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"Fan diffuser having a circular inlet and a rotationally asymmetrical outlet"

The invention relates to a diffuser for a fan of axial, radial or diagonal type of construction~~, having an inlet opening and having an outlet opening for a gaseous medium which flows through a diffuser interior, which is enclosed by an outer housing, in an axially oriented main flow direction from the inlet opening to the outlet opening, wherein the cross section of the outlet opening is larger than the cross section of the inlet opening, and the cross section of the diffuser interior increases from the cross section of the inlet opening to the cross section of the outlet opening, wherein the outer housing forms an outer diffuser part which delimits the diffuser interior to the outside~~. The invention also relates to an outer diffuser part or an inner diffuser part for a diffuser and to a fan arrangement which comprises a fan and a diffuser of said type.

The principle of a diffuser and also the use thereof downstream of a turbomachine have been known for decades. Diffusers are utilized in technical terms to convert kinetic energy into pressure energy. For this purpose, the flow must be decelerated. This is generally achieved by means of a continuous or discontinuous increase in size of the flow cross section, which may be realized geometrically in a variety of ways. In fan engineering, diffusers may be used to slow gas flows and increase the gas pressure. Here, in principle, a diffuser constitutes the inverse of a nozzle in that, by contrast to the nozzle, the cross section of the outlet opening is larger than the cross section of the inlet opening, and the cross

embodiments of the first and second diffusion zones are provided for the diffuser, but these require a relatively high outlay in terms of manufacture.

In the case of the embodiment described in EP 0 581 978 A1 as being preferable, the known diffuser is situated in an exhaust-gas housing of a gas turbine, which exhaust-gas housing is designed such that it does not come into contact with the exhaust-gas flow. The actual flow guidance is performed by the diffuser which, in its first zone, is designed as an insert part for the exhaust-gas housing. For this purpose, an outer delimiting wall and an inner delimiting wall of the diffuser are held by means of flow ribs. The outer delimiting wall, which delimits the cross section of the diffuser interior to the outside, forms an outer housing of the diffuser, and the inner delimiting wall, which delimits the cross section of the diffuser interior to the inside, forms an inner housing. The diffuser can thus be considered as being composed of an outer diffuser part, which delimits the flow space to the outside, and an inner diffuser part, which delimits the flow space to the inside.

It is desirable, therefore, to provide~~the object of the invention to design~~ a diffuser, an outer diffuser part and/or an inner diffuser part for a diffuser and a fan arrangement of known type such that improvements in the operating behavior of an axial, diagonal or radial fan with regard to efficiency and noise can be attained with little outlay in terms of construction.

Such an advantage may be able to be~~Said object is~~ achieved, according to embodiments of the invention described herein, in that, along the main flow direction, the cross section of the outer diffuser part changes from a circular cross section at the inlet opening to a non-circular cross section at the outlet opening. Alternatively, in the case of a generic diffuser in which, in addition,

an inner diffuser part is arranged concentrically with respect to the outer diffuser part in a known way, and which has a housing which, as an inner housing, delimits the diffuser interior to the inside, such an advantage may be able to be~~the object on which the invention is based is~~ achieved by providing an~~in that the~~ inner diffuser part having~~has~~, in at least one section perpendicular to the main flow direction, a non-circular cross section about the axis of rotation of the fan.

In accordance with a first aspect of the invention, there is provided a fan arrangement comprising a diffuser and a fan of axial, radial or diagonal type of construction, wherein the diffusor is fastened to at least one static part of the fan by fastening means or by means of frictionally locking or positively locking connections, or the static part and the diffusor are formed as a single component, wherein the diffusor comprises an inlet opening and an outlet opening for a gaseous medium which flows through a diffuser interior, which is enclosed by an outer housing, in an axially oriented main flow direction from the inlet opening to the outlet opening, wherein the diffusor is located downstream the fan with regard to the main flow direction, wherein for conversion of dynamic pressure into static pressure the cross section of the outlet opening is larger than the cross section of the inlet opening, and the cross section of the diffuser interior increases from the cross section of the inlet opening to the cross section of the outlet opening, wherein the outer housing forms an outer diffuser part which delimits the diffuser interior to the outside, wherein along the main flow direction, the cross section of the outer diffuser part changes from a circular cross section at the inlet opening to a non-circular cross section at the outlet opening, characterized in that concentrically with respect to the outer diffuser part,

there is arranged an inner diffuser part which, with an inner housing, delimits the diffuser interior to the inside, wherein the inner diffuser part has, in at least one section perpendicular to the main flow direction, a non-circular cross section about the longitudinal axis of the inner diffuser part.

In accordance with a second aspect of the invention, there is provided a fan arrangement comprising a diffuser and a fan of axial, radial or diagonal type of construction, wherein the diffusor is fastened to at least one static part of the fan by fastening means or by means of frictionally locking or positively locking connections, or the static part and the diffusor are formed as a single component, wherein the diffusor comprises an inlet opening and an outlet opening for a gaseous medium which flows through a diffuser interior, which is enclosed by an outer housing, in an axially oriented main flow direction from the inlet opening to the outlet opening, wherein the diffusor is located downstream the fan with regard to the main flow direction, wherein for conversion of dynamic pressure into static pressure the cross section of the outlet opening is larger than the cross section of the inlet opening, and the cross section of the diffuser interior increases from the cross section of the inlet opening to the cross section of the outlet opening, wherein the outer housing forms an outer diffuser part which delimits the diffuser interior to the outside, characterized in that, concentrically with respect to the outer diffuser part, there is arranged an inner diffuser part which, with an inner housing, delimits the diffuser interior to the inside, wherein the outer diffuser part and/or the inner diffuser part are/is designed such that the cross section of the diffuser interior is non-rotationally symmetrical at at least one point.

~~In a way which is essential to the invention,~~ T~~t~~herefore, in accordance with present teachings there may on the one hand be provided an outer diffuser part for a fan of axial, radial or diagonal type of construction, which outer diffuser part changes, substantially along the main flow direction, from a circular to a non-circular cross section, wherein an inner diffuser part of arbitrary design is provided. On the other hand, there may also be provided in the diffuser an inner diffuser part which, in at least one section, has a non-circular cross section about the axis of rotation of the fan, wherein an outer diffuser part of arbitrary design is provided. The non-circular cross section may be in particular one which is of polygonal, in particular square, basic shape. Here, the invention encompasses the corresponding design of the outer diffuser part and/or of the inner diffuser part.

As in the case of known diffusers positioned downstream of a fan, a diffuser according to the invention effects a pressure conversion from dynamic pressure into static pressure. Here, the speed of the fluid is reduced and homogenized. Whereas a known diffuser designed so as to be fully rotationally symmetrical with respect to the axis of rotation of the fan converts the speed predominantly in an axial direction - that is to say the axial component of the speed vector - into static pressure, and with assumed swirl constancy reduces the

circumferential component of the speed only to the extent by which the diameter increases, a diffuser according to the invention additionally converts a part of the circumferential speed of the gas into static pressure, because the non-rotationally symmetrical geometry impedes a movement in a circumferential direction. As a result, the diffuser efficiency advantageously increases.

A diffuser having ~~The diffuser according to the invention, which has~~ a not completely rotationally symmetrical flow cross section as a result of the design of its outer diffuser part and/or inner diffuser part, may also offer~~s~~ a further advantage. The maximum installation space available for a diffuser is, in terminal equipment, normally prismatic, and a maximum width, a maximum height and a maximum length are defined by the product. Under these conditions, as a result of the corners present for example in the case of a polygonal, in particular square, cross section, it is possible with a diffuser according to the invention to utilize a larger surface area normal to the axis of rotation of the fan, and thus permit a greater reconversion of the axial speed, by comparison with a completely rotationally symmetrical diffuser. This, too, increases the diffuser efficiency.

Also, ~~in the case of a diffuser according to the invention,~~ owing to the possible utilization of the corners, and without the defined installation space boundaries being crossed, the cross section of the outlet opening has an equivalent radius greater than that of a completely rotationally symmetrical diffuser and can thus achieve an increased pressure reconversion from the circumferential speed. Here, an equivalent radius is to be understood to mean the radius of a circle which has the same surface area as the non-

circular diffuser surface. Twice the equivalent radius is also referred to as the hydraulic diameter.

A diffuser as described hereinaccording to the invention may advantageously be used together with an axial, radial or diagonal fan operated in particular by means of an electric external-rotor motor, without a follow-up guide wheel having to be provided here.

Here, the overall construction of a fan arrangement with a fan and with a diffuser as described hereinaccording to the invention may be of single-part or two-part form. A single-part construction is to be understood here to mean that a static component of the fan, in particular a wall ring, and the entire diffuser - that is to say the inner and/or the outer diffuser part - are formed as a single component. In this way, the wall ring of the fan becomes a constituent part of the diffuser.

A two-part construction is to be understood to mean that the diffuser as described hereinaccording to the invention is formed as a component which is separate from the static components of the fan - that is to say as a separate component - wherein said diffuser however can be or is fastened to the static parts of the fan, in particular to the wall ring or to a protective grille, by fastening means such as screws, rivets, clamps etc., or by means of non-positively locking, positively locking and/or cohesive connections, such as by means of a bayonet lock, by means of a clip connection, by means of a welded connection or the like. Here, it is advantageously also possible for a diffuser according to the invention to be designed so as to be suitable for retroactive mounting on an already-installed fan.

Furthermore, in the case of such a two-part construction of an arrangement, it is also possible for the fan itself to be of multi-part construction, which

is to be understood to mean that it may also be composed of multiple individual diffuser parts which can be or are connected to one another via fastening means or connections as mentioned above. Here, the diffuser parts which can be assembled in this way at the location of use may be designed in a logistically advantageous manner, such that they can for example be stacked, thus reducing the transport volume. In this way, it is possible for the diffuser geometry, in particular the diffuser length, to be varied according to the requirements through the omission or exchange of individual diffuser parts.

Further advantageous embodiments of the invention will emerge from the subclaims and the following description. Embodiments of the~~The~~ invention will be explained in more detail on the basis of a plurality of exemplary embodiments illustrated in the appended figures of the drawing, in which:

figure 1 shows, in a longitudinal section, a diagrammatic illustration of a fan arrangement composed of a fan and a diffuser, in which fan arrangement a diffuser according to an embodiment of the invention is or can be used,

figure 2 shows a perspective view of a gas outlet side of a preferred embodiment of a diffuser according to an embodiment of the invention,

figure 3 shows a perspective view of a gas inlet side of the preferred embodiment of a diffuser according to an embodiment of the invention illustrated in figure 2,

figure 4 shows a fan arrangement according to an embodiment of the invention in a perspective sectional view,

figure 5 shows a perspective view similar to figure 2,

figure 6 shows a perspective view similar to figure 3,

figure 7 shows a graphic illustration of a preferred dependency of a ratio of the cross-sectional area of the diffuser on the gas outlet side to the cross-sectional area of the diffuser on the gas inlet side on a ratio of the length of the diffuser to an outer diameter of the inlet opening of the diffuser,

figure 8 shows a graphic illustration of a preferred dependency of a ratio of the hydraulic diameter to the length of the diffuser on a ratio of the length of the diffuser to an outer diameter of the inlet opening of the diffuser,

figure 9 shows a perspective view of a preferred embodiment of an outer or inner diffuser part according to an embodiment of the invention,

figure 10a / figure 10b and figure 11a / 11b show in each case an axial and a radial half-section of two preferred embodiments of an outer diffuser part according to an embodiment of the invention in a fan arrangement according to the invention,

figure 12a / figure 12b to figure 15a / 15b show in each case an axial and a radial half-section of four preferred embodiments of an inner diffuser part according to an embodiment of the

invention in a fan arrangement according to the invention,

figure 16a / figure 16b and figure 17a / 17b show in each case an axial and a radial half-section of two preferred embodiments of combinations of outer and inner diffuser parts according to the invention in a fan arrangement according to an embodiment of the invention, wherein the outer diffuser part is in each case shortened,

figure 18a / figure 18b and figure 19a / 19b show in each case an axial and a radial half-section of two preferred embodiments of combinations of outer and inner diffuser parts according to an embodiment of the invention in a fan arrangement according to the invention,

figure 20a / figure 20b and figure 21a / 21b show in each case an axial and a radial half-section of two preferred embodiments of combinations of outer and inner diffuser parts according to the invention in a fan arrangement according to an embodiment of the invention, wherein the inner diffuser parts are shortened,

figure 22a shows an axial half-section of a fan arrangement according to an embodiment of the invention with a centrifugal fan,

figure 22b shows an axial half-section of a fan arrangement according to an embodiment of the invention with a diagonal fan,

figure 23a / figure 23b

show in each case an axial and a radial half-section of a fan arrangement according to an embodiment of the invention as in figure 12a / 12b, having an inner diffuser part, wherein the outlet surface is highlighted.

With regard to the following description, it is expressly stated that the invention is not restricted to the exemplary embodiments, and is also not restricted to all or several features of described combinations of features; rather, each individual sub-feature of the exemplary embodiment may also have independent inventive significance separately from all of the other sub-features described in connection therewith.

In the figures of the drawing, the same parts are also always denoted by the same reference signs, such that said parts will generally also be described in each case only once.

As can be seen initially from the illustration of figure 1, a fan arrangement 1 according to the invention comprises a fan 2, for example of axial type of construction as illustrated, and a diffuser 3 which - though not readily apparent from the schematic illustration - is or at least may be designed according to the invention, as shown in an exemplary manner in figures 2 and 3 for a diffuser 3 according to the invention and as shown in more detail in figure 4 for the arrangement 1 according to the invention. The fan 2, which may alternatively also be a fan of radial or diagonal type of construction, is operated by means of a motor 4 and is fastened via a wall ring 5 to a support base 6, such as a wall.

Figures 2 and 3 and also figures 5 and 6 show that a diffuser 3 according to the invention has an inlet

Claims

1. A fan arrangement ~~(1)~~ comprising a diffuser ~~(3)~~ and a fan ~~(2)~~ of axial, radial or diagonal type of construction, wherein the diffusor ~~(3)~~ is fastened to at least one static part of the fan by fastening means or by means of frictionally locking or positively locking connections, or the static part and the diffusor ~~(3)~~ are formed as a single component, wherein the diffusor ~~(3)~~ comprises an inlet opening ~~(10)~~ and an outlet opening ~~(20)~~ for a gaseous medium which flows through a diffuser interior ~~(I)~~, which is enclosed by an outer housing ~~(30)~~, in an axially oriented main flow direction ~~(S)~~ from the inlet opening ~~(10)~~ to the outlet opening ~~(20)~~, wherein the diffusor ~~(3)~~ is located downstream the fan ~~(2)~~ with regard to the main flow direction ~~(S)~~, wherein for conversion of dynamic pressure into static pressure the cross section ~~(21)~~ of the outlet opening ~~(20)~~ is larger than the cross section ~~(11)~~ of the inlet opening ~~(10)~~, and the cross section of the diffuser interior ~~(I)~~ increases from the cross section ~~(11)~~ of the inlet opening to the cross section ~~(21)~~ of the outlet opening ~~(20)~~, wherein the outer housing ~~(30)~~ forms an outer diffuser part ~~(AD)~~ which delimits the diffuser interior ~~(I)~~ to the outside, wherein
along the main flow direction ~~(S)~~, the cross section of the outer diffuser part ~~(AD)~~ changes from a circular cross section ~~(31)~~ at the inlet opening ~~(10)~~ to a non-circular cross section ~~(32)~~ at the outlet opening ~~(20)~~,
characterized in that
concentrically with respect to the outer diffuser part ~~(AD)~~, there is arranged an inner diffuser part ~~(ID)~~ which, with an inner housing ~~(40)~~,

delimits the diffuser interior ~~(I)~~ to the inside, wherein

the inner diffuser part ~~(ID)~~ has, in at least one section perpendicular to the main flow direction ~~(S)~~, a non-circular cross section ~~(42)~~ about the longitudinal axis ~~(X-X)~~ of the inner diffuser part ~~(ID)~~.

2. A fan arrangement ~~(1)~~ comprising a diffuser ~~(3)~~ and a fan ~~(2)~~ of axial, radial or diagonal type of construction, wherein the diffusor ~~(3)~~ is fastened to at least one static part of the fan by fastening means or by means of frictionally locking or positively locking connections, or the static part and the diffusor ~~(3)~~ are formed as a single component, wherein the diffusor ~~(3)~~ comprises an inlet opening ~~(10)~~ and an outlet opening ~~(20)~~ for a gaseous medium which flows through a diffuser interior ~~(I)~~, which is enclosed by an outer housing ~~(30)~~, in an axially oriented main flow direction ~~(S)~~ from the inlet opening ~~(10)~~ to the outlet opening ~~(20)~~, wherein the diffusor ~~(3)~~ is located downstream the fan ~~(2)~~ with regard to the main flow direction ~~(S)~~, wherein for conversion of dynamic pressure into static pressure the cross section ~~(21)~~ of the outlet opening ~~(20)~~ is larger than the cross section ~~(11)~~ of the inlet opening ~~(10)~~, and the cross section of the diffuser interior ~~(I)~~ increases from the cross section ~~(11)~~ of the inlet opening to the cross section ~~(21)~~ of the outlet

opening ~~(20)~~, wherein the outer housing ~~(30)~~ forms an outer diffuser part ~~(AD)~~ which delimits the diffuser interior ~~(I)~~ to the outside,

characterized in that, concentrically with respect to the outer diffuser part ~~(AD)~~, there is arranged an inner diffuser part ~~(ID)~~ which, with an inner housing ~~(40)~~, delimits the diffuser interior ~~(I)~~ to the inside, wherein

the outer diffuser part ~~(AD)~~ and/or the inner diffuser part ~~(ID)~~ are/is designed such that the cross section of the diffuser interior ~~(I)~~ is non-rotationally symmetrical at at least one point.

3. The fan arrangement ~~(1)~~ as claimed in claim 1 or 2,
characterized in that the non-circular cross section ~~(32)~~ of the outer diffuser part ~~(AD)~~ and/or of the inner diffuser part ~~(ID)~~ is of polygonal, in particular square, basic shape.

4. The fan arrangement ~~(1)~~ as claimed in any one of the preceding claims,
characterized by the diffusor ~~(3)~~ composed of a plurality of individual diffuser parts which are connected to one another by fastening means such as screws, rivets, clamps or the like, or by means of frictionally locking, positively locking and/or cohesive connections, such as by means of a bayonet lock, by means of a clip connection, by means of a welded connection or the like.

5. The fan arrangement ~~(1)~~ as claimed in any one of the preceding claims,

characterized in that the diffuser ~~(3)~~, or at least one diffuser part ~~(ID, AD, 30, 40)~~, is composed of originally planar plates which are bent and connected to one another, in particular of punched metal sheets, or of a flexible cover ~~(P)~~, which is/are if appropriate tensed and/or stiffened with the aid of additional add-on parts such as supporting struts ~~(9b)~~ and/or bearing and shaped rings ~~(9a)~~.

6. The fan arrangement ~~(1)~~ as claimed in any one of the preceding claims,
characterized in that the inner housing ~~(40)~~, the outer housing ~~(30)~~ and/or parts thereof are/is composed of plastic and are/is produced preferably by primary forming or shaping processes such as injection molding, extrusion, rotary molding, foaming, vacuum deep-drawing, blow molding or the like.

7. The fan arrangement ~~(1)~~ as claimed in claim 6,
characterized in that mechanically highly loaded regions of the inner housing ~~(40)~~, of the outer housing ~~(30)~~ and/or of the parts thereof are reinforced by at least one metal part inlaid during the primary forming process or subsequently attached.

8. The fan arrangement ~~(1)~~ as claimed in any one of the preceding claims,
characterized in that a load-bearing structure of the diffuser ~~(3)~~ is a framework spanned by a thin material composed in particular of plastic or sheet metal.

9. The fan arrangement ~~(1)~~ as claimed in any one of the preceding claims,

characterized in that a touch guard, for example in the form of rectangular struts, is arranged on the inner housing ~~(40)~~ and/or on the outer housing ~~(30)~~, which touch guard is formed in one piece with the respective housing ~~(30, 40)~~ or is formed as a separate part fastened to the inner housing ~~(40)~~ and/or to the outer housing ~~(30)~~.

10. The fan arrangement ~~(1)~~ as claimed in any one of the preceding claims,
characterized in that a follow-up guide wheel is arranged on the inner housing ~~(40)~~ and/or on the outer housing ~~(30)~~, which follow-up guide wheel is formed in one piece with the respective housing ~~(30, 40)~~ or as a separate part fastened to the inner housing ~~(40)~~ and/or outer housing ~~(30)~~ and is composed of static guide elements which are designed so as to divert circumferential and/or radial components of the flow speed in the axial direction ~~(X-X)~~.

11. The fan arrangement ~~(1)~~ as claimed in any one of the preceding claims
characterized by a sound-deadening means, wherein in particular the diffuser interior ~~(I)~~ is lined with a sound-deadening material, preferably in such a way that the free surface of the sound-deadening material on that side of the inner housing ~~(40)~~ and/or of the outer housing ~~(30)~~ which faces towards the main flow ~~(S)~~ forms a diffuser wall which is active in terms of flow.

12. The fan arrangement ~~(1)~~ as claimed in claim 11, characterized in that a sound-deadening material is applied to the diffuser outer surface, which faces away from the main flow ~~(S)~~, of the outer housing ~~(30)~~.

13. The fan arrangement ~~(1)~~ as claimed in claim 11, characterized in that the outer diffuser part ~~(AD)~~ and/or the inner diffuser part ~~(ID)~~ is/are composed partially or in particular integrally of the sound-deadening material.

14. The fan arrangement ~~(1)~~ as claimed in any one of the preceding claims, characterized by a system for active noise reduction ("active noise control") for reducing mid- to low-frequency sound radiation.

15. The fan arrangement ~~(1)~~ as claimed in any one of the preceding claims, characterized in that the diffuser ~~(3)~~ is fastened to the at least one static part of the fan, in particular to a wall ring ~~(5)~~ and/or to a protective grille, by screws, rivets, clamps or the like, or by means of a bayonet lock, by means of a clip connection, or by means of a welded connection.