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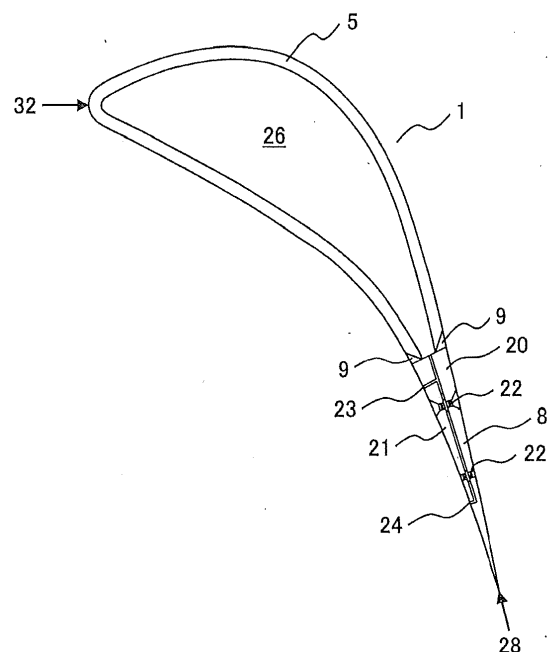
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(54) **Steam turbine, and steam turbine stationary blade**

(57) The present invention is a steam turbine comprising a turbine stage having a stationary blade (1) and a moving blade (2) provided on the downstream side of the stationary blade in a working fluid flow direction, wherein the stationary blade (1) is formed in a hollow blade shape by deformation processing a metal plate, and wherein a slit (24) to guide liquid droplets deposited on a blade wall surface to the inside of the blade is formed in the blade wall by overlaying an airfoil suction-side metal plate (20) and an airfoil pressure-side metal plate (21) with a gap therebetween in a blade tail part (8) of the stationary blade (1).

FIG. 4



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Description

[Technical Field]

[0001] The present invention relates to a steam turbine, and more particularly, to a stationary blade structure to eliminate a liquid film generated on a stationary blade surface so as to reduce moving blade erosion due to collision of water droplets, which are generated particularly with wet steam, with a moving blade.

[Background Art]

[0002] In the final stage of a low pressure turbine or a stage prior to the final stage by 1 or 2 stages, generally, the pressure is very low, accordingly, steam as a working fluid is in a state of wet steam including liquefied minute water droplets (molecules of the vapor). The molecules of the vapor condensed and deposited to the blade surface coalesce to each other and form a liquid film on the blade surface. Further, the liquid film is ripped down with the steam of a working fluid mainstream, or fly in the steam flow again from a blade trailing edge. These water droplets are sprayed to the downstream as coarse droplets far larger in comparison with the initially occurred molecules of the vapor. Then the coarse droplets are broken up into smaller size, however, flow down while being maintained in some size. Then, the coarse droplets do not sharply turn along the passage as in the case of steam due to its inertial force, and collide against the downstream moving blade at a high speed, which causes erosion to erode the blade surface, or causes loss due to action of a force against the rotation of the turbine blade.

[0003] On the other hand, conventionally, to prevent the erosive action by the erosion phenomenon, the end of a moving blade leading edge is coated with erosion shield formed of a hard and high-strength material such as stellite. Otherwise, as in the case of Patent Literature 1 (Japanese Unexamined Utility Model Application No. Sho 61(1986)-142102), a method of mitigating an impulsive force upon collision of liquid droplets with the blade by formation of a coarse surface by various irregularity processing on the surface of the blade leading edge is known. Note that the erosion shield cannot be always set because of its workability. Further, generally, the mere protection of the blade surface is less than perfect as an erosion countermeasure, accordingly, it is employed together with another erosion countermeasure.

[0004] Generally, to reduce the influence of erosion, it is most effective to eliminate liquid droplets themselves. As shown in Patent Literature 2 (Japanese Unexamined Patent Application No. Hei 1(1989)-110812) and Patent Literature 3 (Japanese Unexamined Patent Application No. Hei 11(1999)-336503), to eliminate liquid droplets, a method of sucking the liquid film by providing a hollow stationary blade (hollow nozzle) with a slit in its blade surface and reducing the pressure in the hollow station-

ary blade is used. In many cases, these slits are formed by directly processing the blade surface of a stationary blade structure having a hollow structure. Further, as described in Patent Literature 4 (Japanese Unexamined Patent Application No. 2007-23895), a method of processing a slit member as a separate member and attaching it to a stationary blade is known.

[Citation List]

[Patent Literature]

[0005]

[Patent Literature 1] Japanese Unexamined Utility Model Application No. Sho 61(1986)-142102
[Patent Literature 2] Japanese Unexamined Patent Application No. Hei 1(1989)-110812
[Patent Literature 3] Japanese Unexamined Patent Application No. Hei 11(1999)-336503
[Patent Literature 4] Japanese Unexamined Patent Application No. 2007-23895

[Summary of Invention]

[Technical Problem]

[0006] A tail part, which includes a blade trailing edge, of the blade has an acute shape with a small thickness. Accordingly, even when the hollow structure of the stationary blade is formed by bending one plate and combining in the tail part or when the hollow part is formed by boring the inside of a solid member, it is necessary to form the slit from the blade surface to the blade hollow region by processing a position away to some extent from the blade trailing edge.

[0007] Further, as described in Patent Literature 4, regarding the method of processing a slit member as a separate member and attaching it to the stationary blade, to obtain an acute profile near the trailing edge and to ensure a route to guide liquid droplets from the slit to the hollow part, the slit formation position is necessarily away to some extent from the blade trailing edge as in the case of the above example.

[0008] On the other hand, to efficiently eliminate the liquid film, the slit position is a significant factor. On the downstream side of the stationary blade, as the steam flow velocity is increased, the moisture content integrated on the blade surface is increased. Accordingly, when the slit position is in a position defined with the blade structure as in the case of the conventional slit processing, it is not sufficiently in the downstream region and there is a probability that the moisture content is deposited to the blade again even in the downstream of the slit, and forms a liquid film.

[0009] Further, since the steam flow velocity is increased in the region where the slit is provided, there is a probability that the liquid film is ripped down with the

steam flow and flies from the blade surface. In this case, even when the slit is provided for the pressure reduction and suction, it is impossible to eliminate the moisture content away from the blade surface.

[0010] Accordingly, the object of the present invention is, in a steam turbine, to reduce the erosive action on a moving blade by erosion and improve the reliability.

[Solution to Problem]

[0011] To attain the above-described object, the present invention is a steam turbine comprising a turbine stage having stationary blades and moving blades provided on the downstream side of the stationary blades in a working fluid flow direction, wherein the stationary blade is formed in a hollow blade shape by deformation processing a metal plate, and wherein a slit to guide liquid droplets deposited to a blade wall to the inside of the stationary blade is formed in the blade wall by overlaying an airfoil suction side metal plate and an airfoil pressure side metal plate with a gap therebetween in the tail part of the stationary blade.

[Advantageous Effects of Invention]

[0012] According to the present invention, since it is possible to provide a slit to eliminate a liquid film generated on a blade wall surface of a stationary blade in the vicinity of a trailing edge of the stationary blade and to sufficiently eliminate the liquid film, it is possible to reduce an erosive action on a moving blade by erosion and to improve the reliability.

[Brief Description of Drawings]

[0013]

Fig. 1 is a schematic diagram showing the stage of a conventional steam turbine and a liquid film flowing on a stationary blade surface.

Fig. 2 is a cross-sectional diagram of a passage between the stationary blades, schematically showing a status where liquid droplets fly at a blade trailing edge from the liquid film developed on the stationary blade surface of the conventional turbine.

Fig. 3 is a schematic perspective diagram of a stationary blade according to a first embodiment of the present invention.

Fig. 4 is a cross-sectional diagram in a position shown with an alternate long and two short dashes line in Fig. 3.

Fig. 5 is an enlarged diagram of a tail part in Fig. 4. Fig. 6 is a diagram showing the relation between the thickness of a liquid film generated on a blade surface and a liquid film flow amount.

Fig. 7 is a schematic perspective diagram of the stationary blade according to a second embodiment of the present invention.

Fig. 8 is a blade cross-sectional diagram of the stationary blade according to a third embodiment of the present invention.

Fig. 9 is an enlarged diagram of the tail part in Fig. 8. Fig. 10 is a perspective diagram of a positioning piece.

Fig. 11 is a schematic perspective diagram of the stationary blade according to a fourth embodiment of the present invention.

Fig. 12 is a cross-sectional diagram of an arbitrary cross section of a slit formation part of the stationary blade shown in Fig. 11.

Fig. 13 is a schematic perspective diagram of the stationary blade according to a fifth embodiment of the present invention.

Fig. 14 is a cross-sectional diagram of an arbitrary cross section of the slit formation part of the stationary blade shown in Fig. 13.

[Description of Embodiments]

[0014] First, the status of the occurrence of liquid film and liquid droplets on a turbine blade surface will be briefly described using Figs. 1 and 2.

[0015] Fig. 1 is a schematic diagram showing the stage of a conventional steam turbine and the flow of a liquid film developed on a wall surface of its stationary blade. The turbine stage of the steam turbine has stationary blades (nozzles) 1 fixed to an outer peripheral side diaphragm 4 and an inner peripheral side diaphragm 6, and moving blades (buckets) 2 fixed to a rotor shaft 3 on the downstream side of the stationary blades 1 in a working fluid flow direction. A casing 7 forming a wall surface of the passage is provided on the outer peripheral side at an end of the moving blade 2. With the above structure, a steam mainstream as a working fluid is accelerated upon passing through the stationary blade 1, to provide energy to the moving blade 2, to rotate the rotor shaft 3.

[0016] In a low pressure turbine or the like, when the steam mainstream as a working fluid steam becomes in a state of wet steam, liquid droplets included in the steam mainstream are deposited to the stationary blade 1, and the liquid droplets congregate on the stationary blade surface to form a liquid film. The liquid film flows in a direction of a force determined with a resultant force between pressure and a shear force in a boundary surface with respect to gas steam, and moves to a position in the vicinity of the trailing edge of the stationary blade. Fig. 1 shows a flow 11 of the moving liquid film. The liquid film moved to the position in the vicinity of the trailing edge of the blade becomes liquid droplets 13, and fly together with the steam mainstream toward the moving blade 2.

[0017] Fig. 2 is a cross-sectional diagram of a passage between the stationary blades schematically showing a status where the liquid droplets are surface-stripped from the liquid film developed on the blade surface of the stationary blade 1. When air flow steam 10 passes between the stationary blades, the liquid droplets are deposited

to the stationary blade 1, then the liquid droplets congregate on the stationary blade surface and is developed into a liquid film 12. The liquid film 12 developed on the blade surface of the stationary blade 1 moves to the blade trailing edge, is surface-stripped and flies as the liquid droplets 13 from the blade trailing edge. The surface-stripped liquid droplets 13 collide against the moving blade 2 provided downstream, to cause erosion to erode the moving blade surface or act a force against the rotation of the moving blade and cause loss.

[0018] In view of the above description, the embodiments of the present invention will be described in detail below appropriately with reference to the drawings. Note that corresponding constituent elements in the respective figures including Figs. 1 and 2 have the same reference numerals.

[Embodiment 1]

[0019] A first embodiment according to the present invention will be described.

[0020] Figs. 3 to 5 are explanatory diagrams showing the structure where the preset invention is applied to the stationary blade 1 in Fig. 1. Fig. 3 is a schematic perspective diagram of the stationary blade 1 according to the present embodiment, Fig. 4, a cross-sectional diagram in a position indicated with an alternate long and two short dashes line in Fig. 3, and Fig. 5, an enlarged diagram of a blade tail part in Fig. 4.

[0021] As shown in Fig. 3, the stationary blade 1 of the present embodiment is formed by joining a main body 5 and a blade tail part 8 formed as a separate body of the main body 5 along a welding line 9. As shown in Fig. 4, the main body 5 is formed by plastically deforming a metal plate by pressing or the like, and has a hollow blade shape structure having a hollow part 26 inside. On the other hand, the tail part 8 has a suction side plate 20 which is a metal plate forming a suction side wall surface of airfoil and a pressure side plate 21 plate which is a metal plate forming a pressure side wall surface of airfoil. The pressure side 21 is attached to the suction side plate 20 while positioning piece 22 to be described later is held therebetween.

[0022] As shown in Fig. 10, the positioning piece 22 has a disk-shaped brim 31 which plays a role of spacer and a cylindrical convex member 34 provided at both ends of the brim 31. As described later, it is possible to fix the mutual positions of the suction side plate 20 and the pressure side plate 21 to predetermined positions easily by inserting the both side convex members 34 into piece holes formed as a pair in the suction side plate 20 and the pressure side plate 21. Further, as the disk-shaped brim 31 is held between the suction side plate 20 and the pressure side plate 21, a gap corresponding to the thickness of the brim 31 is formed between the suction side plate 20 and the pressure side plate 21. It is possible to form a predetermined gap between the suction side plate 20 and the pressure side plate 21 easily

by controlling the thickness of the brim 31. Note that the shapes of the brim and the convex member of the positioning piece 22 are not limited to the disk shape and the cylindrical shape as long as they play the roles of position fixing and spacer.

[0023] Returning to the description of the tail part 8, as shown in Fig. 5, one end of the suction side plate 20 is welded and fixed to the metal plate of the main body 5 on the suction side of airfoil, and the other end forms an acute-shaped blade trailing edge. Further, the surface of the suction side plate 20 on the blade inner surface side is partially cut from a position away to some extent from the blade trailing edge toward the main body 5 side, thus a step part 27 is provided.

[0024] On the other hand, the pressure side plate 21 is overlaid on the step part 27 of the suction side plate 20 with a gap therebetween. One end of the pressure side plate 21 is welded and fixed to the metal plate of the main body 5 on the pressure side of airfoil, and the other end thereof has a gap with respect to the step part 27. A slit 24 can be formed by providing the gap between the step part 27 of the suction side plate 20 and the end of the pressure side plate 21. The wall of the slit 24 on the blade leading edge side is formed with the end of the pressure side plate 21, and the wall on the blade trailing edge side is formed with the suction side plate 20, and opened in the blade height direction. For example, in the example shown in Fig. 3, the slit 24 is provided over the entire length in the blade height direction, however, it is not necessary to provide it over the entire length in the blade height direction. It may be provided in a part on the outer peripheral side in the blade height direction.

[0025] In the suction side plate 20 and the pressure side plate 21, a pair of piece holes 29 and 30 where the above-described positioning piece 22 is provided are opened. As shown in Fig. 5, it is possible to form a gap 25 corresponding to the thickness of the brim 31 of the positioning piece 22 between the suction side plate 20 and the pressure side plate 21 by inserting the positioning piece 22 into the piece holes 29 and 30 and holding them between the suction side plate 20 and the pressure side plate 21. Since the pressure side plate 21 is overlaid on the step part 27 of the suction side plate 20 with a gap therebetween, the gap 25 is connected to the slit 24, to form a fluid channel to guide the liquid droplets flowed in from the slit 24 to a hollow part 26.

[0026] The pressure side plate 21 is provided with plural second slits 23 in the blade height direction on the upstream side of the slit 24 in a steam mainstream flow direction as shown in Fig. 3. The second slit 23 is formed through the pressure side plate 21 as shown in Fig. 5. When the pressure side plate 21 is attached to the suction side plate 20, it is connected to the gap 25 between the suction side plate 20 and the pressure side plate 21. Accordingly, it is also possible to guide the liquid droplets flowed in from the second slit 23 through the gap 25 to the hollow part 26.

[0027] The suction side plate 20 and the pressure side

plate 21 are fixed in specified positions and the blade tail part 8 is formed in an integral construction by closing the piece holes 29 and 30 by welding or hard soldering after the attachment of the suction side plate 20, the pressure side plate 21 and the positioning piece 22. The upper and lower ends of the blade tail part 8 are closed with a cover 33 respectively as shown in Fig. 3, or directly welded to the outer peripheral side diaphragm 4 and the inner peripheral side diaphragm 6, so as to prevent leakage of the liquid droplets introduced from the second slit 23, the slit 24 and the gap 25.

[0028] Note that the piece hole may be provided at a fixed interval in plural positions in the blade height direction between the slit 24 and the second slit 23 as shown in Fig. 3. The piece holes are provided in two positions on the blade outer peripheral side and in one position from the blade center to the inner peripheral side since the blade length is short. By fitting the positioning piece into the respective holes, it is possible to stably fix the suction side plate 20 and the pressure side plate 21. However, the arrangement is not limited to the example shown in Fig. 3 as long as the suction side plate 20 and the pressure side plate 21 can be stably fixed. It is possible to easily fix the mutual positions of the suction side plate 20 and the pressure side plate 21 in predetermined positions where the slit 24 and the gap 25 are formed, with the piece holes 29 and 30 provided in pair in the suction side plate 20 and the pressure side plate 21 and the positioning piece 22.

[0029] Next, the installation positions of the slit 24 and the second slit 23 will be described.

[0030] The liquid film generated on the blade surface becomes unstable when the steam flow velocity is increased, and its part is surface-stripped and flies from the blade surface. The unstable phenomenon of the liquid film occurs when relative Weber number $Wr=0.5 \times \rho h(U-W) \times (U-W)/\sigma$, represented with steam concentration ρ , liquid film thickness h , steam flow velocity U , liquid film flow velocity W and liquid film surface tension σ , is equal to or greater than 0.78. Even when the slit is provided in a position where this relative Weber number is equal to or greater than 0.78, a part of the liquid film has been surface-stripped and has flown in the passage, and it is not possible to efficiently eliminate the moisture content. Accordingly, the slit 24 and the second slit processed and formed in the blade tail part 8 are provided in a part where the relative Weber number of the liquid film flow is 0.78.

[0031] Fig. 6 shows the thickness of the liquid film generated on the wall surface and the liquid film thickness (minimum liquid thickness for surface stripping) when the relative Weber number is 0.78. The horizontal axis indicates a dimensionless distance obtained from a distance l measured along the blade surface from the airfoil leading edge 32 to the an arbitrary position of the blade surface shown in Fig. 4, using a distance L measured along the blade surface from the airfoil leading edge end 32 to the trailing edge 28. In a position where the minimum

liquid thickness for surface stripping is thinner than the water film thickness generated on the blade surface, the liquid film cannot be deposited on the blade surface, and it is impossible to sufficiently eliminate the moisture content even with the slit. As the slit position shown in Fig. 3, the upstream-side second slit 23 is provided in the range of $1/L=0.56$ to 0.9 . The increment of the steam flow velocity is large in the downstream region from the range of $1/L=0.65$ to 0.75 . Even though 100% of the liquid film is eliminated with the second slit 23, a large amount of liquid film is generated again on its downstream side. The relative Weber number of the liquid film exceeds the minimum liquid thickness for surface stripping again. Therefore, the slit 24 is provided in a position in the range of $1/L=0.75$ to 0.9 . The liquid film is generated in the downstream region of the slit 24, however, it is possible to eliminate 80% or more of the liquid film generated on the stationary blade surface with the above-described two slits.

[0032] In the present embodiment, the stationary blade is formed as a joint between the main body 5 having the hollow structure and the blade tail part 8. Further, the blade tail part 8 is formed by combining the metal plate on the suction side of airfoil (the airfoil suction-side metal plate) and the metal plate on the pressure side of airfoil (the airfoil pressure-side metal plate). In the blade tail part 8, the airfoil suction-side metal plate and the airfoil pressure-side metal plate are not directly joined. It is possible to provide a slit in the vicinity of the blade trailing edge by inserting a spacer between the airfoil suction-side metal plate and the airfoil pressure-side metal plate and overlaying them so as to form a gap.

[0033] In the blade tail part, the pressure side plate slit-processed in the height direction is attached to the suction side plate forming the acute part at the trailing edge and the step part on one surface, so as to hold the positioning piece therebetween, to form space corresponding to the thickness of the positioning piece on the inner surface side of the suction side plate and the pressure side plate. Further, the gap is provided between the one side end surface of the pressure side plate and the step part of the suction side plate, and the suction side plate and the pressure side plate are attached so as to form the slit. It is possible to set the slit position immediately close to the trailing edge by providing the step part of the suction side plate in a position close to the trailing edge.

[0034] According to the structure of the present embodiment, since it is possible to set the position of the slit to guide the liquid droplets deposited on the blade wall surface to the inside of the blade in a region of the minimum liquid thickness for surface stripping, it is possible to eliminate 80% of the liquid film generated on the stationary blade, to reduce erosive action on the moving blade by erosion, and improve the reliability.

[0035] Note that as the blade tail part 8, it may be manufactured in a separate body from the main body as the blade tail part 8 from the upstream-side position from the second slit 23 on the downstream side of the dimension-

less distance $1/L=0.5$.

[Embodiment 2]

[0036] Next, a second embodiment of the present invention will be described using Fig. 7. In the present embodiment, the slit is not formed in the entire region in the stationary blade height direction, but limitedly in a region opposite to the tip part of the moving blade 2 shown in Fig. 1.

[0037] The liquid film is eliminated with the slit 24 and the second slit 23, however, the steam is also sucked at the same time of the elimination of the liquid film. The increment of the steam removal directly influences the degradation of the performance of the steam turbine. Further, the erosion amount by the liquid droplets flying from the stationary blade is increased in accordance with the increment of the circumferential velocity of the moving blade. Accordingly, the blade structure in the 70% or greater region in the blade height direction is formed with the joint body between the main body 5 and the blade tail part 8 shown in the embodiment 1.

[0038] In the present embodiment, it is possible to eliminate the liquid film in a region of large erosion amount, and reduce the steam removal in the slit, in addition, in a long blade such as a low-pressure turbine final-stage stationary blade, by limiting the region of the 2-body structure to 30% of the blade height direction, i.e., a part in the blade height direction where the liquid film particularly occurs, it is possible to easily manufacture the structure.

[0039] Note that the blade tail part 8 shown in Fig. 3 and Fig. 5 is formed using the positioning piece 22, however, the blade tail part 8 may be formed by precision casting.

[Embodiment 3]

[0040] Next, a third embodiment of the present invention is shown in Fig. 8 and Fig. 9. Fig. 8 shows a cross-section of the stationary blade according to the third embodiment, and Fig. 9 is an enlarged diagram of the blade tail part of the stationary blade shown in Fig. 8.

[0041] In the present embodiment, the blade tail part 8 is not formed completely independently of the main body 5, but the member forming the blade surface of the main body 5 is extended and applied to the suction side plate 20 of the blade tail part 8. That is, on the suction side of airfoil, the main body 5 and the blade tail part 8 are formed with one metal plate. On the other hand, on the pressure side of airfoil, as in the case of the embodiment 1, the metal plates forming the main body 5 and the blade tail part 8 are separate bodies. The pressure side plate 21 is overlaid on the step part 27 of the suction side plate 20 integrally formed with the main body 5 with a gap therebetween, and its one end is welded and fixed to the metal plate of the main body 5 on the pressure side of airfoil along the welding line 9. On the other hand, the other end of the pressure side plate 21 has a gap

with respect to the step part 27 of the suction side plate 20 integrally formed with the main body 5. As in the case of the embodiment 1, by overlaying the suction side plate 20 and the pressure side plate 21 with a gap therebetween, the slit 24 is formed by forming one wall of the slit with the end of the pressure side plate 21 and forming the other wall with the step part of the suction side plate. It is possible to form the slit 24 between the step part 27 of the suction side plate and the end of the pressure side plate 21 by providing the gap.

[0042] The method of joining the pressure side plate 21 with the positioning piece 22 to the suction side plate 20 is similar to the method shown in Fig. 3. According to the present embodiment, in addition to the advantage of the embodiment 1, as the suction side plate of the blade tail part 8 and the metal plate of the main body 5 is one metal plate, it is possible to reduce the number of processing steps such as welding and member cutting and to reduce the erosive action on the moving blade by erosion at a lower cost.

[Embodiment 4]

[0043] Next, a fourth embodiment of the present invention is shown in Fig. 11 and Fig. 12. Fig. 11 is a schematic perspective diagram of the stationary blade according to the present embodiment. Fig. 12 is a cross-sectional diagram of an arbitrary cross section of a slit formation part in Fig. 11. The structure of the airfoil shown in Fig. 8 is applied to the structure of the airfoil in Fig. 11. The pressure side plate 21 of the blade tail part 8 is not formed as a separate member of the main body, but the member forming the blade surface of the main body is extended and applied.

[0044] In the present embodiment, the entire airfoil is previously formed by emboss-press processing one plate member. After the emboss-press processing, the pressure side of airfoil is cut in a position sufficiently away from the leading edge, and the pressure side plate 21 is removed. In the blade tail part of the suction side plate and the pressure side slit formation part, the blade plate member is cut in its thickness direction, to form the outer shape of the airfoil and a gap fluid channel part between the suction side and the pressure side of the blade inner surface. A reinforcing rib 36 is fixed by welding or the like to the blade inner side of a cut-out part 35 of the pressure side plate 21 at the leading edge. The pressure side plate 21 is fixed by welding on this rib. The blade tail side of the pressure side plate 21 is fixed to the upstream side of the second slit 23 with the positioning piece provided between the slit 24 and the second slit 23. Further, the reinforcing rib 36 is provided with a vent hole 37 communicable with the hollow part 26 divided with the rib 36. By providing the vent hole 37, it is possible to uniform the pressure of the blade hollow part and to mitigate the load due to the pressure acting on the reinforcing rib 36.

[0045] In the present embodiment, in addition to the advantages of the embodiment 1 and the embodiment

3, the strength of the structure of the hollow blade is increased by providing the reinforcing rib 36 inside the blade.

[Embodiment 5]

[0046] Next, a fifth embodiment of the present invention will be described using Fig. 13 and Fig. 14. Fig. 13 is a schematic perspective diagram of the stationary blade according to the present embodiment. Fig. 14 is a cross-sectional diagram of an arbitrary cross section of the slit formation part of the stationary blade shown in Fig. 13. In the embodiment shown in Fig. 5 or Fig. 9, the positioning piece shown in Fig. 10 is used so as to fix the suction side plate and the pressure side plate and to ensure the size of the gap between the suction side plate and the pressure side plate. In the present embodiment, in place of the positioning piece, a rib 40 formed inside the suction side plate is provided.

[0047] In the surface on the blade inner side of the suction side plate 20, a concave part forming a gap portion through which the water film flow sucked from the slit flows is formed by engraving. Further, the rib 40 is provided in a direction along the flow direction of the steam mainstream in plural positions in the concave member in the blade height direction. A gap fluid channel having a width of the height of the rib 40 is formed between the suction side plate 20 and the pressure side plate 21 by joining the pressure side plate 21 to the rib 40 when the suction side plate 20 and the pressure side plate 21 are overlaid. Note that the pressure side plate 21 is provided so as to cover the rib 40 and is fixed by welding or the like. According to the present embodiment, the width of the gap fluid channel can be controlled by controlling the rib height.

[0048] Note that in the embodiment in Fig. 13, the rib is provided on the inner surface of the suction side plate 20, however, it may be provided on the inner surface side of the pressure side plate 21. Further, the stationary blade shown in Fig. 13 is an example where in the stationary blade explained in the embodiment 2, the rib 40 of the present embodiment is applied in place of the positioning piece. The rib 40 of the present embodiment in place of the positioning piece may be applied in the stationary blade of the embodiment 1, the embodiment 3 or the embodiment 4.

[0049] In the present embodiment, as in the case of the other embodiments, it is possible to set a position immediately close to the trailing edge as the slit position, to reduce the erosive action on the moving blade by erosion and to improve the reliability. In addition, as a part completely separated from the suction side plate and the pressure side plate such as the positioning piece is not required for formation of the gap fluid channel and joint between the suction side plate and the pressure side plate, it is possible to reduce the manufacturing cost of the hollow stationary blade by reduction of the number of assembly parts and reduction of the number of assem-

bly steps.

[Reference Signs List]

5 **[0050]**

- | | |
|----|-------------------------|
| 1 | stationary blade |
| 2 | moving blade |
| 5 | main body |
| 10 | blade tail part |
| 20 | suction side plate |
| 21 | pressure side plate |
| 22 | positioning piece |
| 23 | second slit |
| 15 | 24 slit |
| 25 | gap |
| 26 | hollow part |
| 27 | step part |
| 28 | trailing edge |
| 20 | 29 piece hole |
| 30 | piece hole |
| 31 | brim |
| 32 | leading edge of airfoil |
| 34 | convex member |
| 25 | 36 rib |
| 37 | vent hole |
| 40 | rib |

30 **Claims**

1. A steam turbine stationary blade (1) having a slit (24), to guide liquid droplets deposited on a blade wall surface to the inside of the stationary blade (1), in the blade wall surface, wherein the stationary blade (1) is formed in a hollow blade shape by deformation processing a metal plate, and wherein the slit (24) is formed by overlaying an airfoil suction-side metal plate (20) and an airfoil pressure-side metal plate (21) with a gap therebetween in a blade tail part (8) of the stationary blade (1).
2. The steam turbine stationary blade according to claim 1, further comprising second slits (23) provided in a plurality of positions in a blade height direction on the upstream side of the slit (24) in a mainstream flow direction, wherein the second slits (23) are connected to the gap (25) provided between the airfoil suction-side metal plate (20) and the airfoil pressure-side metal plate (21).
3. The steam turbine stationary blade according to claim 2, wherein the slit (24) and the second slits (23) are provided on the pressure side of airfoil, and wherein the second slit (23) is provided in a position

in a range of 0.65 to 0.75 as 1/L ratio between a distance 1 along a blade surface from the airfoil leading edge end (32) of the stationary blade to an arbitrary position of the blade surface and a distance L along the blade surface from the airfoil leading edge end (32) to the trailing edge (28) of the stationary blade, and the slit (24) is provided in a portion in a range of 0.75 to 0.9 as the 1/L ratio.

4. The steam turbine stationary blade according to any one of claims 1 to 3, further comprising:

a pair of piece holes (29, 30) provided in the airfoil suction-side metal plate (20) and the airfoil pressure-side metal plate (21);
a positioning piece (22) having a spacer (31), held between the airfoil suction-side metal plate (20) and the airfoil pressure-side metal plate (21), to form a gap (25), and a convex member (34), provided at both ends of the spacer (31) and inserted in the piece holes (29, 30), to fix mutual positions of the airfoil suction-side metal plate (20) and the airfoil pressure-side metal plate (21); and
a step part (27), provided on the blade inner surface side of the airfoil suction-side metal plate (20), overlaid on the trailing edge side end of the airfoil pressure-side metal plate (21) with a gap therebetween, to form the slit (24).

5. The steam turbine stationary blade according to any one of claims 1 to 4, wherein the airfoil suction-side metal plate (20) and the airfoil pressure-side metal plate (21) are respectively formed with a separate metal plate of a metal plate forming the main body (5) of the stationary blade.

6. The steam turbine stationary blade according to claim 5, wherein the airfoil suction-side metal plate (20) and the airfoil pressure-side metal plate (21) are respectively formed with the separate metal plate of the main body (5) of the stationary blade at a part of a region on the outer peripheral side in the stationary blade height direction.

7. The steam turbine stationary blade according to any one of claims 1 to 4, wherein the airfoil suction-side metal plate (20) is formed with the same member as the metal plate forming the main body (5) of the stationary blade, and wherein the airfoil pressure-side metal plate (21) is formed with a separate metal plate of the metal plate forming the main body (5) of the stationary blade.

8. The steam turbine stationary blade according to claim 7, wherein the stationary blade has a reinforcing rib (36), to reinforce a welded part between the metal plate forming the main body (5) of the station-

ary blade and the airfoil pressure-side metal plate (21), in the blade hollow part (26), and wherein the reinforcing rib (36) has a vent hole (37) to communicate the blade hollow parts divided with the reinforcing rib (36) into two sections.

9. The steam turbine stationary blade according to any one of claims 1 to 8, further comprising a rib (40) formed on the blade inner-side surface of the airfoil suction-side metal plate (20) or the airfoil pressure-side metal plate (21), wherein the airfoil suction-side metal plate (20) and the airfoil pressure-side metal plate (21) are joined via the rib (40).

10. A steam turbine comprising a turbine stage having a stationary blade (1), with a slit (24) to guide liquid droplets deposited on a blade wall surface to the inside of the stationary blade, in the blade wall surface, and a moving blade (2) provided on the downstream side of the stationary blade (1) in a working fluid flow direction, wherein the stationary blade (1) according to any one of claims 1 to 9 is used as the stationary blade (1).

FIG. 1

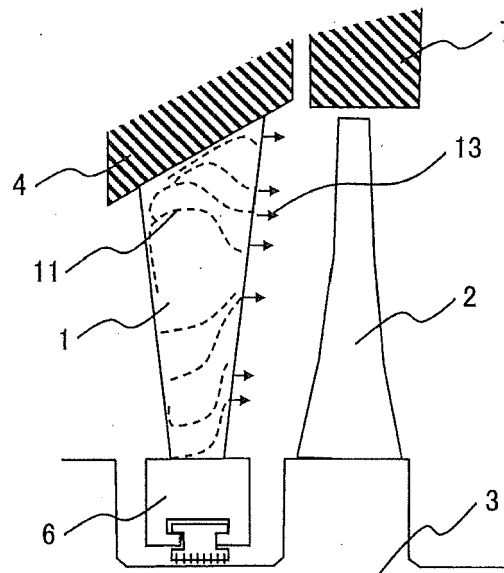


FIG. 2

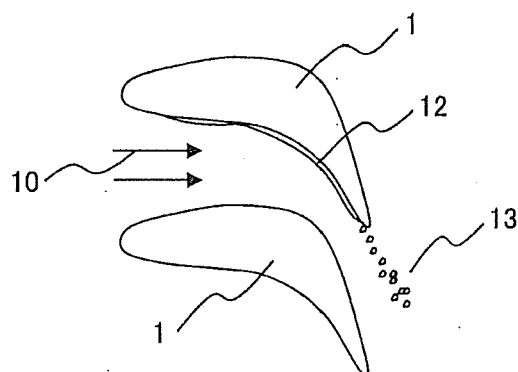


FIG. 3

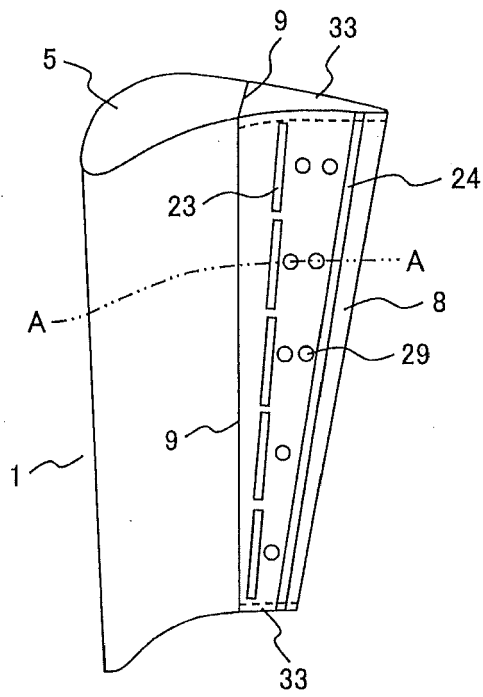


FIG. 4

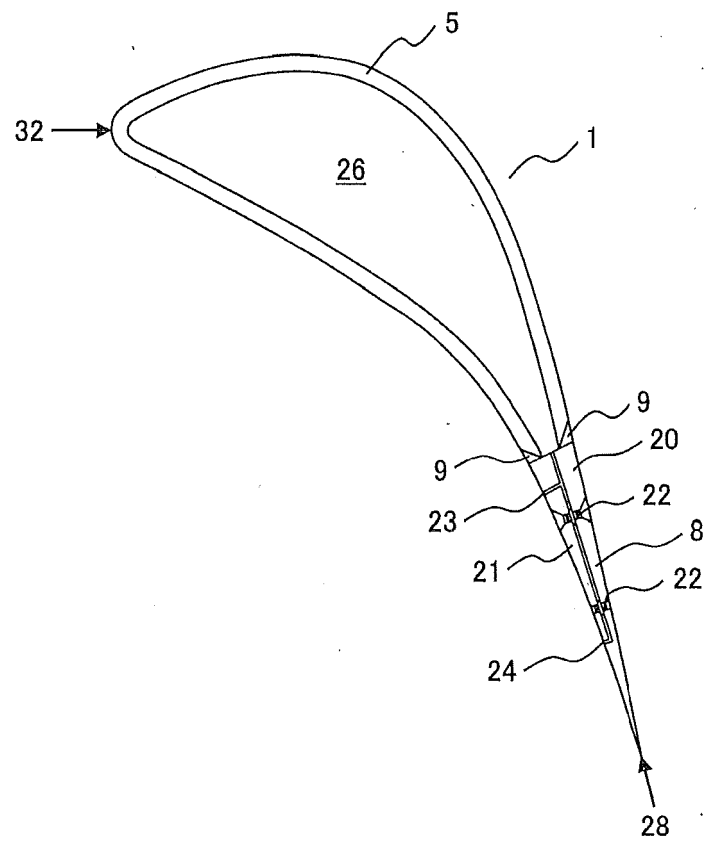


FIG. 5

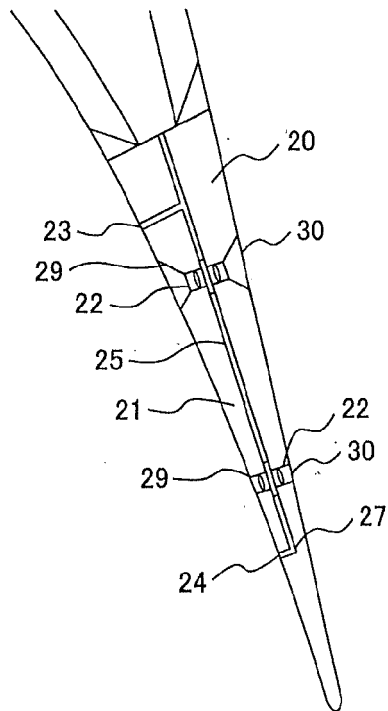


FIG. 6

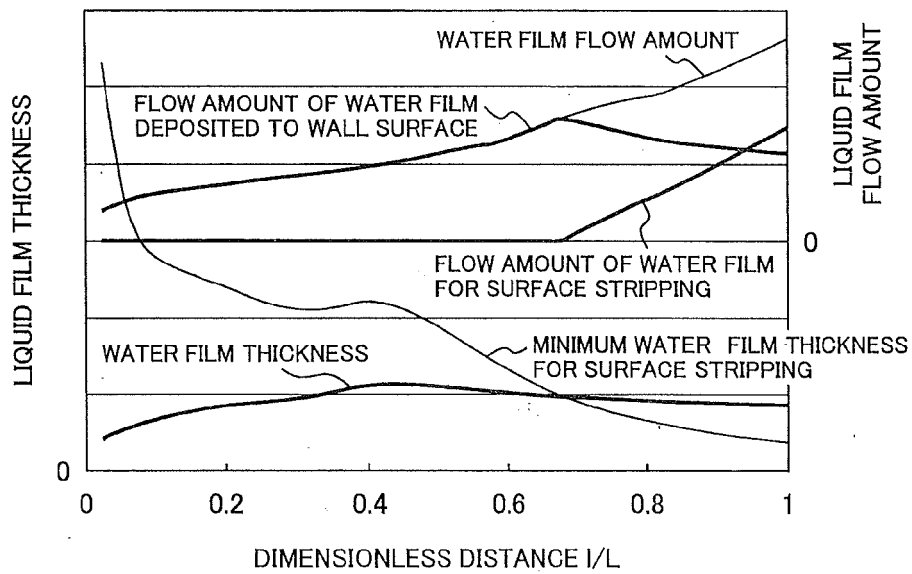


FIG. 7

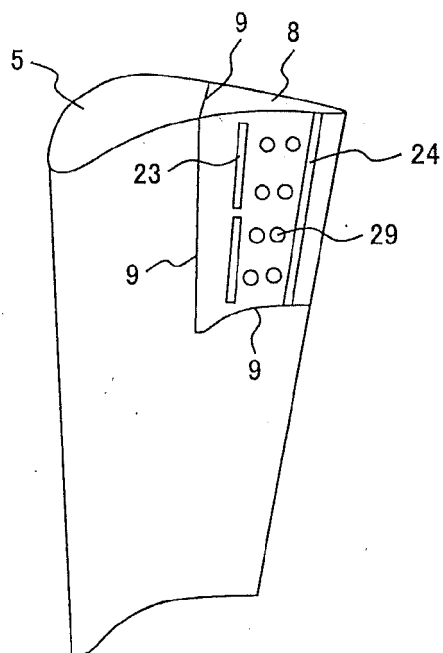


FIG. 8

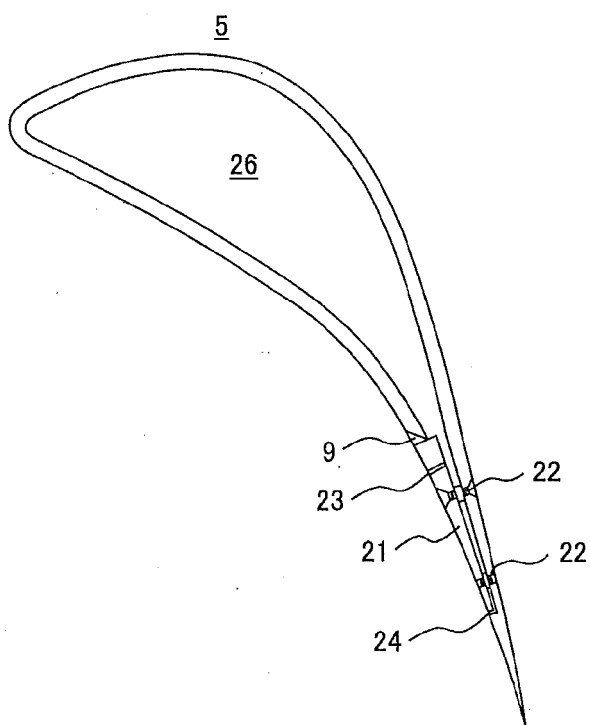


FIG. 9

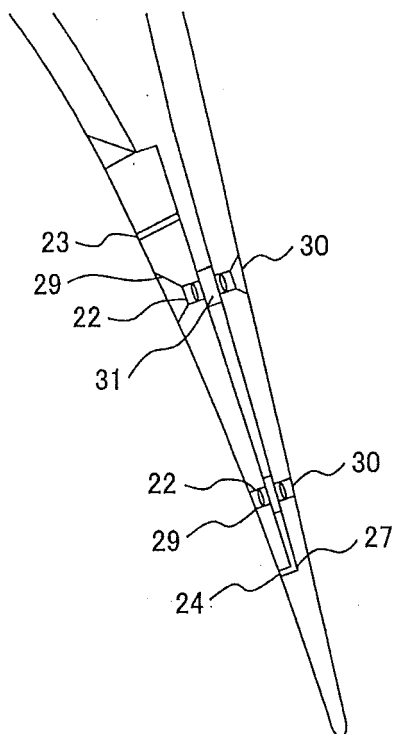


FIG. 10

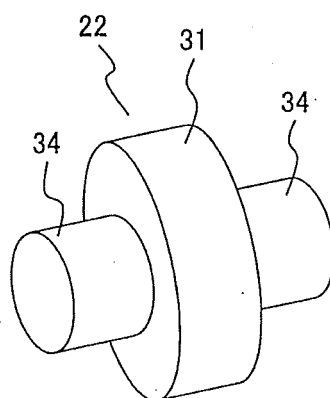


FIG. 11

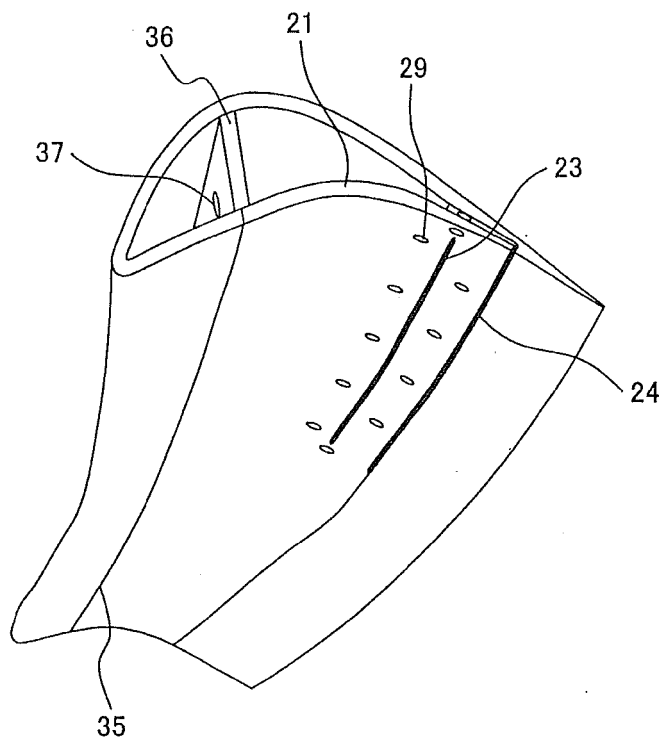


FIG. 12

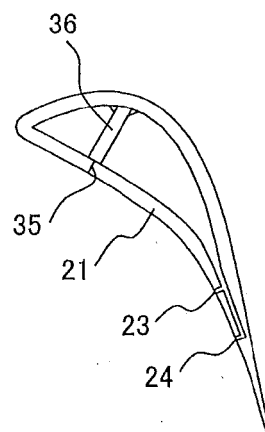


FIG. 13

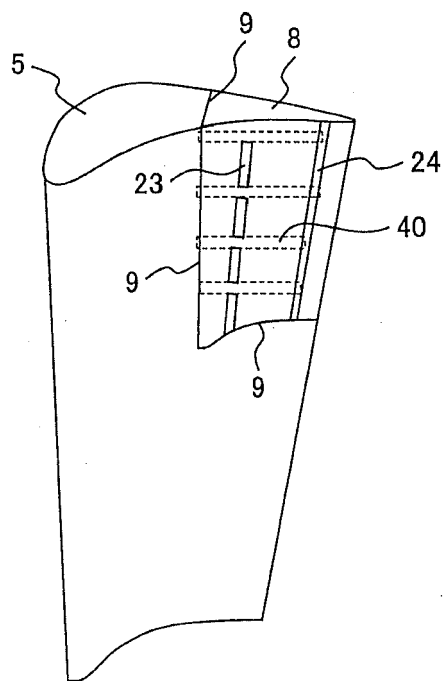
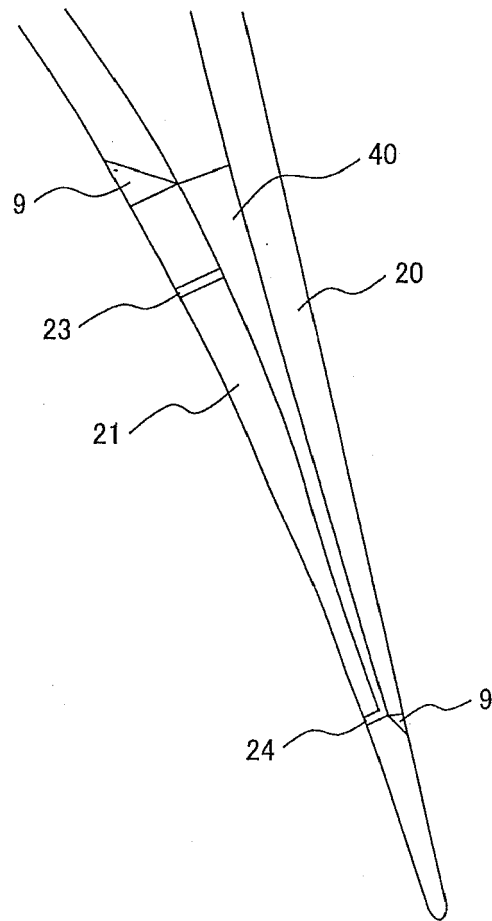


FIG. 14



REFERENCES CITED IN THE DESCRIPTION

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