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(54) Radial-flow turbo machine.

(57) A radial-flow turbo machine comprising an impeller in which the center line of each moving vane in a cross section perpendicular to the axis of rotation becomes more distant toward the back surface side of the vane from a radial straight line passing through the axis of rotation and through an intersection where the center line of the vane and a hub line intersect as a radius having the axis of rotation as its center increases.

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RADIAL-FLOW TURBO MACHINE

BACKGROUND OF THE INVENTION:

This invention relates to a radial-flow turbo machines such as superchargers, gas turbines or radial compressors.

One example of the structure of a conventional radial-flow turbine impeller is shown in Fig. 4 in which the impeller 10 includes plurality of moving vanes 100 joined to a disc 200 and rotates around an axis 500.

The inlet edge, outlet edge and outer periphery of each vane, and the joining line between disc 200 and vane 100 are referred to as the front edge 110, rear edge 120, shroud line 300, and hub line 400, respectively.

In the impeller 10, the portion of each moving vane 100 on the side of the rear edge 120 after the line X-X substantially bisecting the axial length of the vane is formed by a curved surface.

In this curved surface, the center line 150 of the cross section of each moving vane 100 drawn in the cross section along the line V-V (Fig. 5) is represented by

$Y = f(Z)$ .... (1)

where Z is the axial distance from the reference line X-X. The function f (Z) is a function having an order equal to, or higher than, 2.

The center line 150 of each moving vane 100 at a distance of Z in a cylindrical cross section VI-VI (Fig. 6) takes the form determined by the function f (Z), and the thickness of the vane is added thereto to form a back surface 130 and a stomach surface 140 thereof. The moving vanes 100, each drawn in a cross section parallel to the cross section V-V, namely, orthogonal to the axis of rotation 500, are formed radially from the axis 500. The center lines 150 of the vanes pass necessarily through the axis 500. Design is made such that no bending stresses due to the centrifugal force produced by rotation of the impeller will not be produced in any cross section orthogonal to the axis 500.

In each of the moving vanes of the conventional radial-flow turbine, design is made such that the bending stress in a cross section orthogonal to the axis 500 will be small, as described above.

Fig. 7 is a back view of a moving vane 100 obtained when the vane 100 is viewed from the side of its back edge 120 and the arrow shows the direction in which the centrifugal force acts. The vane 100 has the form represented by Equation (1), so that as shown in Fig. 7, the centrifugal force in each cross section acts along the center line 150 and no bending stress will be produced in each cross section.

However, the vane elements 160, 170 and 180 constituting the portions between these cross sections are interconnected one to the other, so that for the vane element 160, it is pulled by the elements 170 and thus a bending stress is produced, which is substantially proportional to the magnitude of y in Equation (1), because the portion 160 is pulled by the portion 170. Thus, as shown in Fig. 8, a tensile stress σt produced by the above bending stress is superposed on a tensile stress σT produced by the centrifugal force acting along the center line at the root 161 of the vane element 160 on the side of its stomach surface and a compression stress σb is superposed on the tensile stress σT at the root 162 of the vane portion 160 on the side of its back surface.

As just described above, in the conventional impeller, a large tensile stress acts on the stomach surface side root 161 of the rear edge portion of the moving vane 100, so that the root 161 is the weakest portion of the vane. Therefore, measures to alleviate the stress at the stomach side root 161 are required.

SUMMARY OF THE INVENTION:

It is therefore an object of this invention to provide a turbo machine with an impeller which alleviates the bending stress due to the centrifugal force of the moving vanes.

In order to reduce the bending stress acting on the moving vanes, this invention is characterized in that each moving vane is inclined in advance toward its back surface at an angle substantially proportional to y of Equation (1).

Thus, a force due to the centrifugal force acts on each moving vane so as to bend the vane from its back surface toward its stomach surface. A compression stress and a tensile stress are superimposed on the corresponding centrifugal force at the stomach surface and back surface side roots, respectively, to thereby reduce the tensile stress at the stomach surface side root produced by the resultant force of the centrifugal forces.

BRIEF DESCRIPTION OF THE DRAWINGS:

Figs. 1 - 3 show an embodiment of this invention.

Fig. 1 is a partial cross-sectional view of a radial-flow turbine impeller.

Fig. 2 is a cross-sectional view taken along the line II-II of Fig. 1.

Fig. 3 is a partial cross-sectional view (corresponding to Fig. 2) of a moving vane as a second embodiment of this invention.

Fig. 4 is a partial cross-sectional view of a conventional radial-flow turbine impeller.

Fig. 5 is a partial cross-sectional view taken along the line V-V of Fig. 4, showing the shape of a conventional moving vane.

Fig. 6 is a partial cylindrical cross-sectional view taken along the line VI-VI of Fig. 4, showing the shape of the conventional moving vane.

Fig. 7 illustrates a centrifugal force acting on a moving vane.

Fig. 8 illustrates the mode of a stress occurring at the root of a moving vane.

DETAILED DESCRIPTION:

One embodiment of this invention will now be described with reference to Figs. 1 - 3. In these Figures, reference numeral 10 denotes an impeller; 200, a disc of the impeller; and 100, a plurality of moving vanes fixed equispacedly to the periphery of the disc.

Reference numeral 110 denotes the front edge of the moving vane 100; 120, the rear edge of the vane; 300, a shroud line; and 400, a hub line; and 500, the axis of rotation.

Like the conventional moving vane shown in Fig. 6, the portion of each moving vane 100 on the side of rear edge 120 after the cross section X-X passing through substantially the midpoint of the axial length of the vane has a curved surface represented by the aforementioned function f (Z) having an order equal to at least 2, in an exploded cylindrical plane. The moving vane 100 in this invention is also formed such that as shown in Fig. 2, the angle θ subtended between the center line 190 of the vane 100 and a straight line 700 passing through the axis of rotation 500 and through an intersection 600 where the vane center line 190 and a hub line 400 intersect (the center line 150 of the conventional moving vane shown in Fig. 5 is used as a reference $\theta = 0$.) increases smoothly from the cross section X-X toward the rear edge 120.

Namely, as shown in Fig. 2, the center line 190 of the vane 100 projected axially is inclined from the straight line 700 passing through the axis 500 toward the back surface 130. While in the above description the center line 190 of the vane 100 is described as a straight line, the center line 190 may be formed by a curve represented by the following Equation (2) as shown in Fig. 3 in a range where the bending stress of the moving vane 100 does not increase extremely,

θ = Rf (Z) .... (2)

During the operation of a turbo machine using the impeller having the above structure, by the vanes 100 inclined toward their back surfaces 130, a force due to a centrifugal force acts on each vane so as to bend the vane from the back surface 130 toward the stomach surface 140.

This causes bending stresses to be cancelled by each other which is produced by the resultant force of centrifugal forces in each of cross sections of a vane occurring due to an axial increase, toward its rear edge 120, in the angle at which the vane is mounted.

This invention has the above structure and according to this invention, a bending stress due to a centrifugal force accompanied by an increase, toward the rear edge of a moving vane, in the angle at which the vane is mounted is cancelled by the bending action due to the vane being inclined toward its back surface, thereby alleviating the bending force on the entire vanes.

Claims

1. A radial-flow turbo machine comprising an impeller in which the center line of each moving vane in a cross section perpendicular to the axis of rotation becomes more distant toward the back surface side of the vane from a radial straight line passing through the axis of rotation and through an intersection where the center line of the vane and a hub line intersect as a radius having the axis of rotation as its center increases.

2. A machine of claim 1, wherein the center line of the moving vane in a cross section perpendicular to the axis of rotation is a straight line.

3. A machine of claim 1, wherein the center line of the moving vane in a cross section perpendicular to the axis of rotation is a curved line.

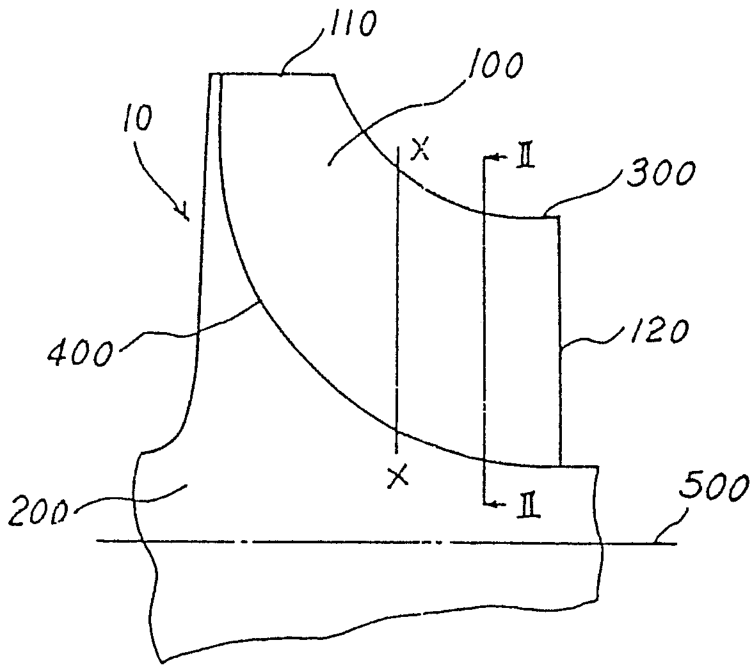

Fig. 1

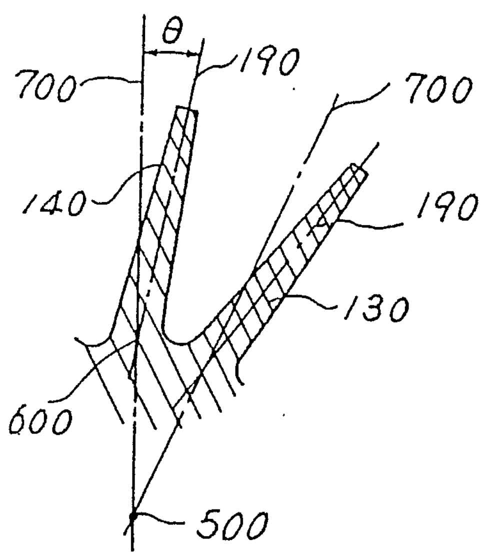

Fig. 2

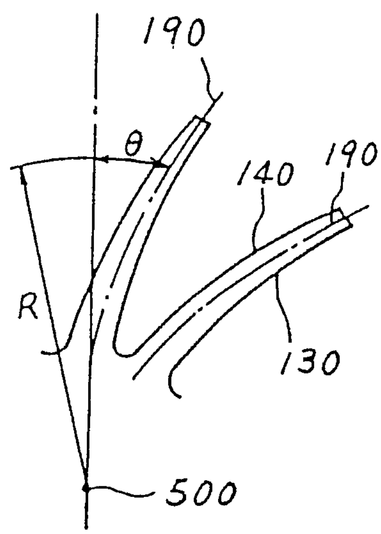

Fig. 3

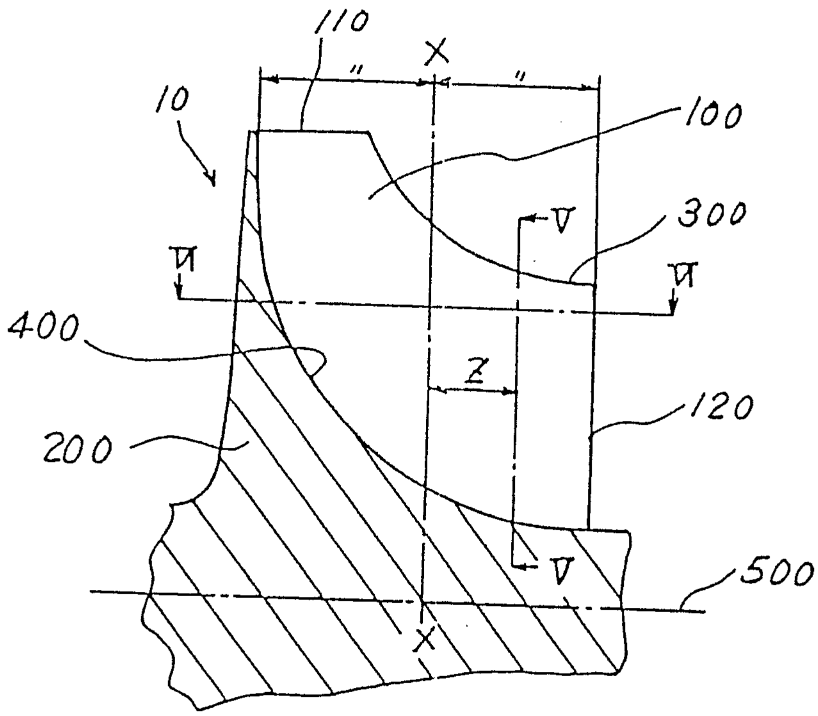

Fig. 4

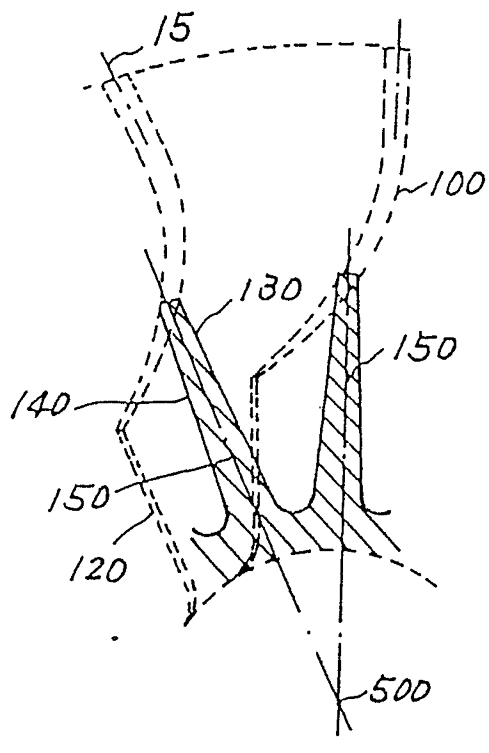

Fig. 5

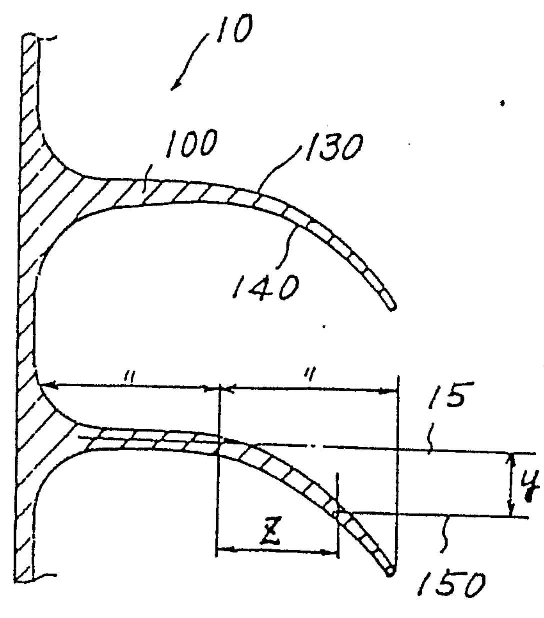

Fig. 6

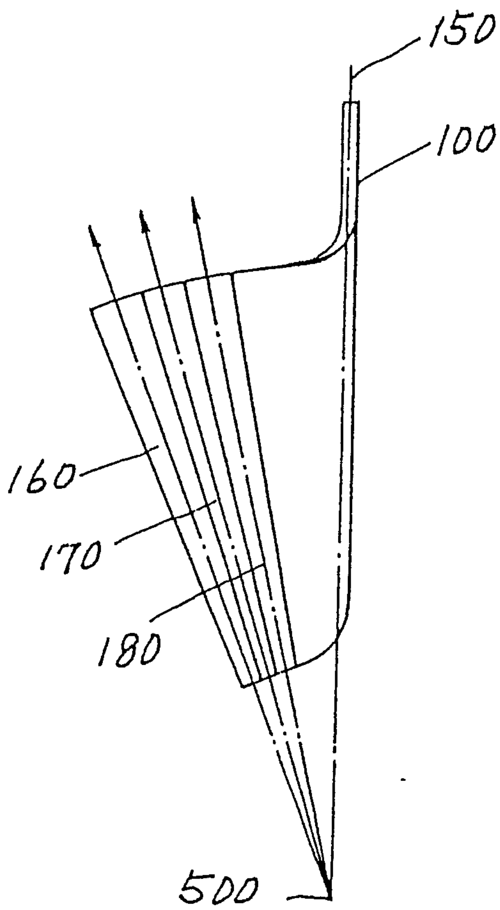

Fig. 7

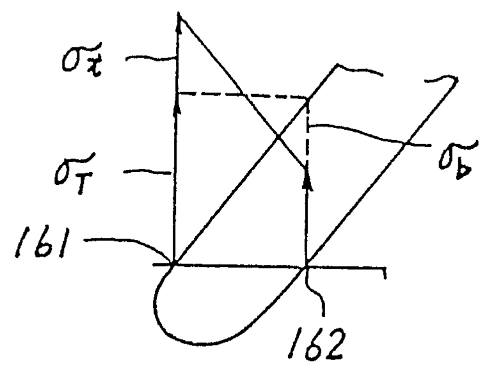

Fig. 8