

FLUID IMPELLER

This invention relates to mixed flow fans such as fans for moving air or other gases.

Various motor-driven fan configurations have been proposed to meet respective different requirements for performance, noise generation, cost and so on.

Figures 1 and 2 show schematic end and cut-away side views respectively of an axial flow fan. The impeller comprises a number of aerofoil blades 10 mounted on a central hub 20, which is generally enclosed within a stationary cowling 30. The impeller is driven by a motor 40, and air is driven by the impeller in a direction 50 which is substantially along the axis of rotation of the fan blade assembly.

Axial flow fans provide large volume flow rates of air, but operate at relatively low pressures. As the pressure increases, the fan is liable to stall.

Figures 3 and 4 of the accompanying drawings show schematic end and cut-away side views of a centrifugal fan. This type of fan comprises blades 60 mounted on a rotating hub 70 driven by a motor 80 the fan has a casing 90 which allows air to enter generally along the axis of rotation of the blade assembly but to exit perpendicular to the entry direction.

In the centrifugal fan, air is forced to rotate by movement of the blades 60 and is flung outwards towards the exit port 100 by the centrifugal effect. Centrifugal fans are recognised for a low volume but high pressure performance, generally without the stalling problems exhibited by axial flow fans. However, the fans are generally not suitable for use with large volume flow rates.

The so-called mix flow fan was developed as a compromise between the axial and centrifugal techniques, to operate at generally higher pressures than an axial flow fan, but provide a generally greater volume flow rate than a centrifugal fan. Figures 5 and 6 are schematic end and cut-away side views respectively of a mixed flow fan.

The mixed flow fan comprises a number of blades 110 attached to a central frusto-conical hub 120 and to a generally frusto-conical shroud 130. The blades 110, hub 120, and shroud 130 form a complete rotating assembly, driven by a motor 140.

In operation, the fan behaves as a combination of the axial and centrifugal flow devices, so that air entering the shroud 130 is drawn into the impeller, with a velocity component along the axis of rotation, but is also driven outwards in a similar manner to the centrifugal fan, with a velocity component perpendicular to the axis of rotation. These two velocity components combine to give an output direction 150 illustrated in Figure 6.

Figure 7 is a schematic pressure-volume flow rate performance graph for the fans of Figures 1 to 6.

In Figure 7, a schematic curve 160 represents the high-pressure, low volume performance of a centrifugal flow fan. A schematic curve 170 represents the high-volume, low-pressure operation of an axial flow fan. (The stalling characteristic of the axial flow fan is not shown on Figure 7, but is very well described elsewhere).

Finally, a schematic curve 180 shows the performance of a mixed flow fan, which provides a generally higher volume but lower pressure performance in comparison to the centrifugal fan, and a higher pressure but lower volume performance in comparison to the axial flow fan.

Each of the performance curves shown schematically in Figure 7 relates to a particular fan configuration

(fan diameter, number of blades and angle of blades) and rotation speed of the blade assembly. Once these fan characteristics have been set, the fan performance is generally fixed, so that, for example, if the pressure is specified for the fan, the resulting volume flow-rate which will be obtained is defined by the performance curve.

However, it is desirable in manufacturing and installing these fans to be able to vary the performance of the fans. This allows a manufacturer to market a range of fans having different performance curves, but sharing some or all of their components in common.

In the case of an axial flow fan, it is relatively easy to vary the fan's performance while still using the same mechanical components. For example, the blade angle of incidence can be varied to give dramatic changes in the performance characteristics. In one example, a change in blade angle of incidence from, say, 10° to 40° could result in 2:1 change in volume flow rate (and a correspondingly large change in driving power consumption).

However, in the centrifugal and mixed flow fans described above, there is little scope for changing the fan's performance. The number of blades can be varied, but this tends to give dramatic, rather than gradual, changes in performance. The motor speed could be varied, but this requires either a belt drive system, which adds to the mechanical complexity of the fan, or the use of different motors, such as two-pole, four-pole, six-pole motors etc. Again however, since the rotation speed of a two-pole motor is twice that of a four-pole motor, this again leads to dramatic, rather than gradual, variations in the fan's performance.

In summary, none of the previously proposed fans described above provide relatively high pressure operation and allow the fan performance to be varied easily.

This invention provides a mixed flow fan comprising:

one or more rotatable fluid impelling blades; and
a hub adjacent to an edge of the blades, at least a blade facing surface of the hub being formed substantially as a segment of a sphere of radius r_1 about a centre of curvature;

a shroud adjacent to an outer edge of each blade, at least a blade facing surface of the shroud being formed substantially as a segment of a sphere of radius r_2 about the centre of curvature;

in which each blade has a hub abutting edge curved substantially to fit against a sphere of radius r_1 and a shroud abutting edge curved substantially to fit against a sphere of radius r_2 so that each blade is attachable to the hub and the shroud at various angles about an axis passing through the centre of curvature while the hub abutting and shroud abutting edges of the blade remain substantially abutting the hub and the shroud respectively.

In embodiments of a mixed flow fan according to the invention, the performance characteristics of a mixed flow fan can be obtained, while allowing the performance to be varied easily by changing the blade angle of incidence. Because the hub and/or shroud surfaces are based on segments or sections of spherical surfaces, a blade having a complementary shape at each end can be fixed at different angles between the two surfaces.

For ease of adjustment of the fan characteristics, it is preferred that each blade is pivotable about a respective mounting point on the flow guiding member. In particular, it is also preferred that each blade is pivotable about a respective mounting point on the hub and on the shroud, the mounting points on the shroud and the hub lying substantially on an axis of curvature of the hub and the shroud.

An embodiment of the invention will now be described, by way of example only, with reference to the accompanying drawings throughout which like parts are

referred to by like references, and in which:

FIGURE 1 is a schematic end view of an axial flow fan;

FIGURE 2 is a schematic cutaway side view of the fan of Figure 1;

FIGURE 3 is a schematic end view of a centrifugal fan;

FIGURE 4 is a schematic cutaway side view of the fan of Figure 3;

FIGURE 5 is a schematic end view of a mixed flow fan;

FIGURE 6 is a schematic cutaway side view of the fan of Figure 5;

FIGURE 7 is a schematic pressure-volume performance graph for the fans of Figures 1 to 6;

FIGURE 8 is a schematic side view of a fan according to an embodiment of the invention; and

FIGURE 9 is a schematic sectional side view of a fan blade for the fan of Figure 8.

Figures 1 to 7 of the above drawings have been described above.

Referring now to Figure 8, a fan according to an embodiment of the invention comprises a number of blades 200 held between a rotating hub 210 and a rotating shroud 220, so that the hub, blades and shroud form a single rotating assembly. The rotating assembly is driven by a motor 230, coupled to the hub 210 via a bracket 240.

The fan operates as the mixed flow fan described above, so that air enters in a generally axial direction 250 at an entrance of the shroud 220, and is driven axially and outwardly by the rotating blades 200 to emerge in an exit direction 260.

The blade angle can be easily adjusted in the fan of Figure 8. This is because the hub 210, or at least that part 270 which contacts the blades 200, forms part of the surface of a sphere centred around a point 280. The edge 290 of each blade 200 which mates against the hub 210 is

arranged to fit against the spherical surface of the hub, in this example, it is a segment of a circle centred on the point 280. The inner surface of the shroud 220, or at least the part 300 which contacts the blades 200, forms part of a sphere centred around the point 280. Finally, the outer edge 310 of each blade is again arranged to fit against the spherical surface of the shroud, and in this example forms a segment of a circle centred around the point 280.

In fact, at least a part of each of the hub and the shroud in this embodiment is frusto-spherical in shape.

Each blade is attached to the hub 210 and to the shroud 220 by pivotable attachment points 320, such as nut and bolt connections. The attachment points 320 are arranged so that for each blade, the two attachment points 320 (one of each end of the blade) lie on a single axis 330 centred on the point 280.

In order to explain how this arrangements allows the blades to be positioned at different blade angles, it is first noted that a circular disc of radius r can be positioned at any orientation within a sphere of inside radius r . Whatever the orientation of the disc within the sphere, however, the centre of the disc will lie at the centre of the sphere. Now, in Figure 8, each blade 200 could be considered as a segment of the disc, and the inside surface of the shroud 220 could be considered as a part of the inside surface of the sphere referred to above. This means that the outer edge of the blade 200 can be placed at any angle to the inside surface of the shroud 220, so long as the centre of curvature of the shroud 220 and the outer edge of the blade 200 remains at the common point 280. This is in fact ensured by providing the pivot points 320 on the axis 330 passing through the point 280. Accordingly, the blades 200 can be pivoted around the pivotable attachment points 320 at various angles, but the outer edge 310 of the blade 200 will remain in contact with the inner surface of the shroud 220.

This argument can easily be extended to show that the blade angle can be varied while the inner edge of each blade 200 remains in contact with the outer surface of the hub 210.

Figure 9 is a schematic sectional side view of a fan blade 200 for the fan of Figure 8.

Although the pivot points 320 about which each blade is pivotable for blade angle adjustment should lie on an axis 330 from the common central point 280, it is not in fact necessary for the pivot points to coincide with the part-circular edges of the blade 200. In fact, the blade 200 could pivot around displaced pivot points 340, (e.g. connected to the blades 200 by mounting plates 350). This allows easier access to the nut and bolt connection of the pivotable mounting.

The blade of Figure 9 is shown having a flat cross-section, but it will be appreciated that the blade could be twisted to give an aero-dynamic shape using known design techniques.

The embodiment of Figure 8 shows air which is driven by the fan emerging at the motor end of the fan. Similarly, the motor 230 need not be directly attached to the hub 210, but could drive via a belt or gear arrangement. Various different numbers of blades could be used, depending on the application of the fan.

Other possible modifications include the possibility that the blades need not be pivotally mounted with respect to the hub or the shroud. In fact, the blades could be fixed in place (e.g. by welding or brazing) at the time of manufacture. The advantage still remains, however, that the fan manufacturer can stock a single pattern of blade and use it to produce fans of a variety of blade angles.



CLAIMS:

1. A mixed flow fan comprising:
one or more fluid impelling blades; and
a hub adjacent to an edge of the blades, at least a blade facing surface of the hub being formed substantially as a segment of a sphere of radius r_1 about a centre of curvature;
a shroud adjacent to an outer edge of each blade, at least a blade facing surface of the shroud being formed substantially as a segment of a sphere of radius r_2 about the centre of curvature;
in which each blade has a hub abutting edge curved substantially to fit against a sphere of radius r_1 and a shroud abutting edge curved substantially to fit against a sphere of radius r_2 so that each blade is attachable to the hub and to the shroud at various angles about an axis passing through the centre of curvature while the hub abutting and shroud-abutting edges of the blade remain substantially abutting the hub and the shroud respectively, the hub shroud and blades forming a single rotatable assembly.
2. A fan according to Claim 1 in which the hub abutting edge of each blade is curved about the centre of curvature with a radius substantially equal to r_1 .
3. A fan according to Claim 1 or Claim 2, in which each blade is pivotable about a respective mounting point on the hub.
4. A fan according to any one of Claims 1 to 3 in which each blade is pivotable about a respective mounting point on the shroud.
5. A fan according to Claim 3 and Claim 4, in which the mounting points on the shroud and the hub lie substantially on an axis passing through the centre of curvature of the hub and the shroud.



6. A fan according to any one of the preceding Claims, comprising drive means for rotatably driving at least the blades.

7. A fan according to Claim 6, in which the drive means comprises a motor.

8. A fan according to any one of the preceding Claims in which at least a part of the hub is frusto-spherical in shape.

9. A fan according to any one of the preceding Claims in which at least a part of the shroud is frusto-spherical in shape.