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- **DERWENT'S ABSTRACT, No. D0626K/09, Week 8309; & SU,A,922 324, (VOROSHILOVGRADSKII), 23 April 1982.**

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Description

[0001] The present invention relates to a rotor blade to be attached to a hub in a rotor, such as a vane to be attached to a hub of a fan.

[0002] Fan blades are usually made of metal, for instance steel or aluminium. There is today a need of manufacturing fan blades of a material which is more chemically resistant than metal and consequently can resist a chemically aggressive environment in a better manner than metal, for instance in the chemical process industry. There is also a need of making the fan blades lighter, which means that the fan on which the blades are mounted can be operated at higher speeds, and that in some cases the fan can be made smaller and thus less expensive. Attempts have therefore been made to manufacture fan blades of composite material of fibre-reinforced plastic. These fan blades are chemically resistant and light, but it has proved difficult to fasten them to a hub of a fan in a satisfactory manner. The connection between blade and hub usually is a bolt connection with bolts, which extend through the base of the blade and are screwed into the hub or a holder arranged thereon. Such connections are known, for example from US-A-3 565 547. Regrettably, it has been found that the fan blades made of composite material tend to be destroyed at high speeds of the fan and thus great stress since cracks arise in the base of the blade in the area of the bolt connection.

[0003] A specific object of the present invention therefore is to provide a fan blade, which has the desired properties and besides can be attached to a hub of a fan in a satisfactory manner.

[0004] A more general object of the invention is to provide a rotor blade, which has the desired properties and can be attached to a hub in a rotor without breaking at high rotor speeds and when subjected to great stress.

[0005] According to the invention, this object is achieved by a rotor blade, which is characterised in that the rotor blade is made essentially of a composite material of fibre-reinforced plastic, that the base of the rotor blade comprises a metal ring with means for attaching the rotor blade to the hub, said ring having an opening, which has a cross-sectional area increasing in the direction away from the rotor blade, that a rigid reinforcing element is arranged in the opening of the ring, and that the composite material extends into the ring, reinforcing fibres in the base of the rotor blade extending into the opening of the ring between the reinforcing element and the wall of the opening essentially in parallel therewith.

[0006] In a preferred embodiment, the opening of the ring has the form of a truncated cone.

[0007] The reinforcing element suitably contains carbon fibres and, in a preferred embodiment, is formed of a carbon-fibre strand, which is rolled into a disk-shaped roll and which during manufacture of the rotor blade in a mould is arranged in the opening of the ring to press the reinforcing fibres in the opening in the direction of

the wall of the opening.

[0008] The composition of the composite material of fibres and plastic in the base of the rotor blade is preferably selected such that the composite material therein has a linear expansion characteristic adapted to the metal ring. The composite material suitably is glass-fibre reinforced epoxy plastic. In a preferred embodiment, the glass-fibre reinforcement in the base of the rotor blade is supplemented with a carbon-fibre reinforcement with carbon fibres, which extend substantially transversely of the glass fibres in the glass-fibre reinforcement in the base.

[0009] The invention will now be described in more detail with reference to the accompanying drawings, in which

Fig. 1 is a side view of a fan blade according to the present invention,

Fig. 2 is a top plan view of the fan blade,

Fig. 3 is a sectional view of the fan blade along the line III-III in Fig. 1, and

Fig. 4 corresponds to Fig. 3, but shows the base portion of the fan blade on a larger scale.

[0010] The drawings illustrate a fan blade 1, which is to be attached to a hub (not shown) in a fan (not shown) by means of four fixing bolts (not shown), which are to be screwed into the hub or a holder arranged thereon.

[0011] The blade 1 is made of a composite material of fibre-reinforced plastic. In a preferred embodiment, the composite material is a glass- and carbon-fibre reinforced epoxy plastic. However, it will be appreciated that other fibres than glass fibres and carbon fibres, e. g. aramide fibres, can be used as fibre reinforcement. It will also be appreciated that other polymers than epoxy plastic can be used as a matrix.

[0012] In the manufacture of the blade 1, two mats, each consisting of several layers of oriented glass fibres, and an intermediate plastic core 2 (Fig. 4) are placed in a mould, whereupon a circular ring 3 of metal, e.g. steel, is arranged in the mould at one end thereof. The ring 3 has an opening 4 which is conical in a truncated manner and is of a cross-sectional area increasing in the direction away from the mould. The glass fibres at the end of the mats closest to the ring 3 (this end constituting the base end of the completed blade 1) are introduced into the opening 4 of the ring 3 and are pressed against the wall of the opening 4. A "bundle" of glass fibres is arranged in the pointed portion A, indicated by dashed lines in Fig. 4, between the mat glass fibres pressed against the wall of the opening 4. A carbon-fibre strand, which is rolled into a disk-shaped roll and which is to form a rigid reinforcing element 5 in the completed blade 1, is arranged in the opening 4 of the ring 3 on the outside of the bundle of glass fibres in order to retain the glass fibres in the position when pressed in the direction of the wall of the opening 4. The mould is closed, whereupon epoxy plastic is injected so as to

form the blade 1.

[0013] The completed blade 1 thus consists of a composite material 6 (including the area A) of glass-fibre reinforced epoxy plastic and having a core 2 of plastic and a reinforcing element 5 in the form of a carbon-fibre/epoxy-plastic composite.

[0014] The base of the blade 1 consists of the metal ring 3, the reinforcing element 5 and that part of the composite material 6 which is located in the opening 4 of the ring 3 and in which the glass fibres extend conically along the wall of the opening 4 between the wall and the reinforcing element 5, which prevents the glass fibres in the ring 3 from being pressed towards the centre of the ring when the blade 1 is subjected to great stress, and the body of the blade from being pulled out of the ring 3.

[0015] The ring 3 has a bolt hole 7 for each fixing bolt. As mentioned above, the blade 1 is attached to a hub by means of the fixing bolts, which are inserted into the holes 7 in the ring 3 and screwed into the hub or a holder arranged thereon. The above-described fan blade 1 is light compared with previously used metal blades, and besides it has appeared to withstand high speeds of the fan without its base breaking adjacent to the bolt connection.

[0016] The composition of fibres and plastic in the composite material 6 in the blade base is selected such that the composite material therein has a linear expansion characteristic which is adapted to the metal ring 3, thereby reducing as much as possible the effects of the expansion and contraction of the ring under various temperature conditions, i.e. such that the composite material is able to follow the ring 3 in the temperature-dependent movements thereof. To this end, the glass-fibre reinforcement in the blade base is, in a preferred embodiment of the fan blade 1, supplemented with a carbon-fibre reinforcement with carbon fibres, which in the manufacture of the blade in the mould are arranged among the glass fibres in the area of the ring 3 so as to extend in the completed blade 1 substantially transversely of these glass fibres in the composite material.

Claims

1. A rotor blade to be attached to a hub in a rotor, such as a vane (1) to be attached to a hub of a fan, **characterised in that** the rotor blade is made essentially of a composite material (6) of fibre-reinforced plastic, that the base of the rotor blade comprises a metal ring (3) with means (7) for attaching the rotor blade to the hub, said ring having an opening (4), which has a cross-sectional area increasing in the direction away from the rotor blade, that a rigid reinforcing element (5) is arranged in the opening (4) of the ring (3), and that the composite material (6) extends into the ring, reinforcing fibres in the base of the rotor blade extending into the opening (4) of the ring (3) between the reinforcing element (5) and

the wall of the opening (4) essentially in parallel therewith.

2. A rotor blade as claimed in claim 1, **characterised in that** the opening (4) of the ring (3) has the form of a truncated cone.
3. A rotor blade as claimed in claim 1 or 2, **characterised in that** the reinforcing element (5) contains carbon fibres.
4. A rotor blade as claimed in claim 3, **characterised in that** the reinforcing element (5) is formed of a carbon-fibre strand, which is rolled into a disk-shaped roll and which during manufacture of the rotor blade in a mould is arranged in the opening (4) of the ring (3) to press the reinforcing fibres in the opening in the direction of the wall of the opening.
5. A rotor blade as claimed in any one of claims 1-4, **characterised in that** the composition of the composite material (6) of fibres and plastic in the base of the rotor blade is selected such that the composite material therein has a linear expansion characteristic adapted to the metal ring (3).
6. A rotor blade as claimed in any one of claims 1-5, **characterised in that** the composite material (6) is a glass-fibre reinforced epoxy plastic.
7. A rotor blade as claimed in claims 5 and 6, **characterised in that** the glass-fibre reinforcement in the base of the rotor blade is supplemented with a carbon-fibre reinforcement with carbon fibres, which extend substantially transversely of the glass fibres in the glass-fibre reinforcement in the base.

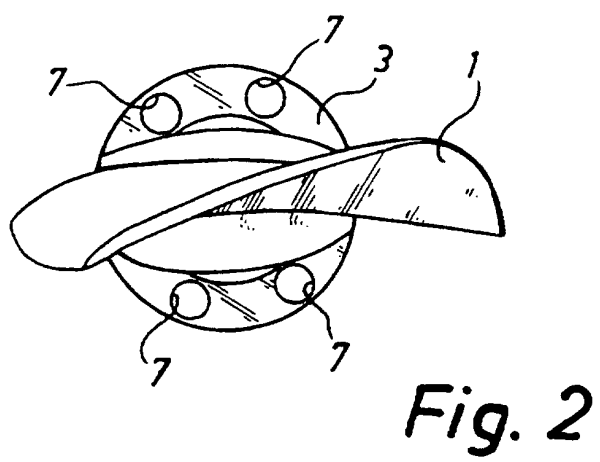
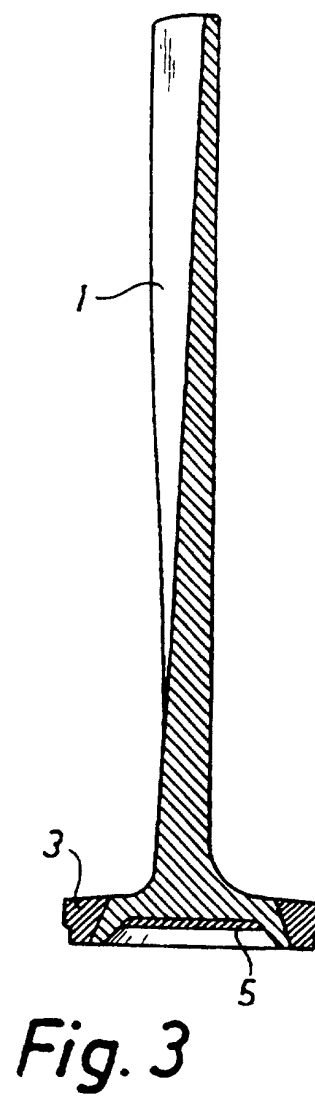
Patentansprüche

1. Ein an eine Nabe in einem Rotor anbringbares Rotorblatt wie beispielsweise eine an eine Nabe eines Ventilators anbringbare Schaufel (1), **dadurch gekennzeichnet, dass** das Rotorblatt im wesentlichen aus einem Compositmaterial (6) aus faserverstärktem Plastik besteht, dass die Basis des Rotorblatts einen Metallring (3) mit Mitteln (7) zum Anbringen des Rotorblatts an der Nabe aufweist, wobei der Ring eine Öffnung (4) hat, welche eine Querschnittsfläche hat, die mit steigender Entfernung von dem Rotorblatt ansteigt, dass ein festes Verstärkungselement (5) in der Öffnung (4) des Rings (3) angeordnet ist, und dass sich das Compositmaterial (6) in den Ring hinein erstreckt, wobei sich Verstärkungsfasern in der Basis des Rotorblatts in die Öffnung (4) des Rings (3) zwischen dem Verstärkungselement (5) und der Wand der Öffnung (4) im wesentlichen parallel dazu erstrecken.

2. Rotorblatt nach Anspruch 1, **dadurch gekennzeichnet, dass** die Öffnung (4) des Rings (3) die Form eines Kegelstumpfes hat.
3. Rotorblatt nach Anspruch 1 oder 2, **dadurch gekennzeichnet, dass** das Verstärkungselement (5) Carbonfasern beinhaltet.
4. Rotorblatt nach Anspruch 3, **dadurch gekennzeichnet, dass** das Verstärkungselement (5) aus einem Carbonfaserstrang besteht, welcher zu einer scheibenförmigen Rolle gerollt ist und welcher während der Herstellung des Rotorblatts in einer Form in der Öffnung (4) des Rings (3) angeordnet ist, um die Verstärkungsfasern in der Öffnung in Richtung der Wand der Öffnung zu drücken.
5. Rotorblatt nach einem der Ansprüche 1 bis 4, **dadurch gekennzeichnet, dass** die Zusammensetzung des Compositmaterials (6) aus Fasern und Plastik in der Basis des Rotorblatts so ausgewählt ist, dass das Compositmaterial darin eine lineare Ausdehnungskennlinie hat, die an den Metallring (3) angepasst ist.
6. Rotorblatt nach einem der Ansprüche 1 bis 5, **dadurch gekennzeichnet, dass** das Compositmaterial (6) ein glasfaserverstärktes Epoxidplastik ist.
7. Rotorblatt nach Anspruch 5 und 6, **dadurch gekennzeichnet, dass** die Glasfaserverstärkung in der Basis des Rotorblatts durch eine Kohlefaserverstärkung mit Kohlefasern ergänzt ist, welche sich im wesentlichen quer zu den Glasfasern in der Glasfaserverstärkung in der Basis erstrecken.
2. Lame de rotor suivant la revendication 1, **caractérisée en ce que** l'ouverture (4) de l'anneau (3) a la forme d'un cône tronqué.
3. Lame de rotor suivant la revendication 1 ou 2, **caractérisée en ce que** l'élément (5) de renfort contient des fibres de carbone.
4. Lame de rotor suivant la revendication 3, **caractérisée en ce que** l'élément (5) de renfort est formé d'un cordon de fibres de carbone qui est enroulé en un rouleau en forme de disque et qui, pendant la fabrication de la lame de rotor dans un moule, est disposé dans l'ouverture (4) de l'anneau (3) pour presser les fibres de renfort dans l'ouverture dans la direction de la paroi de l'ouverture.
5. Lame de rotor suivant l'une quelconque des revendications 1 à 4, **caractérisée en ce que** la composition de la matière (6) composite de fibres de matière plastique dans la base de la lame du rotor est choisie de façon à ce que la matière composite qui ait une caractéristique de dilatation linéaire adaptée à l'anneau (3) métallique.
6. Lame de rotor suivant l'une quelconque des revendications 1 à 5, **caractérisée en ce que** la matière (6) composite est une matière plastique époxy renforcée par de la fibre de verre.
7. Lame de rotor suivant les revendications 5 et 6, **caractérisée en ce que** le renfort de fibres de verre dans la base de la lame du rotor est complété par un renfort de fibres de carbone ayant des fibres de carbone qui s'étendent sensiblement transversalement aux fibres de verre du renfort de fibres de verre de la base.

Revendications

1. Lame de rotor à fixer à un moyeu d'un rotor, telle qu'une aube (1) à fixer à un moyeu d'un ventilateur, **caractérisée en ce que** la lame du rotor est constituée essentiellement d'un matériau (6) composite de matière plastique renforcée par de la fibre, en ce que la base de la lame du rotor comprend un anneau (3) métallique ayant des moyens (7) pour fixer la lame de rotor au moyeu, l'anneau ayant une ouverture (4) qui a une surface de section transversale augmentant dans la direction en s'éloignant de la lame du rotor, en ce qu'un élément (5) rigide de renfort est disposé dans l'ouverture (4) de l'anneau (3) et en ce que la matière (6) composite s'étend dans l'anneau, des fibres de renfort dans la base de la lame du rotor s'étendant dans l'ouverture (4) de l'anneau (3) entre l'élément (5) de renfort et la paroi de l'ouverture (4) en y étant sensiblement parallèles.



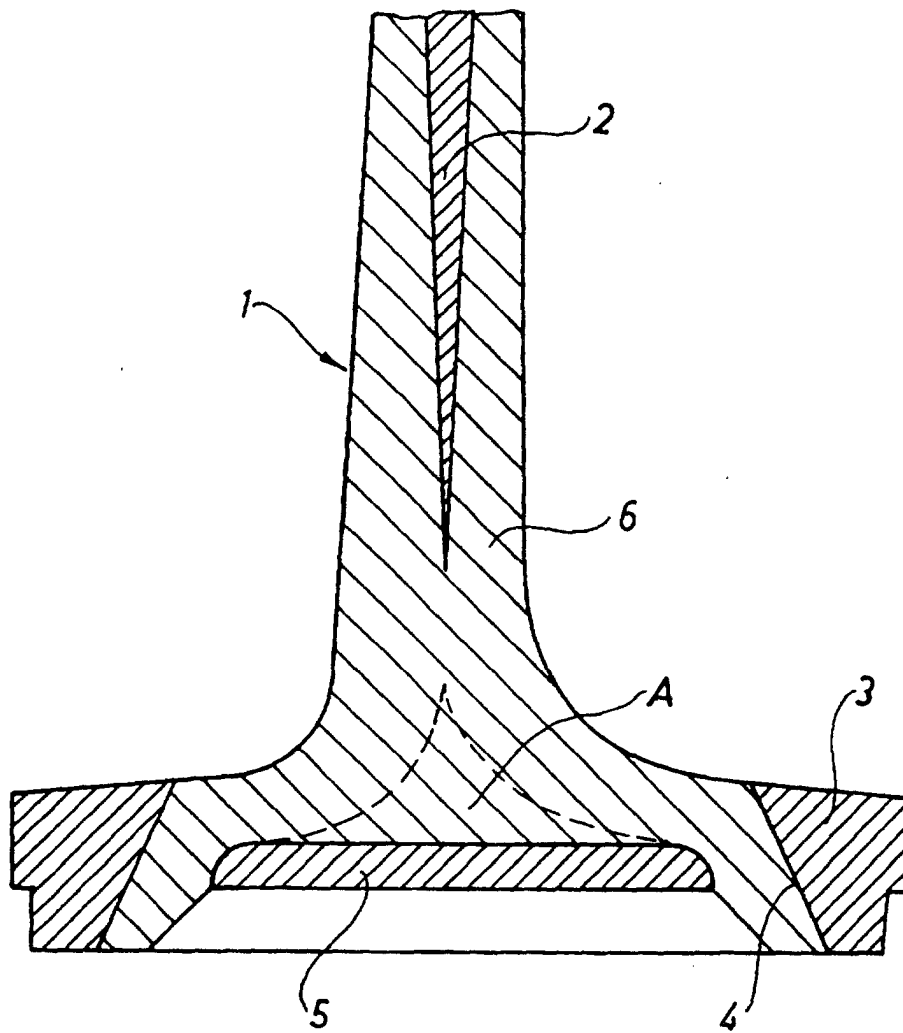


Fig. 4