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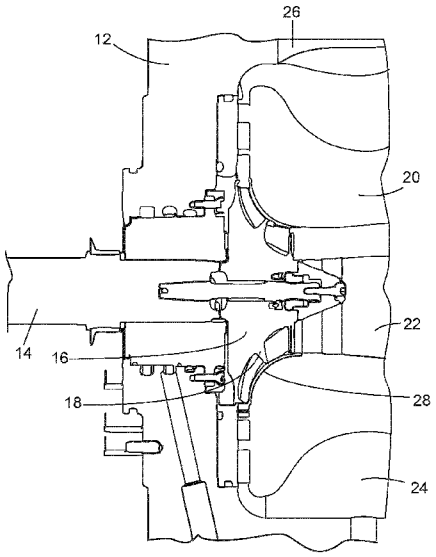
(54) Title: DIFFUSER OF ROTATING FLUID MACHINES

(57) Abstract: A diffuser20of a rotating fluid machine that processes a gas with high level of contaminants is provided, the diffuser20having an annular surface portion28facing rotating vanes18of a rotor16of the rotating fluid machine, the annular surface portion 28 being at least partially covered with an abradable and anti-encrustation coating including (A) a first lower metal-based coating layer30applied on the annular surface portion28of the diffuser-20, and (B) a second upper polymer-based coating layer32applied on the first lower metal-based coating layer30, wherein the first lower metal-based coating layer30 comprises 99% by weight of aluminum powder based on the total weight of the first lower- based coating layer and is anchored to the annular surface with a nickel and aluminum (NiAl) binder.

Fig. 2



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DIFFUSER OF ROTATING FLUID MACHINES

FIELD OF THE INVENTION

The present invention relates to a diffuser for rotating fluid machines, in particular but not exclusively for centrifugal compressors with an open 3D impeller and integral reducer.

DESCRIPTION OF THE RELATED ART

As is known, a compressor is a machine capable of raising the pressure of a compressible fluid (gas) with the use of mechanical energy. Among the various types of compressors used in process plants on an industrial scale, so-called centrifugal compressors can be mentioned, in which the energy to the gas is supplied in the form of centrifugal acceleration due to the rotation, generally driven by a driver (electric motor or vapour turbine), of an organ called rotor or impeller.

Centrifugal compressors can be equipped with a single rotor, in the so-called single-stage configuration, or several impellers arranged in series, in this case being called multistage compressors. More specifically, each stage of a centrifugal compressor normally includes of a suction duct for the gas to be compressed, an impeller, which is capable of supplying kinetic energy to the gas, and a diffuser, whose function is to convert the kinetic energy of the gas leaving the impeller into pressure energy.

In centrifugal compressors installed in petrochemical process plants, gases are often treated, which can contain various kinds of contaminating agents. These contaminating agents can influence the performances of the compressor, giving rise to encrustation and/or corrosion processes especially in the presence of particular metal-based coating films applied on some parts of the compressor itself.

In order to avoid possible interferences between the impeller and the relative fixed diffuser, in particular during the start-up phase of the compressor, at the same time maintaining minimum tolerances between the parts for a better performance of the compressor itself,

the application of an abradable coating on the portion of the diffuser in contact with the vanes of the impeller is in fact envisaged. After a more or less prolonged use of the compressor and abrasion caused by the gas due to the rotation of the vanes, however, this type of coating, normally including of aluminum powder and polyester, has a rough surface which facilitates the formation of encrustations, even more evident and diffused in the presence of gas containing contaminating agents.

Furthermore, certain contaminating agents present in the gas can also cause the partial or complete detachment of the abradable coating film, as a result of crystallization processes of the gas itself inside the porosities of the aluminum-based film, with the risk of causing possible damage, also serious, to the components of the compressor.

In compressors coated with abradable films of the known type which process gas with a high content of contaminating agents, it is therefore necessary to effect periodic maintenance operations for the cleaning and removal of the encrustations, and also for a possible restoration of the coating film should it become detached from the surface, generally metallic, on which it is to be applied.

This requires frequent and prolonged machine stoppage times which can jeopardize the good functioning of the compressor and whole plant in which it is inserted.

An objective of the present invention is therefore to solve the problems of the abradable coatings according to the known art, by providing an abradable coating for rotating fluid machines, in particular but not exclusively for centrifugal compressors which process gas containing contaminating agents, which limits the formation of encrustations on its surface as much as possible, thus improving the performances of the machine.

Another objective of the invention is to provide an abradable coating for rotating fluid machines which prevents the detachment, also partial, of the coating itself from the metallic surface of the machine on which it is applied, also in the presence of particularly aggressive contaminating agents, so as to reduce the number of maintenance interventions to be

effected on the machine.

A further objective of the invention is to provide a coating for rotating fluid machines which keeps its abradable characteristics unaltered with respect to the coatings of the known type currently adopted.

BRIEF SUMMARY OF THE INVENTION

These objectives according to the present invention and others appreciated by those of ordinary skill in the applicable arts are achieved by providing an abradable and anti-encrustation coating for rotating fluid machines, in particular but not exclusively for centrifugal compressors which process gases containing contaminating agents.

BRIEF DESCRIPTION OF THE DRAWINGS

The characteristics and advantages of an abradable and anti-encrustation coating for rotating fluid machines according to the present invention will appear more evident from the following illustrative and non-limiting description, referring to the enclosed schematic drawings in which:

Figure 1 is a raised sectional side view of a centrifugal compressor equipped with an abradable and anti-encrustation coating according to the present invention;

Figure 2 is an enlarged sectional view which shows in detail the portion of the compressor of figure 1 on which the abradable and anti-encrustation coating according to the present invention is applied;

Figure 3 is a plan view of the portion of the compressor of figure 1 on which the abradable and anti-encrustation coating according to the present invention is applied; and

Figure 4 is a highly enlarged sectional view of an application example of the abradable and anti-encrustation coating according to the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

With reference to the Figures, these show a generic centrifugal compressor, of the single-stage type, indicated as a whole with the reference number 10, as shown in Figure 1. The compressor 10 comprises a casing or stator 12 in which a shaft 14 is rotatingly assembled, equipped at one of its ends, with a rotor 16, in turn equipped with a series of circumferential vanes 18 having a substantially radial development.

A diffuser 20, which defines an axial duct 22, generally have a truncated-conical form, is made integral with the casing 12, in correspondence with the rotor 16, for the suction of the gas. On the diffuser 20 there is also a supply chamber 24, having a toroidal form, for the pressurized gas leaving the rotor 16, said supply chamber 24 sending the compressed gas towards a radial outlet duct 26.

In the embodiment illustrated, the vanes 18 of the rotor 16 have an outer edge with a curved profile which faces a corresponding curved profile obtained on an annular surface portion 28 of the diffuser 20 in contact with the rotor 16 itself, as can be observed in detail in Figure 2.

As the distance between the moveable vanes 18 and the fixed annular surface portion 28 is reduced to the minimum for a better performance of the compressor 10 and to prevent interference phenomena between the rotor 16 and the diffuser 20, said annular surface portion 28 is at least partially covered with a coating made with a material which can be abraded on the part of the outer edge of the vanes 18, especially in the start-up phase of the compressor 10 or in the presence of vibrations of a significant entity.

According to the invention, said coating of abradable material includes of a first metal-based coating layer 30, or lower layer, applied on the surface of the annular portion 28 of the diffuser 20, and a second polymer-based coating layer 32, or upper layer, applied on the first metal-based coating layer 30.

The thickness of the upper polymer-based coating layer 32 preferably ranges from 1 mm

to 1.5 mm, with a particularly preferred thickness value of about 1.2 mm. The thickness of the first metal-based coating layer 30, on the other hand, can vary according to the manufacturing tolerances of the compressor 10, i.e. on the basis of the distance between the vanes 18 of the rotor 16 and the annular portion 28 of the diffuser 20. On the basis of experimental tests carried out on compressors having components with predefined dimensions, it was possible to define an average thickness ranging from 1 mm to about 1.5 mm for said lower coating layer.

Although numerous metal-based and polymer-based materials can be used for the first coating layer 30 and the second coating layer 32, respectively, from experimental tests it has been found that a particularly preferred material for the first coating layer 30 can include of an aluminum powder at 99% by weight, based on the total weight of the first lower-based coating layer 30 anchored to the metallic substrate by means of a nickel and aluminum (NiAl) alloy. In the specific embodiment example illustrated herein, said material for the first coating layer 30 was obtained by combining known coatings with the commercial name "Metco 54NS" and "Metco 450" (anchoring agent) produced by Sulzer Metco.

For the second coating layer 32, which forms the abradable portion of the coating applied to the surface of the annular portion 28 of the diffuser 20, a material known with the trade-name "Halar® ECTFE 6014", produced by Solvay, was selected in the specific embodiment example illustrated herein. This material is a high-performance thermoplastic fluoropolymer (ethylene-chloro-trifluoroethylene), which can be easily applied as a particularly smooth coating. This coating has excellent insulating properties, resistance to atmospheric agents and radiations. It also has good adhesion to the underlying coating, is easy to clean and has chemical resistance to most acids, bases and industrial solvents. At the same time, it guarantees sufficient abradable characteristics on the part of the vanes 18 of the rotor 16.

Operationally, after defining and insulating the portion 28 of the diffuser 20 on which the

abradable coating according to the invention is to be applied, the application is effected, on the basis of known methods, of the first metal-based coating layer 30. Once the thickness of the coating layer 30 applied has been measured, verifying that it corresponds to the thickness envisaged on the basis of the tolerances between the rotor 16 and diffuser 20, the second polymer-based coating layer 32 is applied.

A method adopted for the application of the second coating layer 32, for example, corresponds to the following procedure:

visual control of the first aluminum coating 30, in order to verify the absence of impact and damage;

thermal degreasing in an oven at a temperature of about 300°C and for about 30 minutes;

sandblasting, with aluminum oxide at a maximum pressure of 4 bar, of the aluminum layer 30 previously applied, covering the areas to be protected with a strip of paper and subsequent blowing with compressed air;

application in layers, after interfacing with primers, of the abradable and anti-encrustation coating layer 32 with a fluid bed electrostatic gun onto the piece preheated in an oven, at a temperature of about 270°C and for about 30 minutes; and

cleaning and final controls of the thickness and porosity with a spessimeter for non-magnetic bases and scintillograph at 5,000 Volts with direct current, respectively.

At this point, it is possible to assemble the diffuser 20 equipped with the abradable coating according to the invention.

The experimental tests effected showed that this coating has a very low surface roughness (< 0.2 μm), measured therefore on the upper polymer-based coating layer 32. At the same time, the lower layer 30 has significant adhesion values to the substrate of the diffuser 20, resisting stress value of over 40 MPa.

These combined characteristics demonstrate the anti-encrustation properties of the coating according to the invention, which maintains a limited surface roughness also after the envisaged abrasion on the part of the rotor vanes. Furthermore, the resistance to contaminating agents of the upper layer avoids any possibility of even partial detachment of the underlying metallic layer, protecting it, with evident advantages in terms of durability and efficiency of the compressor.

It can thus be seen that the abradable and anti-encrustation coating for rotating fluid machines, in particular for centrifugal compressors which process gases containing contaminating agents, according to the present invention, achieves the objectives indicated above. The abradable and anti-encrustation coating for centrifugal compressors of the present invention thus conceived can in any case undergo numerous modifications and variants, all included in the same inventive concept. The protection scope of the invention is therefore defined by the enclosed claims.

CLAIMS:

1. A diffuser of a rotating fluid machine that processes a gas with high level of contaminants,

the diffuser comprising:

an annular surface portion facing rotating vanes of a rotor of the rotating fluid machine, the annular surface portion being at least partially covered with an abradable and anti-encrustation coating including (A) a first lower metal-based coating layer applied on the annular surface portion of the diffuser, and (B) a second upper polymer-based coating layer applied on the first lower metal-based coating layer;

wherein the first lower metal-based coating layer comprises 99% by weight of aluminum powder based on the total weight of the first lower-based coating layer and is anchored to the annular surface with a nickel and aluminum (NiAl) binder.

2. The diffuser according to claim 1, wherein ~~a~~ the thickness of the second upper polymer-based coating layer ranges from 1 mm to 1.5 mm.

3. The diffuser according to claim 1 or claim 2, wherein ~~a~~ the thickness of the second upper polymer-based coating layer is about 1.2 mm.

4. The diffuser according to any preceding claim, wherein the thickness of the first lower metal-based coating layer ranges from 1 mm to 1.5 mm

5. The diffuser according to any preceding claim, wherein the second upper polymer-based coating layer is a thermoplastic fluoropolymer.

6. The diffuser according to claim 5, wherein the thermoplastic fluoropolymer is ethylene-chloro-trifluoroethylene.

7. The diffuser of any preceding claim, wherein the first lower metal based-based coating layer adheres to the annular surface portion to resist a stress value over 40 MP.

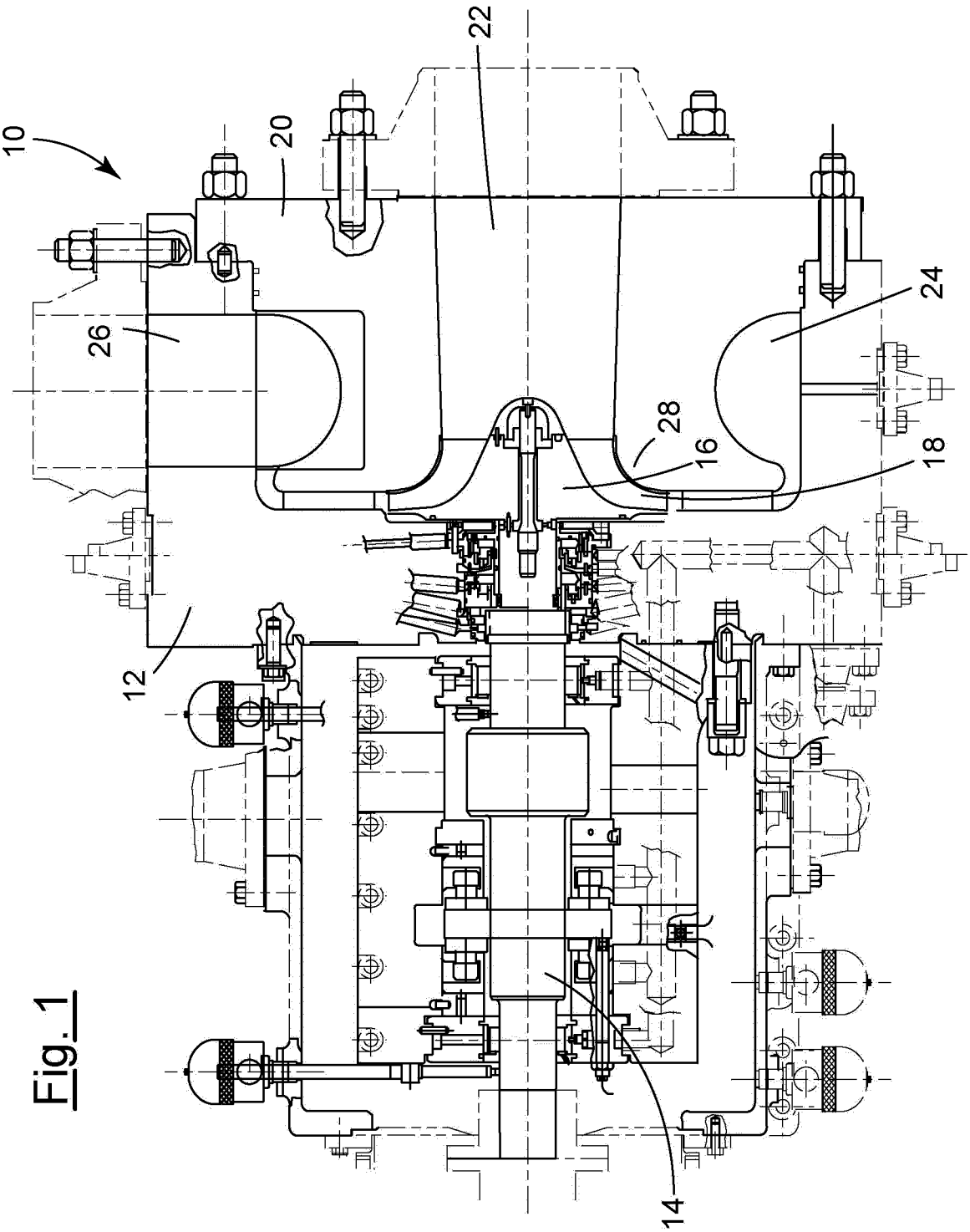


Fig. 1

Fig. 2

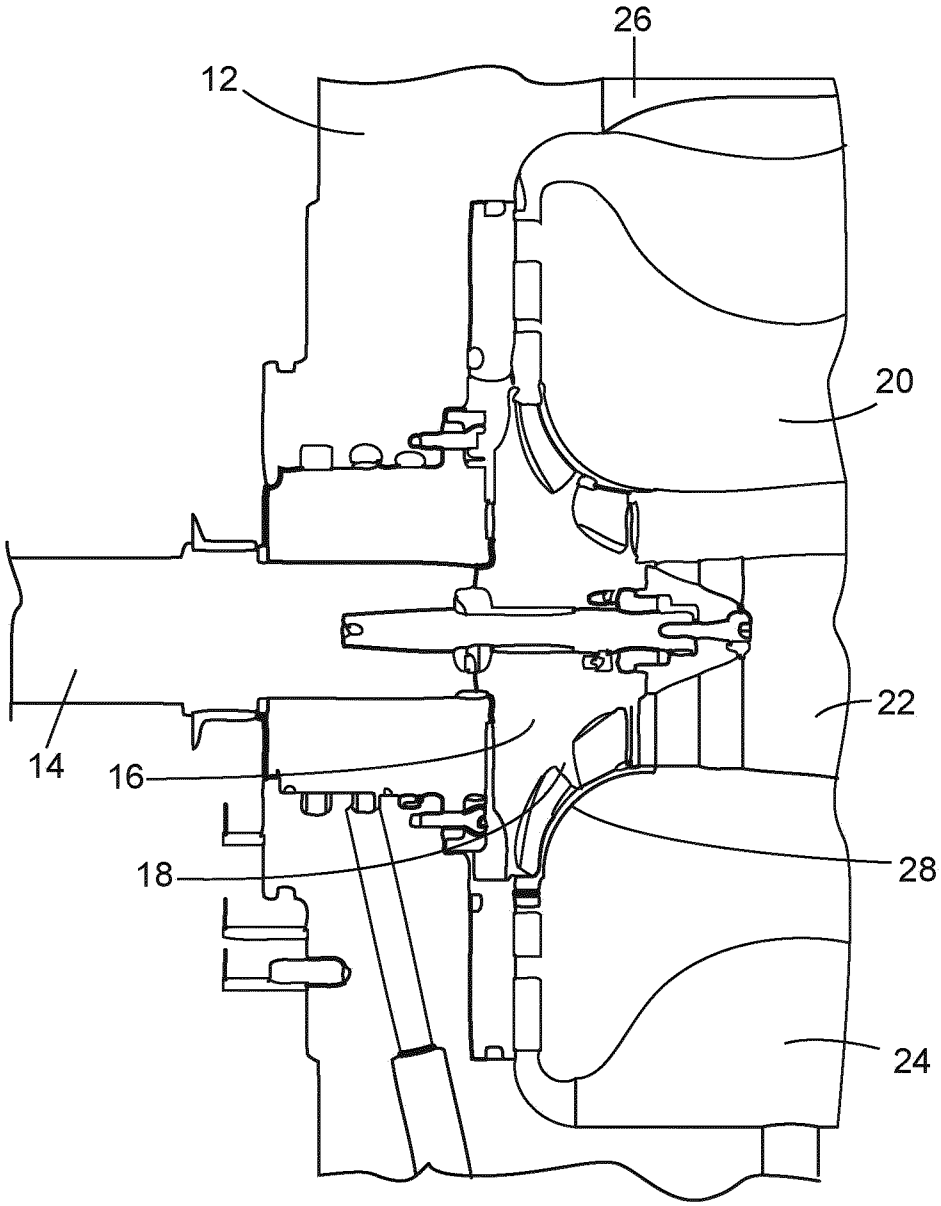


Fig. 3

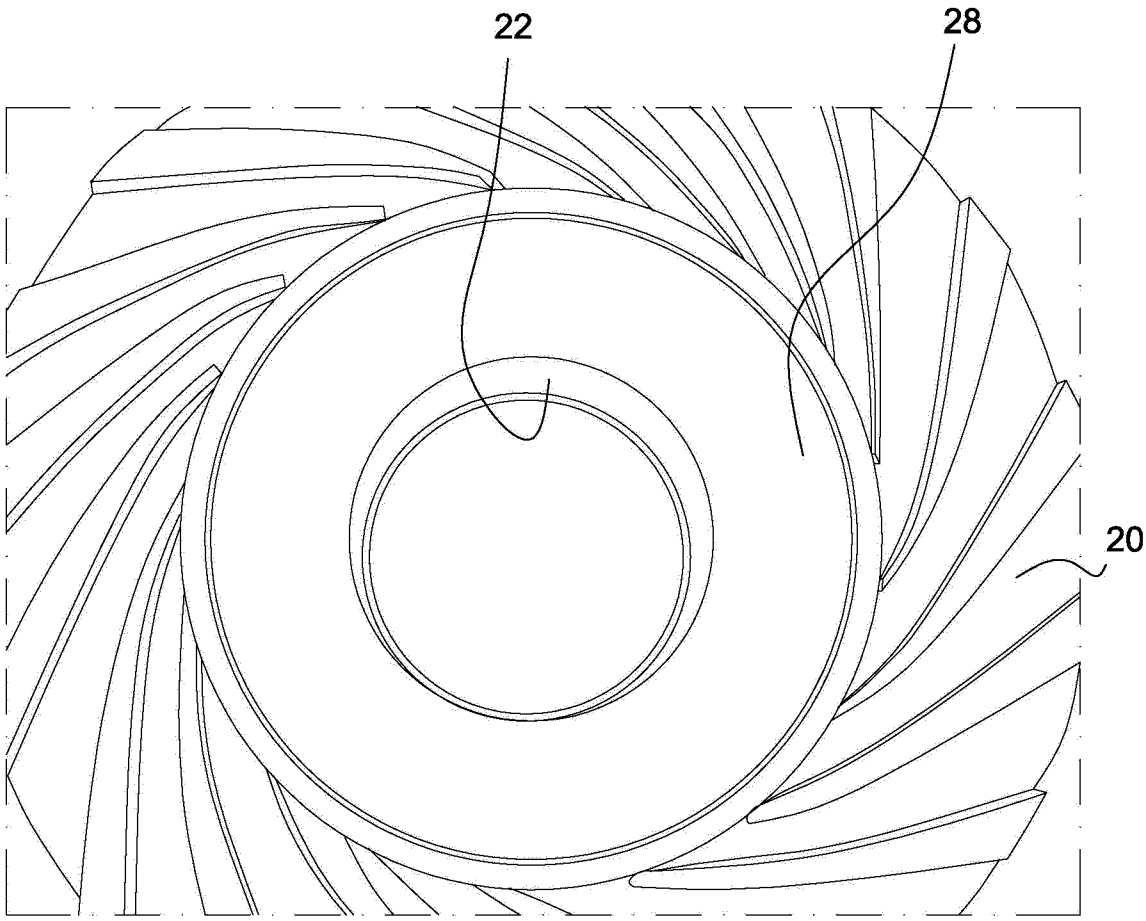
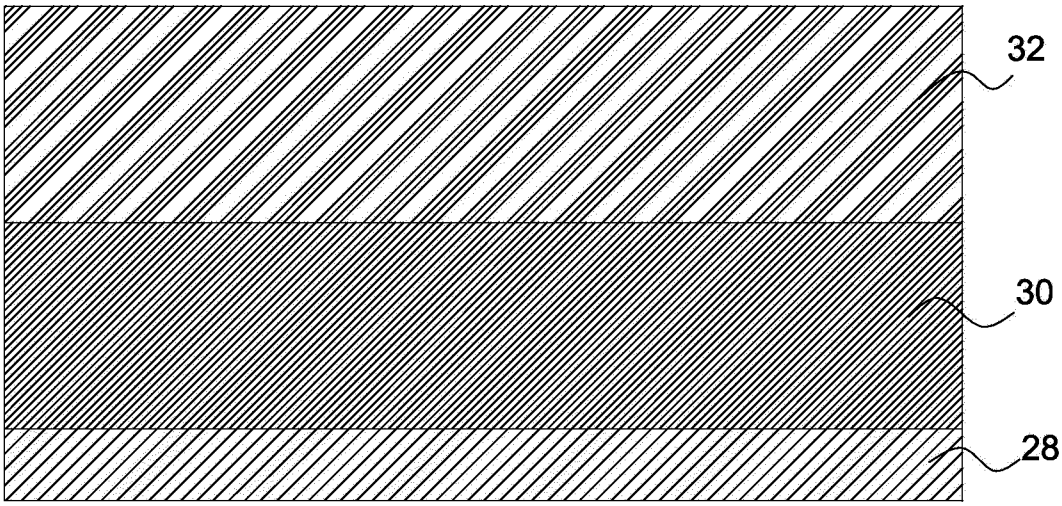


Fig. 4



INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2016/076197

A. CLASSIFICATION OF SUBJECT MATTER
INV. F04D29/02 F04D29/28 F04D29/44
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F04D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 1 992 419 A2 (NUOVO PIGNONE SPA [IT]) 19 November 2008 (2008-11-19) abstract paragraph [0001] - paragraph [0028] claims figures -----	1-7

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

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Date of the actual completion of the international search	Date of mailing of the international search report
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Name and mailing address of the ISA/	Authorized officer
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INTERNATIONAL SEARCH REPORT

Information on patent family members

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 1992419 A2	19-11-2008	CN 101275583 A	01-10-2008
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