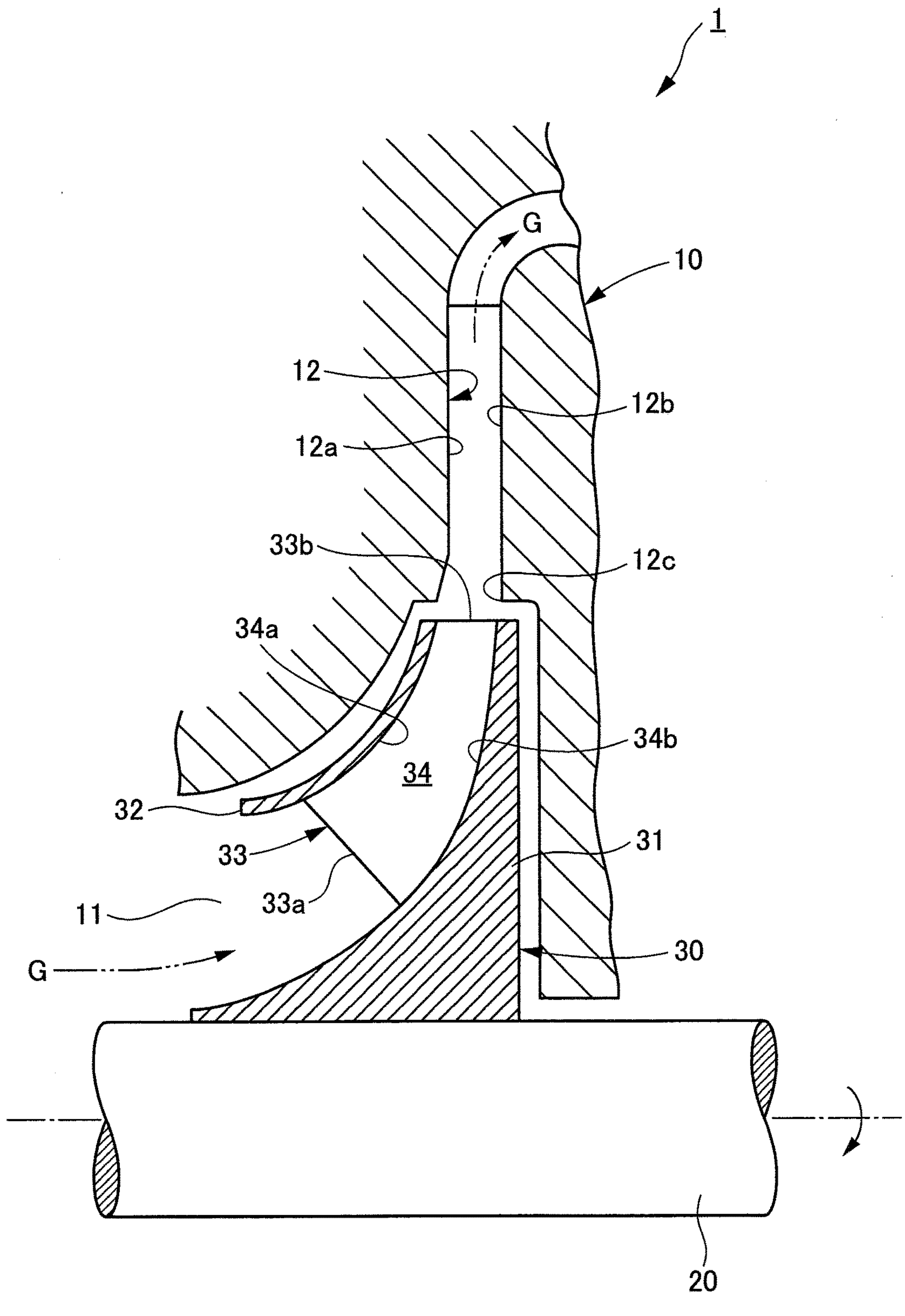
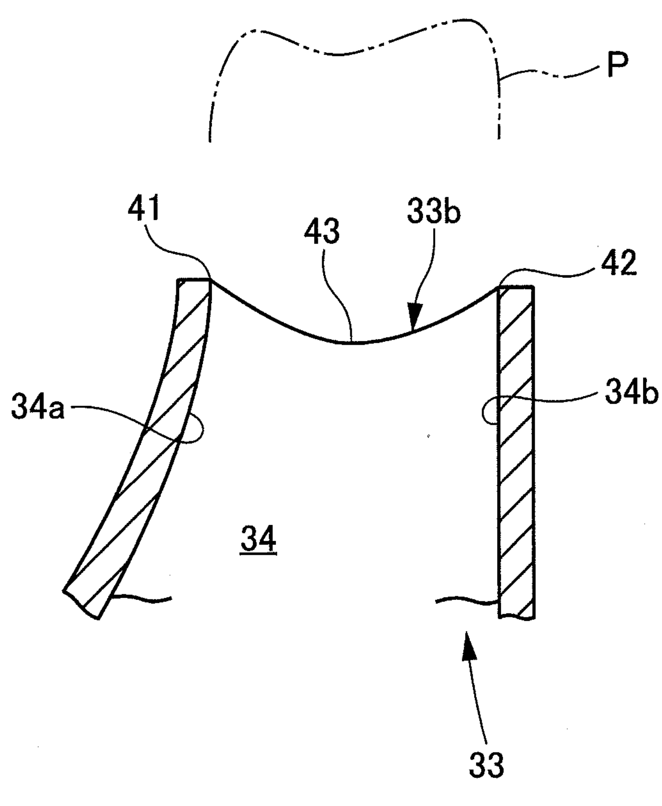


Fig.2



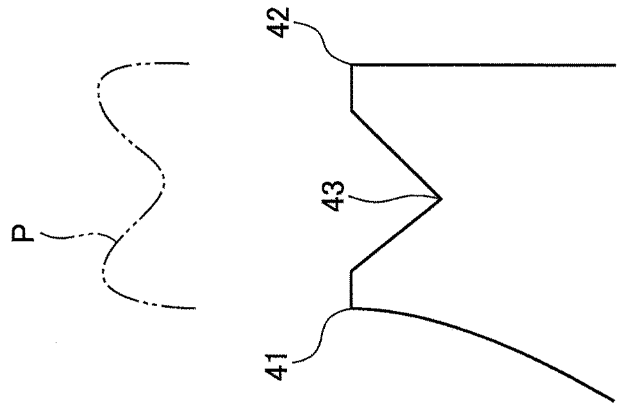


Fig.3D

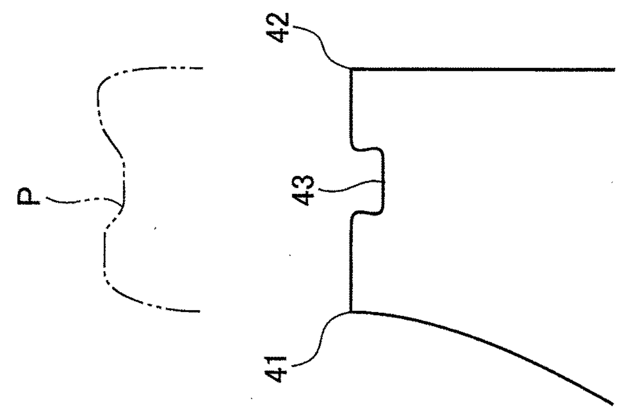


Fig.3C

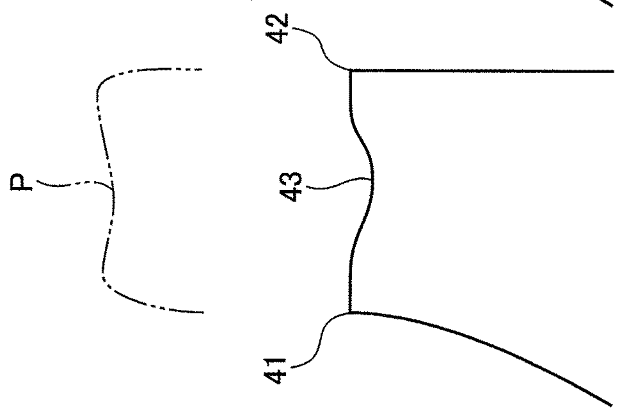


Fig.3B

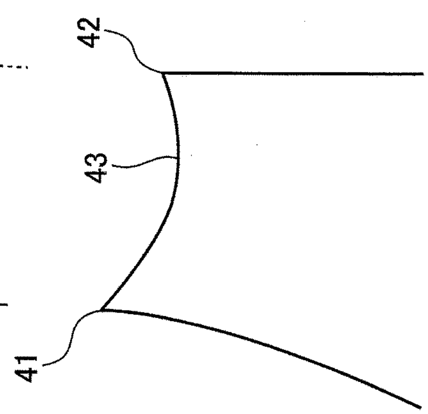
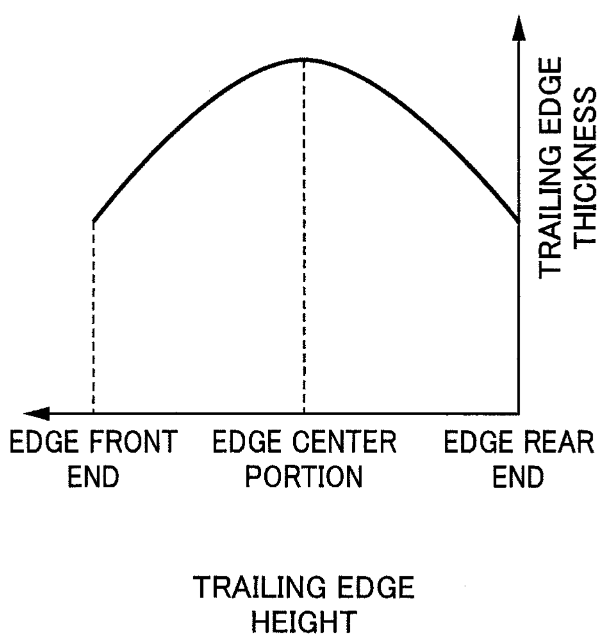


Fig.3A

Fig.4


TRAILING EDGE THICKNESS
EDGE FRONT END
EDGE CENTER PORTION
EDGE REAR END
TRAILING EDGE HEIGHT

CENTRIFUGAL COMPRESSOR IMPELLER

TECHNICAL FIELD

[0001] The present invention relates to a shape of a trailing edge of a blade in an impeller used in a centrifugal compressor.

BACKGROUND ART

[0002] Generally, a centrifugal compressor utilizes centrifugal force of an impeller rotating together with a rotating shaft to pump a fluid, taken in from the leading edge side of the impeller, outward in a rotating shaft radial direction from the trailing edge side of the impeller and discharge the fluid into a diffuser. Specifically, the fluid taken into the centrifugal compressor is increased in pressure while passing through a flow passage of the rotating impeller and then the speed of the fluid is decreased by flowing through a diffuser. For example, Patent Document 1 discloses such a conventional centrifugal compressor.

PRIOR ART DOCUMENT

Patent Document

[0003] Patent Document 1: Japanese Patent No. 3383023

SUMMARY OF THE INVENTION

Problem to be Solved by the Invention

[0004] When the fluid passes through the flow passage of the impeller, friction is generated between the fluid and a flow passage wall surface. Accordingly, the total pressure of the fluid flowing on the flow passage wall surface side decreases at the trailing edge of the impeller which forms an exit of the flow passage, and this leads to pressure loss. Particularly, when the centrifugal compressor is operated at a low flow rate, separation of the fluid becomes significant on a flow passage wall surface of the diffuser, and this leads to further pressure loss.

[0005] Moreover, diffusers of centrifugal compressors include a vaned diffuser and a vaneless diffuser. Generally, the pressure loss can be suppressed by providing diffuser vanes in the diffuser.

[0006] The centrifugal compressor disclosed in Patent Document 1 listed above includes a vaned diffuser, and the shape of a trailing edge of an impeller is specified in order to reduce noise and pressure pulsation generated when a fluid flowing into the diffuser comes into contact with diffuser vanes. In other words, the shape of the trailing edge of the impeller disclosed in Patent Document 1 is not for dealing with pressure loss occurring in a vaneless diffuser.

[0007] The present invention solves the problem described above and an object thereof is to provide a centrifugal compressor impeller capable of improving machine operation efficiency by causing a fluid flowing into a vaneless diffuser to have even total pressure distribution.

Means for Solving the Problem

[0008] A centrifugal compressor impeller in a first aspect of the present invention for solving the aforementioned problem is a centrifugal compressor impeller which comprises a plurality of blades provided radially about a rotating shaft and which utilizes centrifugal force generated by rotating together with the rotating shaft to pump a fluid, taken in from a leading edge side of each of the blades, outward in a rotating shaft radial direction from a trailing edge side of the blade and then discharge the fluid into a vaneless diffuser, the impeller characterized in that

[0009] an edge front end and an edge rear end of the trailing edge are disposed outside an edge center portion of the trailing edge in the rotating shaft radial direction.

[0010] A centrifugal compressor impeller in a second aspect of the present invention for solving the aforementioned problem is characterized in that the edge front end and the edge rear end are disposed to be shifted from each other in the rotating shaft radial direction.

[0011] A centrifugal compressor impeller in a third aspect of the present invention for solving the aforementioned problem is characterized in that thicknesses of the edge front end and the edge rear end are smaller than a thickness of the edge center portion.

Effect of the Invention

[0012] In the centrifugal compressor impeller of the present invention, the edge front end and the edge rear end in the trailing edge of the blade are disposed outside the edge center portion in the trailing edge of the blade in the rotating shaft radial direction. The centrifugal force acting on the fluid passing the edge front end and the edge rear end can be thereby made greater than the centrifugal force acting on the fluid passing the edge center portion. Accordingly, the total pressure distribution of the fluid passing the trailing edge can be set such that the pressure gradually increases from the edge center portion toward the edge front end and the edge rear end. Hence, even when pressure loss occurs due to friction generated between the fluid discharged from the impeller into the vaneless diffuser and a wall surface of the diffuser, the fluid flowing through the diffuser can have an even (uniform) total pressure distribution. As a result, operation efficiency of the centrifugal compressor can be improved.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] FIG. **1** is a vertical cross-sectional view illustrating a schematic configuration of a centrifugal compressor to which an impeller in one embodiment of the present invention is applied.

[0014] FIG. **2** is an enlarged view of a main portion of FIG. **1** and is a view illustrating an example of a trailing edge shape in a blade.

[0015] FIGS. **3**A to **3**D are views illustrating other examples of the trailing edge shape in the blade.

[0016] FIG. **4** is a graph illustrating a relationship between a trailing edge height of the blade and a trailing edge thickness of the blade.

MODE FOR CARRYING OUT THE INVENTION

[0017] A centrifugal compressor in the present invention is described below in detail by using the drawings.

Embodiment

[0018] As illustrated in FIG. **1**, the centrifugal compressor **1** includes a casing **10**, a rotating shaft **20**, an impeller **30**, and the like. Specifically, the casing **10** has a hollow shape and the rotating shaft **20** is rotatably supported in the hollow portion via a bearing. The impeller **30** is fitted on the rotating shaft **20**.

[0019] The impeller **30** includes a hub **31**, a front shroud **32**, and multiple blades **33**. The hub **31** is formed in an annular shape whose outer diameter gradually increases from front to rear in a rotating shaft direction, and the rotating shaft **20** is fitted in a center hole of the hub **31**. Moreover, the front shroud **32** is disposed outside the hub **31** in a radial direction, and is formed in an annular shape whose inner diameter gradually increases from front to rear in the rotating shaft direction.

[0020] Furthermore, the blades **33** are provided radially about the rotating shaft **20**, between an outer peripheral surface of the hub **31** and an inner peripheral surface of the front shroud **32**, and are formed to gradually curve toward the outside in the rotating shaft radial direction while extending from front to rear in the rotating shaft direction.

[0021] Specifically, multiple spaces which are each surrounded by the outer peripheral surface of the hub **31**, the inner peripheral surface of the front shroud **32**, and two blades **33** adjacent to each other in a rotating shaft circumferential direction are formed in the impeller **30** radially about the rotating shaft **20**, and each serve as a flow passage **34** through which a fluid G passes. A front wall surface **34*a*** and a rear wall surface **34*b*** of the flow passage **34** are formed by the inner peripheral surface of the front shroud **32** and the outer peripheral surface of the hub **31**, and the flow passage **34** as a whole is formed to gradually curve toward the outside in the rotating shaft radial direction while extending from front to rear in the rotating shaft direction.

[0022] The impeller **30** can thus utilize centrifugal force generated by rotating together with the rotating shaft **20** to take in the fluid G from the leading edge **33*a*** side of the blade **33** forming an entrance of the flow passage **34**, and then discharge the fluid G outward in the rotating shaft radial direction from the trailing edge **33*b*** side of the blade **33** forming an exit of the flow passage **34**. In this case, the fluid G taken into the impeller **30** is increased in pressure while passing through the flow passage **34**.

[0023] Meanwhile, an intake passage **11** and a diffuser **12** serving as a discharge passage are formed in the casing **10**.

[0024] The intake passage **11** is disposed in front of the impeller **30** in the rotating shaft direction (upstream of the impeller **30** in a fluid flow direction), and is an annular passage which guides the fluid G taken in from the outside of the casing **10** toward the leading edge **33*a*** of the blade **33** in the impeller **30** in the rotating shaft direction.

[0025] Meanwhile, the diffuser **12** is disposed outside the impeller **30** in the rotating shaft radial direction (downstream of the impeller **30** in the fluid flow direction), and is an annular passage extending in the rotating shaft radial direction. In other words, a front wall surface **12*a*** and a rear wall surface **12*b*** which have an annular shape as a whole are formed in the diffuser **12**. An annular entrance **12*c*** of the diffuser **12** is formed by an inner end of the front wall surface **12*a*** in the radial direction (upstream end of the front wall surface **12*a*** in the fluid flow direction) and an inner end of the rear wall surface **12*b*** in the radial direction (upstream end of the rear wall surface **12*b*** in the fluid flow direction), and is opposed to the exit (trailing edge **33*b*** of the blade **33**) of the flow passage **34** in the impeller **30** in the rotation shaft radial direction.

[0026] The diffuser **12** thus takes in the fluid G compressed in the flow passage **34** of the impeller **30**, between the front wall surface **12*a*** and the rear wall surface **12*b*** and then discharges the taken-in fluid G outward in the rotating shaft radial direction while reducing the speed of the fluid G.

[0027] Note that the diffuser **12** is a so-called vaneless diffuser and do not have diffuser vanes for suppressing pressure loss inside the diffuser.

[0028] Accordingly, when the centrifugal compressor **1** is operated, the rotating shaft **20** rotates and the impeller **30** also rotates together with the rotating shaft **20**. The fluid G sucked into the intake passage **11** of the casing **10** by this rotation is compressed by being taken into the flow passage **34** of the rotating impeller **30**, and is then discharged from the inside of the flow passage **34**. Next, the fluid G discharged from the impeller **30** is taken into the diffuser **12** such that the speed thereof is reduced and the flow thereof is regulated, and then discharged from the inside of the diffuser **12**.

[0029] Here, as illustrated in FIG. **2**, in the impeller **30**, the trailing edge **33*b*** of the blade **33** forming the exit of the flow passage **34** is recessed inward in the rotating shaft radial direction in an arc shape.

[0030] Specifically, the trailing edge **33*b*** is formed to gradually curve inward in the rotating shaft radial direction from an edge front end **41** and an edge rear end **42** toward an edge center portion **43**. To be more specific, the edge front end **41** and the edge rear end **42** are disposed at the same position in the rotating shaft radial direction and are disposed outside the edge center portion **43** in the rotating shaft radial direction.

[0031] Note that the edge front end **41** is a portion of the trailing edge **33*b*** located closest to the front shroud **32** and is joined to a downstream end of the inner peripheral surface of the front shroud **32** (downstream end of the front wall surface **34*a*** in the flow passage **34**). Moreover, the edge rear end **42** is a portion of the trailing edge **33*b*** located closest to the hub **31** and is joined to a downstream end of the outer peripheral surface of the hub **31** (downstream end of the rear wall surface **34*b*** in the flow passage **34**). Furthermore, the edge center portion **43** is located in an intermediate portion between the edge front end **41** and the edge rear end **42** and is a portion where a main flow of the fluid G flowing through the flow passage **34** passes.

[0032] The radius of a circle centered on a rotation center of the rotating shaft **20** and passing the edge front end **41** and the edge rear end **42** is thus greater than the radius of a circle centered on the rotation center of the rotating shaft **20** and passing the edge center portion **43**. Centrifugal force greater than that acting on the fluid G flowing through a center portion of the flow passage **34** and passing the edge center portion **43** thereby acts on the fluid G flowing along the front wall surface **34*a*** of the flow passage **34** and passing the edge front end **41** and the fluid G flowing along the rear wall surface **34*b*** of the flow passage **34** and passing the edge rear end **42**.

[0033] Accordingly, a total pressure distribution P of the fluid G passing the trailing edge **33*b*** can be set such that the pressure gradually increases from the edge center portion **43** toward the edge front end **41** and the edge rear end **42**. Hence, even when pressure loss occurs due to friction generated between the fluid G discharged from the impeller **30** into the diffuser **12** and each of the front wall surface **12*a*** and the rear wall surface **12*b***, the fluid G flowing through the diffuser **12** can have an even (uniform) total pressure distribution. As a result, operation efficiency of the centrifugal compressor **1** can be improved.

[0034] Note that, although the recess shape of the trailing edge **33***b* is the arc shape in the aforementioned embodiment, the recess shape of the trailing edge **33***b* only needs to be such that the edge front end **41** and the edge rear end **42** are disposed outside the edge center portion **43** in the rotating shaft radial direction. For example, the recess shape of the trailing edge **33***b* may be the recess shapes illustrated in FIGS. **3**A to **3**D.

[0035] Specifically, in the recess shape illustrated in FIG. **3**A, the trailing edge **33***b* of the blade **33** is recessed inward in the rotating shaft radial direction in an arc shape, and the edge front end **41** and the edge rear end **42** are shifted from each other in the rotation shaft radial direction. To be more specific, the edge front end **41** and the edge rear end **42** are disposed outside the edge center portion **43** in the rotating shaft radial direction and, in addition, the edge front end **41** is disposed outside the edge rear end **42** in the rotating shaft radial direction. Note that the configuration may be the opposite such that the edge rear end **42** is disposed outside the edge front end **41** in the radial direction.

[0036] Meanwhile, in the recess shape illustrated in FIG. **3**B, although the trailing edge **33***b* of the blade **33** is recessed inward in the rotating shaft radial direction in an arc shape, only the edge center portion **43** is recessed inward in the rotating shaft radial direction. Specifically, the edge front end **41** and the edge rear end **42** are disposed at the same position in the rotating shaft radial direction and are disposed outside the edge center portion **43** in the rotating shaft radial direction.

[0037] When only the edge center portion **43** is to be recessed inward in the rotating shaft radial direction as described above, the edge center portion **43** may be notched in a rectangular shape or a wedge shape as illustrated in FIGS. **3**C and **3**D.

[0038] Furthermore, although the total pressure of the fluid G passing the edge front end **41** and the edge rear end **42** is made higher than the total pressure of the fluid G passing the edge center portion **43** by forming the trailing edge **33***b* of the blade **33** in the recess shape in the aforementioned embodiment, a further total pressure difference may be generated by additionally varying the thickness of the trailing edge **33***b* among the edge front end **41**, the edge rear end **42**, and the edge center portion **43**.

[0039] Specifically, as illustrated in FIG. **4**, the thickness of the trailing edge **33***b* is made to gradually decrease from the edge center portion **43** toward the edge front end **41** and the edge rear end **42**. In the trailing edge **33***b* of the blade **33**, the smaller the thickness is, the more the pressure loss is suppressed. Accordingly, the total pressure of the fluid G passing the edge front end **41** and the edge rear end **42** can be made higher than the total pressure of the fluid G passing the edge center portion **43**.

[0040] Hence, even when large pressure loss occurs due to friction generated between the fluid G discharged into the diffuser **12** and each of the front wall surface **12***a* and the rear wall surface **12***b*, the fluid G flowing through the diffuser **12** can have an even (uniform) total pressure distribution.

INDUSTRIAL APPLICABILITY

[0041] The impeller of the centrifugal compressor in the present invention can improve the total pressure distribution of the fluid in the trailing edge. Accordingly, the impeller can be utilized to be highly beneficial in improving the operation efficiency of a machine.

EXPLANATION OF THE REFERENCE NUMERALS

[0042] **1** centrifugal compressor
[0043] **10** casing
[0044] **11** intake passage
[0045] **12** diffuser
[0046] **20** rotating shaft
[0047] **30** impeller
[0048] **31** hub
[0049] **32** front shroud
[0050] **33** blade
[0051] **33***a* leading edge
[0052] **33***b* trailing edge
[0053] **34** flow passage
[0054] **41** edge front end
[0055] **42** edge rear end
[0056] **43** edge center portion
[0057] G fluid
[0058] P total pressure distribution

1. A centrifugal compressor impeller which comprises a plurality of blades provided radially about a rotating shaft and which utilizes centrifugal force generated by rotating together with the rotating shaft to pump a fluid, taken in from a leading edge side of each of the blades, outward in a rotating shaft radial direction from a trailing edge side of the blade and then discharge the fluid into a vaneless diffuser, the impeller characterized in that

an edge front end and an edge rear end of the trailing edge are disposed outside an edge center portion of the trailing edge in the rotating shaft radial direction, and

thicknesses of the edge front end and the edge rear end are smaller than a thickness of the edge center portion.

2. The centrifugal compressor impeller according to claim **1**, characterized in that the edge front end and the edge rear end are disposed to be shifted from each other in the rotating shaft radial direction.

3. (canceled)

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