

DESCRIPTION

PROPELLER FAN FOR ELECTRIC FAN, AND ELECTRIC FAN

5 TECHNICAL FIELD

The present invention relates to a propeller fan for electric fan and an electric fan, which utilize a direct air current in lowering a sensible temperature or in circulating indoor air.

10 BACKGROUND ART

For example, PTL 1 discloses a configuration of a propeller fan for electric fan in the related art.

Hereinafter, a shape of the propeller fan for electric fan in the related art will be described with reference to FIGS. 9(a) and 9(b).

15 FIG. 9(a) is a front view when the propeller fan for electric fan in the related art is viewed in a rotary shaft direction. FIG. 9(b) is a side view when one piece of blade at rotation position $\alpha 5$ of the propeller fan for electric fan in the related art is viewed in a front edge direction.

As illustrated in FIG. 9(a), propeller fan 101 includes hub 103 having
20 rotary shaft 102, and a plurality of blades 104 formed on an outer periphery of hub 103. Furthermore, blade 104 has front edge 105 having an arc shape, and rear edge 106 having the same arc shape.

When a line indicating a rotation position is drawn around rotary shaft 102, a position in which an air current firstly blows out from a blade is referred
25 to as $\alpha 1$, and a position in which the air current lastly blows out from the blade is referred to as $\alpha 5$. $\alpha 2$, $\alpha 3$, and $\alpha 4$ between $\alpha 1$ and $\alpha 5$ are respectively referred to as positions in which the air currents sequentially blow out from the

blade. A contact point position between $\alpha 5$ and rear edge 106 is referred to as Pr.

As illustrated in FIG. 9(b), if one piece of blade is viewed from a side surface, in a case where a contact point position between a plane perpendicular to rotary shaft 102 and rear edge 106 is referred to Pz, Pr and Pz are present at mutually different positions.

Citation List

Patent Literature

PTL 1: Japanese Patent Unexamined Publication No. 2005-133677

SUMMARY OF THE INVENTION

In one aspect, a propeller fan for electric fan comprising

a hub whose rotation center has a rotary shaft; and

a plurality of blades arrayed around the hub,

wherein solidity $\sigma=L/T$ configured to include blade chord length L of each of the blades and inter-blade pitch T is set to 0.50 to 0.95,

wherein hub ratio $D2/D1=0.2$ to 0.4 configured to include diameter D1 of the blade and diameter D2 of the hub is set,

wherein the propeller fan is configured to blow an air current in a direction of the rotary shaft,

wherein a shape of the blade is a shape obtained by continuously connecting an arc-shaped blade tip portion located on an outermost periphery and a blade root portion in contact with the hub to each other,

wherein when a region of 0.65 to 0.85 times than R1 with respect to radius R1 from a center of the rotary shaft to the blade tip portion is set to a blade intermediate portion, a curve shape of a rear edge when viewed from a meridional plane is a shape in which the blade intermediate portion includes

an axial extreme point whose axial height is located on a most leeward side, and which gradually tilts to a windward side from the axial extreme point toward the blade tip portion,

wherein a curve shape of the rear edge when viewed in the direction of the rotary shaft is a shape in which the blade intermediate portion includes a rotational extreme point located on a most rearward side in a rotation direction, and which gradually moves forward from the rotational extreme point toward the blade tip portion, and

wherein the axial extreme point and the rotational extreme point are aligned with each other.

It has been desired that an electric fan enables a person to enjoy a cool feeling and improves comfort of the person by directing an air current to the person. Therefore, a wind speed of the air current blowing out from a propeller fan needs to become faster. However, due to a shape of a blade of the propeller fan for electric fan in the related art, the wind speed of the blowing air current is greatly attenuated. Consequently, there is a problem in that the wind speed of the air current becomes slower.

In this regard, for example, if the air current is analyzed in a case of the propeller fan for electric fan in the related art illustrated in FIGS. 9(a) and 9(b), and if an air flow is observed in a case where a blade is rotated from rotation positions $\alpha 1$ to $\alpha 5$, it can be confirmed that the air current is generated as follows.

First, air flows in from a front edge of a blade tip at rotation position $\alpha 1$. At rotation position $\alpha 2$, the air flows in the entire front edge from the blade tip to a blade root, and the air flows on a blade surface. While the air flowing on the blade surface is caused to accelerate a flow speed by the rotation of the

blade, the air flows as the air current. At the time of rotation position $\alpha 3$, the air current blows out from a blade tip portion. Thereafter, at the time of rotation position $\alpha 4$, the air current blows out from contact point Pz. At this time, the air current blowing out from the blade tip flows adjacent to an outside
5 in a radial direction of the air current of contact point Pz. However, the air current inside in the radial direction of contact point Pz has not yet reached rear edge 106. Accordingly, the air current does not blow out, and the inside is brought into in a state having no air current. Therefore, the air current blowing out from contact point Pz has a wind speed which is greatly different
10 from that of the inside air, thereby attenuating the wind speed. While reaching rotation position $\alpha 5$, the air currents sequentially blow out from rear edge 106 of contact point Pz toward inside contact point Pr. At this time, as illustrated in FIG. 9(b), the air current blowing out from contact point Pz has already flowed downstream in an axial direction, and has received air
15 resistance. It is understood that the air current is brought into a state where the wind speed is greatly attenuated.

As a graph schematically showing this state, FIG. 10(a) illustrates a relationship between a radial blade position and a blowing wind speed at the time of rotation positions $\alpha 3$ to $\alpha 5$ where the air current starts to blow out.
20 In addition, FIG. 10(b) illustrates a relationship among a shape of the rear edge, the radial blade position, and an axial position of the air current at rotation positions $\alpha 3$ to $\alpha 5$ where the air current starts to blow out.

As illustrated in FIG. 10(a), at the time of rotation position $\alpha 3$, the air current starts to blow out from a blade tip side. At the time of rotation
25 position $\alpha 4$, the air current also starts to blow out from a blade center side. However, at this time, the wind speed of the air current on the blade tip side is lowered due to attenuation. The wind speed at the time of rotation position $\alpha 5$

is finally attenuated and becomes slower outside in the radial direction, since a time has already elapsed after the air current starts to blow out. The wind speed is not attenuated inside the radial direction in which contact point P_r is present, since the air current blows out immediately before. However, since a
5 blade radius is small, a circumferential speed is slow. Compared to the blowing wind speed on the blade tip side, the wind speed is relatively slower. In addition, as illustrated in FIG. 10(b), according to a relationship between the radial position and the position in the rotary shaft direction of the rear edge, contact point P_z is maximized, and a height of the air current is lowered as the
10 position is far away from contact point P_z in the radial direction. However, until the air current reaches rotation positions α_3 to α_5 , the air currents sequentially blow out from the outside in the radial direction. Accordingly, it is understood that at the time of rotation position α_5 , a height position of the air current blowing on the blade tip side considerably is moved downstream.

15 If FIGS. 10(a) and 10(b) are compared with each other, it is understood that contact point P_r and contact point P_z of the rear edge have mutually different radial positions. Referring to FIG. 10(a), it is understood that at a position of the air current when blowing out from contact point P_z at the time of rotation position α_3 , the air current blows from the most downstream side due
20 to a shape of the rear edge with reference to rotation position α_3 in FIG. 10(b). At this time, there is no air current inside in the radial direction of contact point P_z . Moreover, as the air current reaches rotation position α_4 , the air current starts to blow out from the inside in the radial direction of contact point P_z . However, the position of the rear edge is low, and the air current blows out
25 from the upstream side. Accordingly, the rear edge is not adjacent to the air current already blown out from contact point P_z . Therefore, the wind speed of the air current blowing out from contact point P_z is attenuated.

In addition, as another problem, for example, another example will be described as follows which shows the blade shape of the propeller fan for electric fan in the related art. In order to facilitate description, in a cylindrical cross-sectional shape at any optional radial position of the blade, an angle
5 formed between a straight line connecting a front edge point and a rear edge point to each other and a plane perpendicular to the rotary shaft is referred to as a mounting angle.

When the propeller fan is rotated, in order to increase the blowing wind speed of the air current on the blade tip side where the circumferential speed is
10 fastest, the mounting angle of the blade tip portion is widened. Then, pressure generated on a positive pressure surface of the blade tip portion increases, and resistance increases when the propeller fan is rotated. Consequently, a problem arises in that rotational torque required for a motor increases and power consumption of the motor increases.

15 The present invention is made in order to solve the above-described problems in the related art, and an object thereof is to restrain power consumption of a motor from increasing by restraining wind speed attenuation of an air current so as to generate an air current having a fast wind speed without increasing rotational torque.

20 In order to achieve this object, a propeller fan for electric fan according to the present invention includes a hub whose rotation center has a rotary shaft, and a plurality of blades arrayed around the hub. In addition, in the propeller fan for electric fan, solidity $\sigma=L/T$ configured to include blade chord length L of each of the blades and inter-blade pitch T is set to 0.50 to 0.95, and hub ratio
25 $D2/D1=0.2$ to 0.4 configured to include diameter $D1$ of the blade and diameter $D2$ of the hub is set. In addition, the propeller fan is configured to blow an air current in a direction of the rotary shaft. In addition, a shape of the blade is a

shape obtained by continuously connecting an arc-shaped blade tip portion located on an outermost periphery and a blade root portion in contact with the hub to each other. In addition, when a region of 0.65 to 0.85 times than R1 with respect to radius R1 from a center of the rotary shaft to the blade tip portion is set to a blade intermediate portion, a curve shape of a rear edge when viewed from a meridional plane is a shape in which the blade intermediate portion includes an axial extreme point whose axial height is located on a most leeward side. In addition, the shape gradually tilts to a windward side from the axial extreme point toward the blade tip portion. In addition, a curve shape of the rear edge when viewed in the direction of the rotary shaft is a shape in which the blade intermediate portion includes a rotational extreme point located on a most rearward side in a rotation direction, and which gradually moves forward from the rotational extreme point toward the blade tip portion. In addition, the axial extreme point and the rotational extreme point are aligned with each other. In this manner, an intended object is achieved.

According to the present invention, an air current first blows out to the axial extreme point and the rotational extreme point which are disposed in the blade intermediate portion, from the rear edge on the outside in the radial direction and the inside in the radial direction. Thereafter, the air current blows out from the axial extreme point and the rotational extreme point. In this manner, a wind speed difference between the air currents on the inside and the outside is minimized. Accordingly, it is possible to restrain wind speed attenuation. Therefore, a user can enjoy a cool feeling, and comfort of the user can be improved.

In addition, it is not necessary to widen the mounting angle of the blade tip portion in order to accelerate the wind speed of the air current.

Accordingly, without increasing the rotational torque, it is possible to restrain power consumption of the motor from increasing. Therefore, the present invention can contribute to energy saving.

5 BRIEF DESCRIPTION OF DRAWINGS

FIG. 1 is a front view of a propeller fan for electric fan according to an exemplary embodiment of the present invention.

FIG. 2 is a detailed view when a shape of one piece of blade of the propeller fan for electric fan according to the exemplary embodiment of the present invention is viewed in a direction of a rotary shaft.

FIG. 3 is a sectional view illustrating a deployed cylindrical cross-sectional shape of the propeller fan for electric fan according to the exemplary embodiment of the present invention.

FIG. 4 is a detailed view when a shape of one piece of blade of the propeller fan for electric fan according to the exemplary embodiment of the present invention is viewed from a meridional plane.

FIG. 5(a) is a view illustrating an air current flowing on a surface of one piece of blade of the propeller fan for electric fan when viewed from a front surface according to the exemplary embodiment of the present invention, and FIG. 5(b) is a view illustrating an air current when one piece of blade in rotation of the propeller fan is viewed in a direction of a front edge.

FIG. 6(a) is a schematic view illustrating a relationship between a radial blade position and a blowing wind speed in the blade of the propeller fan for electric fan according to the exemplary embodiment of the present invention, and FIG. 6(b) is a schematic view illustrating a relationship among a rear edge shape in the blade of the propeller fan, a radial blade position where an air current starts to blow out, and an axial position of the air current.

FIG. 7A is a perspective view illustrating a mounting angle of the blade of the propeller fan for electric fan according to the exemplary embodiment of the present invention.

FIG. 7B is a perspective view illustrating a mounting angle of the blade
5 as an example of a widened mounting angle of a blade tip portion of the propeller fan for electric fan according to the exemplary embodiment of the present invention.

FIG. 8 is an external view of an electric fan equipped with the propeller fan for electric fan according to the exemplary embodiment of the present
10 invention.

FIG. 9(a) is a view illustrating an air current when a propeller fan for electric fan in the related art is viewed in a direction of a rotary shaft, and FIG. 9(b) is a view illustrating an air current when one piece of blade of the propeller fan is viewed in a direction of a front edge.

FIG. 10(a) is a schematic view illustrating a relationship between a
15 radial blade position and a blowing wind speed in the blade of the propeller fan for electric fan in the related art, and FIG. 10(b) is a schematic view illustrating a relationship among a rear edge shape in the propeller fan, a radial blade position where an air current starts to blow out, and an axial position of the air
20 current.

DESCRIPTION OF EMBODIMENT

Hereinafter, an exemplary embodiment according to the present invention will be described with reference to the drawings. The following
25 description is intended to indicate an exemplary embodiment, and the exemplary embodiment does not limit the present invention.

FIG. 1 is a front view of a propeller fan for electric fan according to the

exemplary embodiment of the present invention. FIG. 2 is a detailed view when a shape of one piece of blade of the propeller fan for electric fan according to the exemplary embodiment of the present invention is viewed in a direction of a rotary shaft. FIG. 3 is a sectional view illustrating a deployed cylindrical cross-sectional shape in optional radius R of the blade of the propeller fan for electric fan according to the exemplary embodiment of the present invention.

As illustrated in FIG. 1, propeller fan 1 includes circular hub 3 whose rotation center has rotary shaft 2, and plate-shaped blade 4 protruding radially outward from an outer peripheral side of hub 3. A plurality of blades 4 are arranged at equal intervals per each rotation. According to the present exemplary embodiment, 5 pieces are arranged per rotation angle of 72°.

As illustrated in FIG. 2, a shape of blade 4 when viewed in a direction of rotary shaft 2 is a substantially fan shape obtained by continuously connecting arc-shaped blade tip portion 5 located on an outermost periphery and blade root portion 6 in contact with an outer peripheral surface of hub 3 to each other. A rotation direction of blade 4 illustrated in FIG. 2 is a clockwise direction. In a contour connecting blade tip portion 5 and blade root portion 6 to each other, a forward side in the rotation direction is referred to front edge 7, and a rearward side is referred to as rear edge 8.

As an example of a size of blade 4, diameter D1 from the blade tip to the blade and diameter D2 of hub 3 respectively show D1=400 mm and D2=125 mm. Hub ratio D2/D1 is 0.325. Radius R1 from a center of rotary shaft 2 to blade tip portion 5 is 200 mm, and radius R2 from the center of rotary shaft 2 to blade root portion 6 is 62.5 mm. In addition, as illustrated in FIG. 3, when a line connecting front edge 7 and rear edge 8 to each other is set to blade chord 9, a length of blade chord 9 is set to blade chord length L, and a distance between front edges of adjacent blade 4 is inter-blade pitch T, solidity $\sigma=L/T$ is formed in

a range of 0.5 to 0.95.

In addition, on a blade surface which is a surface of blade 4, a surface serving as a front surface in the rotation direction is referred to as positive pressure surface 10, and a surface serving as a rear surface is referred to as
5 negative pressure surface 11.

In propeller fan for electric fan 1 having the above-described configuration, a characteristic of a blade shape according to the present exemplary embodiment will be described hereinafter.

As illustrated in FIG. 2, blade intermediate portion 12 occupies a region
10 of 0.65 to 0.85 times than radius R1 from blade tip portion 5, that is, a radius range of 130 to 170 mm. A curve shape of rear edge 8 when viewed in the direction of rotary shaft 2 has rotational extreme point 13 located on a most rearward side in the rotation direction in blade intermediate portion 12. According to the present exemplary embodiment, rotational extreme point 13 is
15 disposed at a position of radius $R=165$ mm.

In addition, a line connecting centers of blade chords 9 at the respective radial positions from radius R1 to radius R2 is referred to as blade chord center line 14. Blade chord center line 14 and front edge 7 have a shape which moves forward in the rotation direction from blade intermediate portion 12 toward
20 blade tip portion 5, when viewed in the direction of rotary shaft 2.

FIG. 4 is a detailed view when a shape of one piece of blade of the propeller fan for electric fan according to the exemplary embodiment of the present invention is viewed from a meridional plane. A characteristic thereof will be described. Here, the meridional plane is a plane represented by a
25 cylindrical coordinate system in which rotary shaft 2 is set to an origin, the radial direction is set to an X-axis, and the direction of the rotary shaft is set to a Y-axis.

As illustrated in FIG. 4, a curve shape of rear edge 8 when viewed from the meridional plane has axial extreme point 15 whose axial height is located on a most leeward side in blade intermediate portion 12. The curve shape of rear edge 8 is a shape which gradually tilts to the windward side from axial extreme point 15 toward blade tip portion 5. Axial extreme point 15 and rotational extreme point 13 are aligned with each other.

In addition, blade chord center line 14 has a shape whose axial height gradually tilts to the windward side from blade intermediate portion 12 toward blade tip portion 5.

FIG. 5(a) is a front view illustrating an air current flowing on a surface of one piece of blade of the propeller fan for electric fan according to the exemplary embodiment of the present invention. FIG. 5(b) is a side view when one piece of blade at rotation position $\alpha 5$ of the propeller fan for electric fan is viewed in a direction of the front edge. Hereinafter, an air current flow in blade 4 according to the present exemplary embodiment will be described.

FIG. 5(a) illustrates air currents flowing on positive pressure surface 10 of blade 4, sequentially from rotation positions $\alpha 1$ to $\alpha 5$ at which propeller fan 1 is rotated.

Here, the air current which flows on positive pressure surface 10 of blade intermediate portion 12 and blows out from rotational extreme point 13 and axial extreme point 15 of blade intermediate portion 12 is referred to as extreme point air current 16. The air current flows outside in the radial direction of extreme point air current 16 is referred to as outside air current 17. The air current flows inside in the radial direction of extreme point air current 16 is referred to as inside air current 18.

First, at rotation position $\alpha 1$, front edge 7 moves forward from the blade root side to the blade tip side. Accordingly, air flows into positive pressure

surface 10 sequentially from the blade tip side.

Next, at rotation position α_2 , the air flowing on positive pressure surface 10 of blade 4 is pressurized by rotating blade 4, and a wind speed thereof gradually increases. In addition, at this time, blade tip vortex 19
5 turning around from positive pressure surface 10 to negative pressure surface 11 is generated in the blade tip.

Then, at rotation position α_3 , air flowing in the vicinity of blade tip portion 5 outside in the radial direction of blade intermediate portion 12, and air flowing inside in the radial direction of blade intermediate portion 12 reach
10 rear edge 8. The air blows out after respectively becoming outside air current 17 and inside air current 18. At this time, the air flowing in blade intermediate portion 12 including rotational extreme point 13 and axial extreme point 15 has not yet reached rear edge 8. The air continuously flows on positive pressure surface 10, and the wind speed continuously increases.

Furthermore, at rotation position α_4 , the air flows in blade intermediate portion 12 also reaches rear edge 8, and blows out from rotational extreme point 13 and axial extreme point 15 after finally becoming extreme point air current 16. At this time, outside air current 17 outside extreme point
15 air current 16 and inside air current 18 inside extreme point air current 16 are present adjacent to each other. The wind speed of outside air current 17 and inside air current 18 is attenuated due to friction against air around propeller fan 1. Outside air current 17 and inside air current 18 flow parallel to extreme point air current 16. In addition, in a case of a side view, a position at which extreme point air current 16 blows out is the most downstream side.
20 Even if outside air current 17 and inside air current 18 blow out firstly and the air current moves forward to the downstream side, the air currents flow near extreme point air current 16. In this manner, it is possible to restrain the

wind speed from being attenuated.

Lastly, at rotation position $\alpha 5$, the wind speed of extreme point air current 16 is restrained from being attenuated, by outside air current 17 and inside air current 18 which flow adjacent to each other. While a fast wind speed is maintained, extreme point air current 16 is supplied. FIG. 5(b) illustrates a phase when the air current in this state is viewed from a side surface. Outside air current 17 and inside air current 18 first blow out in rear edge 8, and the flow moves forward to the downstream side. Thereafter, although extreme point air current 16 blows out, extreme point air current 16 blows out from a most downstream position of rear edge 8. Accordingly, extreme point air current 16, outside air current 17, and inside air current 18 can flow parallel to each other.

The air currents flow as described above. Extreme point air current 16 in propeller fan for electric fan 1 according to the present exemplary embodiment flows in such a manner that outside air current 17 and inside air current 18 flow parallel to each other outside and inside extreme point air current 16. Accordingly, a wind speed difference from the surrounding air is minimized. Therefore, the air current can be supplied while the wind speed is restrained from being attenuated.

It is desirable that a region of blade intermediate portion 12 for disposing rotational extreme point 13 and axial extreme point 15 is a region of 0.65 to 0.85 times than R1 with respect to radius R1 from the center of rotary shaft 2 to blade tip portion 5. For example, the reason is as follows. In a case where each position of rotational extreme point 13 and axial extreme point 15 is set to 0.65 times or smaller than R1 with respect to radius R1 from the center of rotary shaft 2 to blade tip portion 5, even if propeller fan 1 is rotated at the same rotation speed, the circumferential speed becomes slow. A fast wind

speed is less likely to be obtained. In addition, in a case where each position of rotational extreme point 13 and axial extreme point 15 is set to 0.85 times or greater than R1 with respect to radius R1 from the center of rotary shaft 2 to blade tip portion 5, a region of blade tip portion 5 becomes small. Accordingly, outside air current 17 cannot be sufficiently generated. Therefore, the wind speed of extreme point air current 16 is greatly attenuated.

In order to schematically describe the above-described configuration, FIG. 6(a) illustrates a schematic view illustrating a relationship between a radial blade position and a blowing wind speed at the time of rotation positions $\alpha 3$ to $\alpha 5$ in the blade of the propeller fan for electric fan according to the exemplary embodiment of the present invention. In addition, FIG. 6(b) illustrates a schematic view illustrating a relationship among a rear edge shape, a radial blade position at rotation positions $\alpha 3$ to $\alpha 5$ where the air current starts to blow out, and an axial position of the air current, in the blade of the propeller fan for electric fan according to the exemplary embodiment of the present invention.

As illustrated in FIG. 6(a), at the time of rotation position $\alpha 3$, except for blade intermediate portion 12, the air currents start to blow out from blade tip portion 5 and blade root portion 6. The circumferential speed is fast in blade tip portion 5. Accordingly, an initial speed immediately after the air current blows out becomes faster than that in blade root portion 6.

At this time, referring to rotation position $\alpha 3$ in FIG. 6(b), the air current blowing out from rear edge 8 flows downstream in the axial direction, and moves to the downstream position. Next, if the air current reaches rotation position $\alpha 4$, the air current also blows out from blade intermediate portion 12. At this time, the air currents lastly blow out from axial extreme point 15 and rotational extreme point 13. As illustrated in FIG. 6(b), the axial position of

rear edge 8 is located at the most downstream position. Accordingly, inside air current 18 inside in the radial direction of extreme point air current 16 and outside air current 17 outside in the radial direction can be present adjacent to each other. If the air current further reaches rotation position $\alpha 5$, as
5 illustrated in FIG. 6(a), the wind speed of the air current blowing from the vicinity of blade tip portion 5 and blade root portion 6 is attenuated due to friction against the surrounding air. In contrast, extreme point air current 16 is adjacent to the surrounding. Accordingly, the wind speed attenuation is minimized.

10 Compared to a size of the wind speed attenuation at rotation positions $\alpha 3$ to $\alpha 5$ in the propeller fan for electric fan in the related art illustrated in FIGS. 10(a) and 10(b), it is possible to restrain the wind speed attenuation, particularly in extreme point air current 16.

Therefore, as in the present exemplary embodiment, when extreme
15 point air current 16 after rotational extreme point 13 and axial extreme point 15 are aligned with each other, the air current adjacent to extreme point air current 16 is provided. In this manner, the wind speed is restrained from being attenuated, the air current whose wind speed is fast is provided for a user. Therefore, comfort of the user can be improved.

20 Next, according to propeller fan for electric fan 1 in the present exemplary embodiment, there is also an advantageous effect that rotational torque can be restrained from increasing. Details thereof will be described.

FIG. 7A is a perspective view illustrating a mounting angle of the blade in the propeller fan for electric fan according to the exemplary embodiment of
25 the present invention. FIG. 7B is a perspective view illustrating a mounting angle of the blade as an example of a widened mounting angle of the blade tip portion of the propeller fan for electric fan. Description will be made with

reference to FIGS. 7A and 7B.

In a case of generating the air current whose wind speed is fast which is the object according to the present exemplary embodiment, as an example, it is considered as advantageous to accelerate the wind speed on the blade tip side
5 where the circumferential speed becomes fastest, when propeller fan 1 is rotated. Therefore, a blade shape is employed in which the mounting angle of blade tip portion 5 is widened.

For example, in FIG. 7A, if the mounting angle of blade intermediate portion 12 of blade 4 is defined as θ_1 and the mounting angle of blade tip
10 portion 5 is defined as θ_2 , in a case of the blade shape according to the present exemplary embodiment, $-1^\circ \leq \theta_2 - \theta_1 \leq 1^\circ$ is satisfied, and the mounting angles are substantially equal to each other. In contrast, as a comparative example, in a case where the mounting angle of blade intermediate portion 12 of blade 4 illustrated in FIG. 7B is defined as θ_3 and the mounting angle of blade tip
15 portion 5 is defined as θ_4 , a relationship between θ_3 and θ_4 shows $\theta_4 - \theta_3 \geq 5^\circ$, and shows $\theta_4 > \theta_2$. That is, compared to the mounting angle of blade intermediate portion 12, the mounting angle of blade tip portion 5 is set to be wider.

In a case where blades 4 in FIGS. 7A and 7B are rotated at the same
20 rotation speed, blade 4 in FIG. 7B can accelerate the wind speed of the air current blowing out from rear edge 8 of blade tip portion 5. However, the blade shape in FIG. 7B increases pressure generated on positive pressure surface 10 of blade tip portion 5, thereby causing a problem in that rotational torque increases in the rotation direction of propeller fan 1. The rotational
25 torque is represented by the product of a load and a distance from the center of rotary shaft 2 to a position where the load is generated. Accordingly, the load generated in blade tip portion 5 farthest from the center of rotary shaft 2

significantly increases the rotational torque.

In addition, if the pressure generated on positive pressure surface 10 of blade tip portion 5 increases, a flow of blade tip vortex 19 turning around negative pressure surface 11 from positive pressure surface 10 of blade tip portion 5 is further promoted. Then, the air current flowing in blade tip portion 5 becomes blade tip vortex 19, thereby resulting in a loss. Accordingly, the air current cannot be efficiently supplied.

Therefore, the blade shape according to the present exemplary embodiment illustrated in FIG. 7A can achieve an intended object without widening the mounting angle of blade tip portion 5. Therefore, without increasing the rotational torque, it is possible to restrain power consumption of the motor from increasing.

FIG. 8 is an external view of an electric fan equipped with the propeller fan for electric fan 1 according to the exemplary embodiment of the present invention.

As illustrated in FIG. 8, guard 20 for avoiding collision with a foreign substance without hindering the air current flow is disposed around propeller fan for electric fan 1. In addition, motor 21 is connected to rotary shaft 2 of hub 3, and propeller fan 1 is rotated using a drive force of motor 21. In this manner, electric fan 22 is configured which supplies the air current in the direction of rotary shaft 2.

Propeller fan for electric fan 1 according to the present exemplary embodiment has a blade shape which restrains the wind speed of extreme point air current 16 from being attenuated and which does not increase the rotational torque while maintaining a fast wind speed. In this manner, electric fan 22 can improve comfort of a user. Electric fan 22 can restrain power consumption of motor 21 from increasing. Therefore, electric fan 22 can contribute to

energy saving.

As described above, propeller fan for electric fan 1 according to the present exemplary embodiment includes hub 3 whose rotation center has rotary shaft 2, and a plurality of blades 4 arrayed around hub 3. In addition, in propeller fan for electric fan 1, solidity $\sigma=L/T$ configured to include blade chord length L of each of the blades 4 and inter-blade pitch T is set to 0.50 to 0.95, and hub ratio $D2/D1=0.2$ to 0.4 configured to include diameter D1 of blade 4 and diameter D2 of hub 3 is set. In addition, propeller fan 1 is configured to supply the air current in the direction of rotary shaft 2. In addition, the shape of blade 4 is a shape obtained by continuously connecting arc-shaped blade tip portion 5 located on the outermost periphery and blade root portion 6 in contact with the hub to each other. In addition, when a region of 0.65 to 0.85 times than R1 with respect to radius R1 from the center of rotary shaft 2 to blade tip portion 5 is set to blade intermediate portion 12, the curve shape of rear edge 8 when viewed from the meridional plane is a shape in which blade intermediate portion 12 includes axial extreme point 15 whose axial height is located on the most leeward side, and which gradually tilts to the windward side from axial extreme point 15 toward blade tip portion 5. In addition, the curve shape of rear edge 8 when viewed in the direction of rotary shaft 2 is a shape in which blade intermediate portion 12 includes rotational extreme point 13 located on the most rearward side in the rotation direction, and which gradually moves forward from rotational extreme point 13 toward blade tip portion 5. In addition, axial extreme point 15 and rotational extreme point 13 are aligned with each other.

In this manner, the air current first blows out to axial extreme point 15 and rotational extreme point 13 which are disposed in the blade intermediate portion, from the rear edge outside in the radial direction and inside in the

radial direction. Thereafter, the air current blows out from axial extreme point 15 and rotational extreme point 13. In this manner, the wind speed difference between the air currents on the inside and the outside is minimized. Accordingly, it is possible to restrain the wind speed attenuation. Therefore, a
5 user can enjoy a cool feeling, and comfort of the user can be improved. In addition, it is not necessary to widen the mounting angle of blade tip portion 5 in order to accelerate the wind speed of the air current. Accordingly, without increasing the rotational torque, it is possible to restrain power consumption of motor 21 from increasing. Therefore, the present invention can contribute to
10 energy saving.

In addition, in propeller fan for electric fan 1 according to the present exemplary embodiment, a radius from the center of rotary shaft 2 to blade root portion 6 is set to R_2 , and a line connecting midpoints of blade chords 9 at respective radial positions from radii R_2 to R_1 is set to blade chord center line
15 14. When viewed from the meridional plane, blade chord center line 14 and front edge 7 have a shape whose axial height gradually tilts to the windward side from blade intermediate portion 12 toward blade tip portion 5. In addition, when viewed in the direction of rotary shaft 2, blade chord center line 14 and front edge 7 have a shape which moves forward in the rotation direction
20 from blade intermediate portion 12 toward blade tip portion 5. In this manner, the shape of front edge 7 and the shape of blade chord center line 14 become similar to the shape of rear edge 8. Therefore, positive pressure surface 10 from blade intermediate portion 12 through blade tip portion 5 becomes a smooth surface having no irregularities. The mounting angle of blade tip
25 portion 5 becomes the same angle as the mounting angle of blade intermediate portion 12. Accordingly, when viewed in the direction of rotary shaft 2, all of the air currents flowing in blade intermediate portion 12 and blade tip portion

5 are parallel flows along the circumferential direction. In addition, with respect to a plane perpendicular to rotary shaft 2, an angle of the air current blowing out from rear edge 8 of blade intermediate portion 12 and an angle of the air current blowing out from rear edge 8 of blade tip portion 5 are the same as each other. Therefore, the flowing directions of the air currents can be aligned with each other. Therefore, an advantageous effect which is the same as the above-described one can be obtained.

In addition, electric fan 22 is equipped with propeller fan for electric fan 1 according to the present exemplary embodiment. In this manner, electric fan 22 can improve comfort of a user. Electric fan 22 can restrain power consumption of motor 21 from increasing. Therefore, electric fan 22 can contribute to energy saving.

INDUSTRIAL APPLICABILITY

A propeller fan for electric fan according to the present invention can efficiently supply an air current, and can restrain power consumption of a motor from increasing. Therefore, the propeller fan for electric fan is usefully used as an electric fan for directing an air current to a person so as to enable the person to enjoy a cool feeling, or a circulator for circulating indoor air.

REFERENCE MARKS IN THE DRAWINGS

- | | |
|---|--------------------|
| 1 | PROPELLER FAN |
| 2 | ROTARY SHAFT |
| 3 | HUB |
| 4 | BLADE |
| 5 | BLADE TIP PORTION |
| 6 | BLADE ROOT PORTION |

	7	FRONT EDGE
	8	REAR EDGE
	9	BLADE CHORD
	10	POSITIVE PRESSURE SURFACE
5	11	NEGATIVE PRESSURE SURFACE
	12	BLADE INTERMEDIATE PORTION
	13	ROTATIONAL EXTREME POINT
	14	BLADE CHORD CENTER LINE
	15	AXIAL EXTREME POINT
10	16	EXTREME POINT AIR CURRENT
	17	OUTSIDE AIR CURRENT
	18	INSIDE AIR CURRENT
	19	BLADE TIP VORTEX
	20	GUARD
15	21	MOTOR
	22	ELECTRIC FAN

CLAIMS

1. A propeller fan for electric fan comprising:
 - a hub whose rotation center has a rotary shaft; and
 - 5 a plurality of blades arrayed around the hub,wherein solidity $\sigma=L/T$ configured to include blade chord length L of each of the blades and inter-blade pitch T is set to 0.50 to 0.95,
 - wherein hub ratio $D2/D1=0.2$ to 0.4 configured to include diameter D1 of the blade and diameter D2 of the hub is set,
 - 10 wherein the propeller fan is configured to blow an air current in a direction of the rotary shaft,wherein a shape of the blade is a shape obtained by continuously connecting an arc-shaped blade tip portion located on an outermost periphery and a blade root portion in contact with the hub to each other,
 - 15 wherein when a region of 0.65 to 0.85 times than R1 with respect to radius R1 from a center of the rotary shaft to the blade tip portion is set to a blade intermediate portion, a curve shape of a rear edge when viewed from a meridional plane is a shape in which the blade intermediate portion includes an axial extreme point whose axial height is located on a most leeward side,
 - 20 and which gradually tilts to a windward side from the axial extreme point toward the blade tip portion,wherein a curve shape of the rear edge when viewed in the direction of the rotary shaft is a shape in which the blade intermediate portion includes a rotational extreme point located on a most rearward side in a rotation direction,
 - 25 and which gradually moves forward from the rotational extreme point toward the blade tip portion, andwherein the axial extreme point and the rotational extreme point are

aligned with each other.

2. The propeller fan for electric fan of Claim 1,

5 wherein if a radius from the center of the rotary shaft to the blade root portion is set to R2, and a line connecting midpoints of blade chords at respective radial positions from radii R2 to R1 is set to a blade chord center line, when viewed from the meridional plane, the blade chord center line and a front edge have a shape whose axial height gradually tilts to the windward side from the blade intermediate portion toward the blade tip portion, and

10 wherein when viewed in the direction of the rotary shaft, the blade chord center line and the front edge have a shape which moves forward in the rotation direction from the blade intermediate portion toward the blade tip portion.

15 3. An electric fan comprising:

the propeller fan for electric fan of Claim 1.