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DESCRIPTION

CENTRIFUGAL BLOWER AND METHOD OF FABRICATING THE SAME,
AND AIR CONDITIONING APPARATUS EQUIPPED
WITH THE CENTRIFUGAL BLOWER

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Technical Field

The present invention relates to a centrifugal
blower featuring a vaned structure and a method of
fabricating the same, and to an air conditioning apparatus
10 including the centrifugal blower.

Background Art

Generally, a centrifugal blower includes an
impeller consisting of a hub rotatably mounted around a
15 rotary shaft of a motor, a shroud disposed at a given
distance from and in opposed relation to the hub, and a
plurality of vanes extending between the outer periphery
of the hub and the outer periphery of the shroud and
arranged around and generally radially from the axis of
20 the hub. According to such arrangement, air currents
flowing from the front edge side of the vanes to the rear
edge side thereof are produced by rotation of the impeller.

Such a centrifugal blower has a suction port
provided at a portion forming the axis of the impeller so
25 that the air sucked through the suction port is blown

around the impeller from a blow-off port provided on the outer periphery of the impeller. Such a mode of air suction and blow off will match the mode of air circulation required of a room air conditioner and, more particularly, a ceiling embedded type or hanger type air conditioner (that is, an air circulation mode such that after room air sucked from a center portion of a room is conditioned, the conditioned air is blown out over the whole room area). Therefore, a centrifugal blower is often employed as a blower for room air conditioners.

In centrifugal blowers, the pressure difference between a pressure surface and a negative pressure surface in a vane which performs air supply work is larger as compared to the pressure differences in the case of other types of blowers, such as axial blowers. Therefore, as the impeller rotates, the pressure gradient at the rear edge portion is large enough to cause so much velocity loss in the air current flow in such a case that a high pressure air current flowing along the pressure surface side of the vane from the front edge of the vane toward the rear edge thereof and a low pressure air current flowing along the negative pressure surface side of the vane from the front edge of the vane toward the rear edge thereof meet with each other adjacent the rear edge of the vane, so that the joined air currents are equilibrated to a specified

pressure. Furthermore, in prior art centrifugal blowers, the rear edge configuration of a vane is generally such that the rear edge portion linearly extends widthwise of the vane; therefore, such velocity losses will simultaneously occur all over the whole area of the rear edge portion of the vane. As a result, there will occur a large turbulence in the air flow in the rear edge portion of the vane, which is a source of a comparatively large blast noise. Therefore, blast noise reduction has been highly required of centrifugal blowers and various means intended to meet this requirement have been proposed. In the current state of the art, however, none of the proposals for blast noise reduction have been found satisfactory. The requirement for such noise reduction is particularly high with respect to a room air conditioner including a centrifugal air conditioning blower which is to be set in a room.

Disclosure Of Invention

Therefore, it is an object of the present invention to provide a centrifugal blower of simple construction and low cost which provides for blast noise reduction.

It is another object of the invention to provide a noise reduced type air conditioning apparatus equipped

with the centrifugal blower.

It is another object of the invention to provide a suitable method of fabricating the centrifugal blower.

The centrifugal blower in accordance with the present invention includes an impeller having a hub rotatably mounted around a rotary shaft of a motor, a shroud disposed at a specified distance from the hub and in opposed relation thereto, the shroud being formed with a suction port at a portion defining the axis of the hub, and a plurality of vanes extending between the outer periphery of the hub and the outer periphery of the shroud and arranged generally radially around the axis of the hub, so that air currents flowing from the front edge side of the vanes toward the rear edge side of the vanes are produced by rotation of the impeller, the centrifugal blower characterised in that rear edges of the vanes have a saw teeth configuration zigzagged in the longitudinal direction of the vane and extending widthwise of the vane and the teeth of the saw teeth configuration are each designed to meet a condition of $0.005 < H/D < 0.015$ and a condition of $0.01 < S/D < 0.02$ in relation to an outer diameter "D" of the impeller, where "H" is tooth height and "S" is tooth pitch.

In the centrifugal blower, rear edge of each vane has a saw teeth shape with teeth zigzagged in the longitudinal direction of the vane and extending widthwise of the vane.

Therefore, in the rear edge portion a longer vane portion and a shorter vane portion exist in alternate relation, so that a combined air current flow resulting from the meeting of air current flowing along the pressure surface side with air current flowing along the negative pressure surface side is gradually performed stepwise over the entire length of the rear edge. Thus, for example, as compared to the prior art in which the rear edge portion is configured to extend in a linear fashion so that air currents meet simultaneously all over the rear edge portion of the vane, pressure gradient and velocity loss of air current due to meeting of air currents at the rear edge portion are reduced, with the result that air turbulence at the rear edge portion is restrained and air blast noise is reduced accordingly. That is, by a simple and less expensive arrangement such that the rear edge of the vane is configured to have a saw teeth shape it is possible to readily achieve blast noise reduction with respect to the centrifugal blower.

The teeth of the saw teeth configuration are designed to meet the condition of $0.005 < H/D < 0.015$ and the condition of $0.01 < S/D < 0.02$ in relation to the outer diameter "D" of the impeller, where "H" is tooth height and "S" is tooth pitch. By virtue of this arrangement it is possible to reduce air blast noise more efficiently and to facilitate noise attenuation further with respect to the centrifugal blower.

In the preferred embodiment, where the plurality of teeth which constitute the

saw teeth configuration are each configured to be of a practically triangular shape, the construction of the moulding tool is simplified as compared to the case in which the teeth are configured to have a complex polygonal shape, for example, and this provides a favourable effect such that cost reduction can be achieved so much in the fabrication of the centrifugal blower.

In the preferred embodiment, where tip portions of the plurality of teeth of triangular shape are each configured to have a planar or arcuate shape, the tip portions are less liable to damage due to cracking or the like as compared to the case in which the tip portions are sharp-edged, for example, and this provides for so much improvement in the durability of the centrifugal blower.

The present invention also provides a method of fabricating aforesaid centrifugal blower. In this method, an integrally moulded component comprising a hub and vanes as constituent parts of an impeller which are integrated together is first fabricated, and then a shroud moulded separately from the integrally moulded component is fixedly joined to ends of the vanes, the impeller being thus obtained.

The integrally moulded component is fabricated by carrying out the steps of:

preparing a first moulding die for moulding one of two side surfaces of the hub to which the vanes are to be

attached therealong and the two side surfaces of which are opposite from each other in thickness direction of the hub, a second molding die for molding the other side surface of the hub which is adapted to move toward and away from the first molding die, and a plurality of third molding dies placed in gaps between adjacent vanes so as to be back and forth movable in the longitudinal direction of the vanes, for forming a saw teeth configuration to be provided at least at the rear edge portion of each vane;

10 setting the first molding die, the second molding die, and the third molding dies at predetermined assembly positions respectively to pour molten material into a cavity formed among the molding dies; and

15 moving the first molding die and the second molding die apart from each other to carry out die releasing and moving respective third molding dies in the longitudinal direction of the vanes to carry out die releasing.

20 Unlike conventional fabricating method which employs only molding dies arranged in opposed relation to each other and designed to move toward and away from each other (for example, first molding die and second molding die) and does not enable die releasing (because the teeth extend in a direction perpendicular to the direction of die releasing) and which, therefore, does not enable

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forming of aforesaid saw teeth configuration, the present invention makes it possible to easily form aforesaid saw teeth configuration merely by changing the direction of die releasing with respect to third molding dies for forming of saw teeth configuration to the longitudinal direction of the vanes. Therefore, for example, as compared to the case in which, after the hub and vanes are separately molded, the former and the latter are combined to form an integrally molded component, the present invention makes it possible to easily fabricate aforesaid molded component, which in turn facilitates fabrication of aforesaid impeller and, in effect, makes it possible to provide a less expensive centrifugal blower.

Further, the present invention provides an air conditioning apparatus using the centrifugal blower as an air conditioning blower of the invention. According to the invention, the characteristic effect of the centrifugal blower, that is, high noise attenuation performance is reflected as it is in the operating performance of the air conditioning apparatus, it being thus possible to provide an air conditioning apparatus having high noise attenuation characteristic. Such noise attenuation effect is especially remarkable in case where the air conditioning apparatus is a room air conditioner to be set in a room.

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In accordance to the first aspect of the invention, there is provided a centrifugal blower which includes an impeller having a hub rotatably mounted around a rotary shaft of a motor, a shroud disposed at a specified distance from the hub and in opposed relation thereto, the shroud being formed with a suction port at a portion defining an axis of the hub, and a plurality of vanes extending between an outer periphery of the hub and an outer periphery of the shroud and arranged generally radially around the axis of the hub, so that air currents flowing from front edges of the vanes to rear edges of the vanes are produced by rotation of the impeller, characterized in that:

the rear edges of the vanes have a saw teeth configuration zigzagged in a longitudinal direction of the vane and extending widthwise of the vane and the teeth of the saw teeth configuration are each designed to meet a condition of $0.005 < H/D < 0.015$ and a condition of $0.01 < S/D < 0.02$ in relation to an outer diameter "D" of the impeller, where "H" is tooth height and "S" is tooth pitch.

In accordance to the second aspect of the invention, there is provided a method of fabricating a centrifugal blower which includes an impeller having a hub, a shroud disposed at a specified distance from the hub and in opposed relation thereto, and a plurality of vanes extending between an outer periphery of the hub and an outer periphery of the shroud, rear edges of the vanes having a saw teeth configuration zigzagged in a longitudinal direction of the vane and extending widthwise of the vane, characterized by the steps of:

preparing a first molding die for molding one of two side surfaces of the hub to which the vanes are to be attached therealong and the two side surfaces of which are opposite from each other in thickness direction of the hub, a second molding die for molding the other side surface of the hub which is adapted to move toward and away from the first molding die, and a plurality of third molding dies placed in gaps between adjacent vanes so as to be back and forth movable in a longitudinal direction of the vanes, for forming a saw teeth configuration to be provided at least at a rear edge of each vane;

setting the first molding die, the second molding die, and the third molding dies at predetermined assembly positions respectively so as to pour molten material into a cavity formed among the molding dies;

moving the first molding die and the second molding die apart from each other to carry out die releasing and moving respective third molding dies in the longitudinal direction of

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the vanes to carry out die releasing, so that an integrally molded component into which a hub and vanes are integrated is fabricated; and

fixedly joining the shroud molded separately from the integrally molded component to ends of the vanes in the integrally molded component, so that the impeller is obtained.

Brief Description Of Drawings

Fig. 1 is a perspective view of a centrifugal blower in accordance with the present invention;

5 Fig. 2 is a sectional view of an air conditioning apparatus equipped with the centrifugal blower shown in Fig. 1;

10 Fig. 3 is an enlarged view of a rear edge portion of a vane of the centrifugal blower shown in Fig. 1;

Fig. 4 is a section taken along lines IV-IV in Fig. 3;

Fig. 5 is an explanatory view for explaining the method of fabricating an impeller by die molding; and

15 Fig. 6 is a section taken along lines VI-VI in Fig. 5.

Best Mode for Carrying Out the Invention

20 The centrifugal blower of the present invention and method of fabricating the same, and air conditioning apparatus equipped with the centrifugal blower will now be explained in detail on the basis of the embodiments shown in the accompanying drawings.

25 Fig. 1 shows an impeller 10 of a centrifugal blower X embodying the present invention. Fig. 2 shows a

room air conditioner 2 including the centrifugal blower X.

As Figs. 1 and 2 show, the centrifugal blower X consists of a motor 19 and an impeller 10 to be driven to rotate by the motor 19. The impeller 10 includes a hub 11 consisting of a center portion 11a of generally conical shape, a flat plate-like flange 11b, and a mounting portion 11c rotatably mounted to a motor shaft 19a of the motor 19, a shroud 12 disposed a given distance apart from the hub 11 in opposed relation thereto and centrally formed with an air suction port 16, and a plurality of vanes 13 extending on the outer periphery of the hub 11, more specifically, between the outer periphery of the flange 11b and the outer periphery of the shroud 12, and radially arranged at circumferentially equal intervals. In the impeller 10, an air supply opening 17 is defined between the hub 11 and the outer periphery of the shroud 12, and an air flow path 18 is defined by a passage extending from the air suction port 16 to the air supply opening 17.

The hub 11 is a structure formed from a disc plate of a specified diameter by compression molding the disc plate thicknesswise thereof in the vicinity of the center of the disc plate and, as will be described hereinafter, the hub 11, together with vanes 13, is integrally formed by compression molding of resin material.

The shroud 12 is an annular structure having an arcuate sectional configuration and is formed by compression molding of resin material separately from the hub 11 and the like. After having been molded, the shroud 12 is fixedly joined to an integrally molded structure 15 consisting of the hub 11 and vanes 13 (see Figs. 5 and 6).

The vanes 13 are each a plate member having a curved streamline shape and are arranged radially in plurality (8 vanes in the present embodiment) across the space between the outer periphery of the hub 11 and the outer periphery of the shroud 12 and at circumferentially equal intervals. The vanes 13 are integrally molded with the hub 11 by compression molding of resin material.

The vane 13 has a most important characteristic feature in the construction of its rear edge 13b. In the present embodiment, as shown in Figs. 1 through 4, the rear edge 13b of vane 13 is configured, instead of being linear as in the past, to have a saw teeth shape 20 such that the rear edge 13b is alternately bent i.e. zigzagged in the longitudinal direction of the vane and extending widthwise of the vane. While in the present embodiment the saw teeth shape 20 consists of teeth 21 disposed in succession along the rear edge 13b, as Figs. 3 and 4 show, the shape of tooth is trapezoidal with its front end made to have a linear shape instead of a triangular shape, and

dimensions of tooth 21 are set to meet the condition of $0.005 < H/D < 0.015$ and the condition of $0.01 < S/D < 0.02$ in relation to the outer diameter "D" of the impeller 10, where "H" is tooth height and "S" is tooth pitch. In the
5 present embodiment, the tip portion 21a of tooth 21 is arcuate as shown in Fig. 4; but alternately, it may be planar.

Next, the method of fabricating the impeller 10 (that is, method of fabricating centrifugal blower X) will
10 be explained.

To make the impeller 10, as already mentioned, the hub 11 and vanes 13 are integrally molded (into an integrally molded member 15) from among component members of the impeller 10, namely, the hub 11, the shroud 12, and
15 a plurality of vanes 13. Whilst, the shroud 12 is molded separately from the integrally molded member 15. After these members having been molded, the shroud 10 is joined to the integrally molded member 15 (by deposition joining or adhesive jointing) into an integral structure. Such a
20 fabricating procedure is already known in the art.

However, in a conventional centrifugal blower, a rear edge of a vane is of a straight line shape. Therefore, fabrication of an integrally molded member by compression molding can be easily carried out by using a pair of
25 molding dies (for example, an upper die and a lower die)

disposed in opposed relation and adapted to be movable toward and away from each other. In the present embodiment, however, the rear edge 13b of the vane 13 has the saw teeth configuration 20; therefore, it is impossible to
5 form such an integrally molded structure 15 having vanes 13 and hub 11 integrally combined together by using the above mentioned molding dies, due to difficulty in die release operation of the saw teeth shape portion 20.

Therefore, in the present embodiment, the
10 fabricating method of the invention is employed in forming the integrally molded structure 15 by using three kinds of dies (that is, a lower die 31 and an upper die 32, and a plurality of cutting dies 33).

As shown in Figs. 5 and 6, the lower die 31 is a
15 molding die including a hub interior molding surface 31a for forming the surface on which the vanes 13 of the integrally molded structure 15 are arranged, a vane molding surface 31b for forming the front edge 13a of the vane 13, and a cutting die fitting portion 31c for
20 providing a space for insertion of a cutting die 33 to be described hereinafter. This lower die 31 corresponds to "first molding die" as defined in the accompanying claims.

The upper die 32 is a molding die including a
hub, exterior molding surface 32a for forming the surface
25 on which vanes 13 of the integrally molded structure 15

are not disposed. This upper die 32 corresponds to "second molding die" as defined in the accompanying claims.

5 The cutting die 33 is a molding die disposed between adjacent vanes 13 in the integrally molded structure 15 and includes a saw teeth forming surface 33a for forming the saw teeth configuration 20, and a vane forming surface 33b for forming the rear edge 13b side portion of the vane 13. This cutting die 33 corresponds to "third molding die" as defined in the accompanying claims.

10 The upper die 32 is disposed above the hub interior molding surface 31a of the lower die 31, with its hub exterior molding surface 32a oriented toward the lower die 31, the upper die 32 being enabled to move toward and away from the lower die 31 and in opposite directions.

15 Whilst, the cutting dies 33 are arranged so as to be positioned between the lower die 31 and the upper die 32 from a direction perpendicular to the direction in which the lower die 31 and the upper die 32 are positioned in opposed relation, and between adjacent vanes 13 in the integrally molded structure 15 to be molded by each

20 respective cutting die 33. By arranging molding dies 31, 32, 33 in this way a cavity for forming aforesaid integrally molded structure 15 is formed between these dies. Therefore, the aforesaid integrally molded structure

25 15 is formed by injecting molten resin material into the

cavity.

After the resin material injection and completion of molding operation, the molding dies 31, 32 33 are released. In this case, the upper die 32 is
5 released in a direction in which it is moved away from the lower die 31. Release of the cutting dies 33 is carried out by moving them laterally in the longitudinal direction of the vane 13. By carrying out such a molding method it is possible to readily obtain the integrally molded
10 structure 15 through compression molding despite the fact that each vane 13 is configured to have a saw teeth shape 20 at its rear edge portion 13b. After the integrally molded structure 15 having been formed, the shroud 12 is fixedly joined to the end 22 of each vane 13 to obtain the
15 impeller 10.

In the centrifugal blower X fabricated in such a manner as described above, the rear edge 13b of each vane 13 of the impeller 10 is configured to have a saw teeth shape 20. Therefore, when air blowing is carried out by
20 driving the motor 19 to rotate the impeller 10, the noise level of the air blowing is low as compared to that in the case of the prior art (i.e., the rear edge 13b of the vane 13 having a linear configuration), high noise attenuation effect being thus obtained.

25 The rear edge 13b of each vane 13 has a saw

teeth configuration 20 such that a longer vane portion and a shorter vane portion alternately exist in the rear edge 13b. Therefore, a combined air current flow resulting from meeting at the rear edge 13b of air current flowing along the pressure surface side of the vane 13 with air current flowing along the negative pressure surface side gradually takes place stepwise over the entire length of the rear edge 13b. As a consequence, pressure gradient and velocity loss of air current are reduced due to the meeting of air currents at the rear edge 13b, and air current turbulence at the rear edge 13b is restrained so much, with the result that air blast noise is reduced accordingly.

Further, as in the present embodiment, by setting dimensions of each tooth 21 in the saw teeth configuration 20 to meet the condition of " $0.005 < H/D < 0.015$ " and the condition of " $0.01 < S/D < 0.02$ " in relation to the outer diameter "D" of the impeller 10, where tooth height is designated by "H" and tooth pitch is designated by "S", it is possible to reduce the noise of air blowing more effectively, thereby further enhancing the attenuation of air blowing noise from the centrifugal blower.

Whilst, as Fig. 2 illustrates, in the aforesaid room air conditioner Z including the centrifugal blower X of above described construction, the characteristic effect

of the centrifugal blower X, that is, aforesaid noise attenuation performance, is reflected as it is in the operating performance of the room air conditioner Z. Thus, in effect, by using the centrifugal blower X it is possible to provide a room air conditioner Z having high noise attenuation performance.

The construction of the room air conditioner Z is briefly explained as follows. The room air conditioner Z includes the centrifugal blower X disposed centrally in an air passage 4 in a casing 1, and heat exchanger 5 arranged around the centrifugal blower X. In Fig. 2, numeral 2 designates a suction port corresponding to an air blowing port 16 of the centrifugal blower X. A bell mouth 8 is disposed in the suction port 2, and beneath the bell mouth 8 there is mounted a suction grill 6 having a filter 7. On the outer periphery of the suction grill 6 there is formed an air blowing port 3 confronting the downstream side of the heat exchanger 5.

In the room air conditioner Z, as the centrifugal air conditioner X is driven to operate, indoor air sucked through the suction port 2 is blown from an air blowing port 17 of the centrifugal blower X toward the heat exchanger 5. The air so blown exchanges heat with a refrigerant circulating through the heat exchanger 5 while the air passes through the heat exchanger 5, and is then

blown from the air blowing port 3 into a room to heat or cool the room.

Industrial Applicability

5 The centrifugal blower of the present invention can be utilized as a blower for air conditioning apparatus and can also be used in various application areas for fluid transportation. The air conditioning apparatus of the invention which is equipped with the centrifugal
10 blower can be utilized as a built-in ceiling fixture type or ceiling-mounted hanger type air conditioner for use in various types of buildings.

The claims defining the invention are as follows:

1. A centrifugal blower which includes an impeller having a hub rotatably mounted around a rotary shaft of a motor, a shroud disposed at a specified distance from the hub and in opposed relation thereto, the shroud being formed with a suction port at a portion defining an axis of the hub, and a plurality of vanes extending between an outer periphery of the hub and an outer periphery of the shroud and arranged generally radially around the axis of the hub, so that air currents flowing from front edges of the vanes to rear edges of the vanes are produced by rotation of the impeller, characterized in that:

the rear edges of the vanes have a saw teeth configuration zigzagged in a longitudinal direction of the vane and extending widthwise of the vane and the teeth of the saw teeth configuration are each designed to meet a condition of $0.005 < H/D < 0.015$ and a condition of $0.01 < S/D < 0.02$ in relation to an outer diameter "D" of the impeller, where "H" is tooth height and "S" is tooth pitch.

2. A centrifugal blower as set forth in claim 1, wherein a plurality of teeth which constitute the saw teeth configuration are each configured to be of a practically triangular shape.

3. A centrifugal blower as set forth in claim 2, wherein tip portions of the teeth are each configured to have a planar or arcuate shape.

4. A method of fabricating a centrifugal blower which includes an impeller having a hub, a shroud disposed at a specified distance from the hub and in opposed relation thereto, and a plurality of vanes extending between an outer periphery of the hub and an outer periphery of the shroud, rear edges of the vanes having a saw teeth configuration zigzagged in a longitudinal direction of the vane and extending widthwise of the vane, characterized by the steps of:

preparing a first moulding die for moulding one of two side surfaces of the hub to which the vanes are to be attached therealong and the two side surfaces of which are opposite from each other in thickness direction of the hub, a second moulding die for moulding the other side surface of the hub which is adapted to move toward and away from the first moulding die, and a plurality of third moulding dies placed in gaps between adjacent vanes so as to be back and forth movable in a longitudinal direction of the vanes, for forming a saw teeth configuration to be provided at least at a rear edge of each vane;

setting the first moulding die, the second moulding die, and the third moulding dies at predetermined assembly positions respectively so as to pour molten material into a cavity formed among the moulding dies;

moving the first moulding die and the second moulding die apart from each other to carry out die releasing and moving respective third moulding dies in the longitudinal direction of the vanes to carry out die releasing, so that an integrally moulded component into which a hub and vanes are integrated is fabricated; and

fixedly joining the shroud moulded separately from the integrally moulded component to ends of the vanes in the integrally moulded component, so that the impeller is obtained.

5. An air conditioner characterized by the centrifugal blower according to any one of claims 1 to 3 and a heat exchanger which are disposed in an air passage formed in a casing.