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(54) ANTI-WEAR DEVICE FOR A GUIDE PIVOT OF A VARIABLE-PITCH VANE OF A TURBOMACHINE COMPRESSOR

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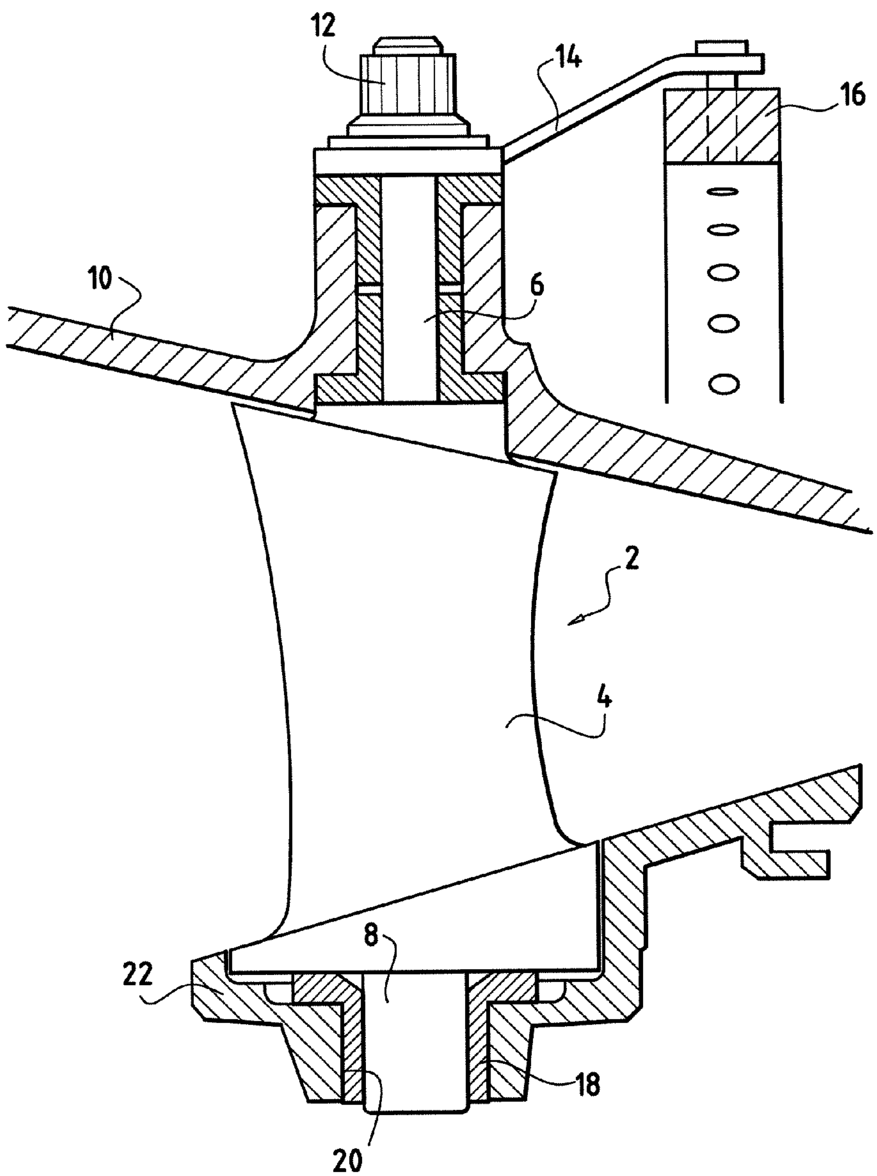
(57) ABSTRACT

The invention relates to a variable-pitch vane for a turbomachine compressor, the vane including a bushing mounted to rotate about a guide pivot of the vane for mounting in a casing of the turbomachine, the pivoting contact between the bushing and the guide pivot being of the nickel-graphite and titanium type.



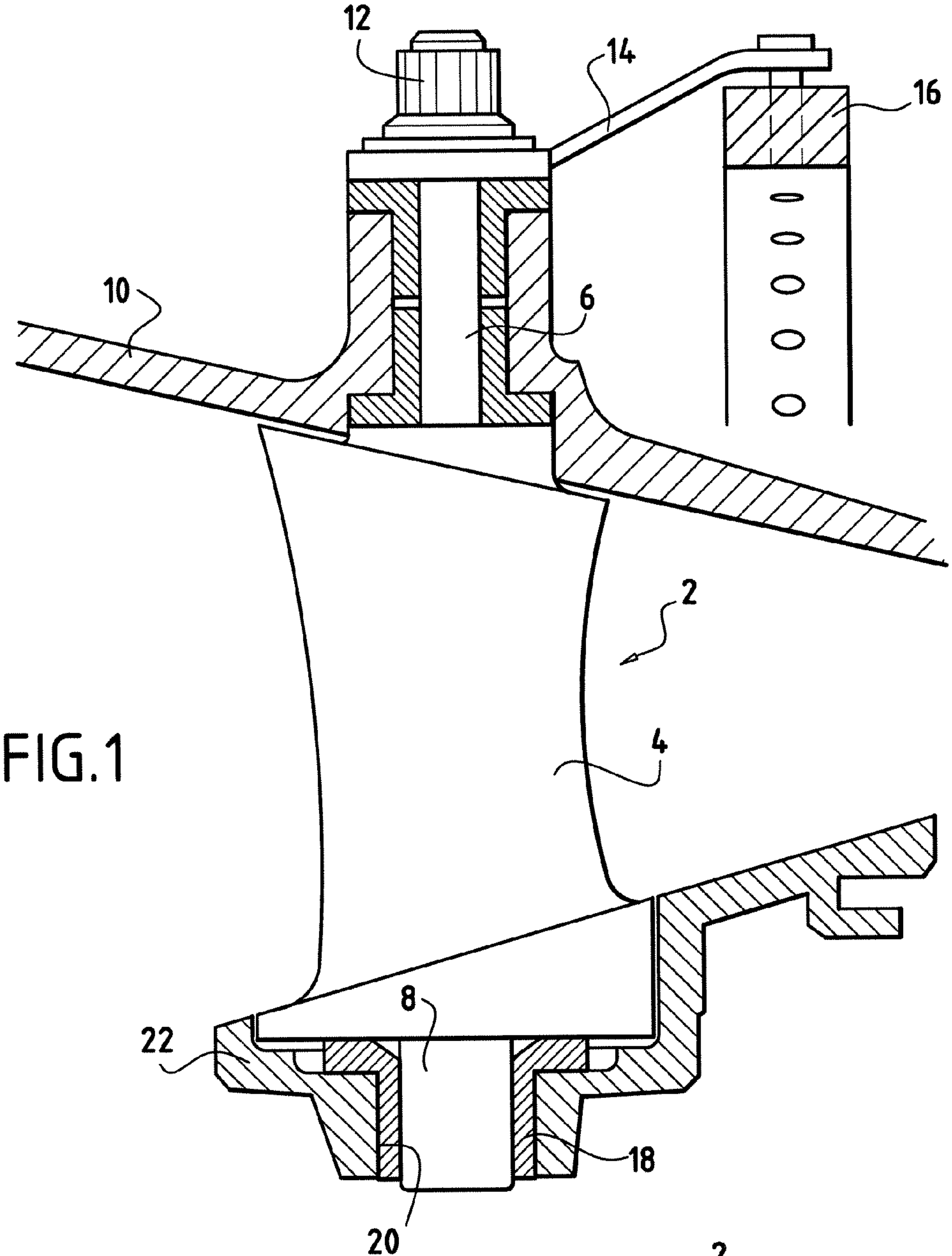


FIG.1

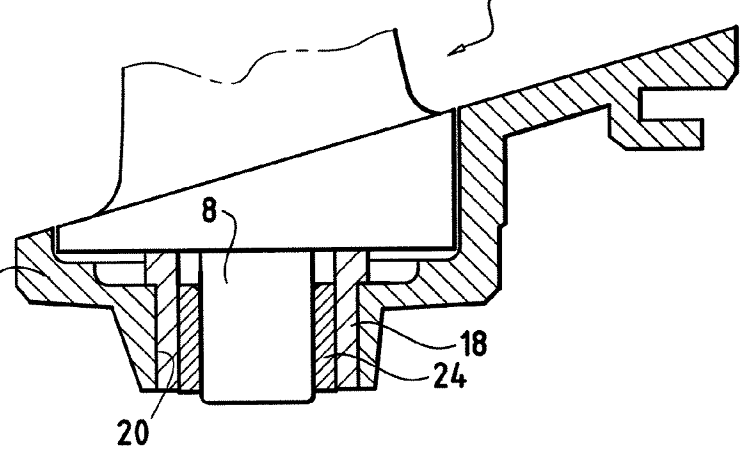


FIG.2

ANTI-WEAR DEVICE FOR A GUIDE PIVOT OF A VARIABLE-PITCH VANE OF A TURBOMACHINE COMPRESSOR

BACKGROUND OF THE INVENTION

[0001] The present invention relates to the general field of variable-pitch vanes. A particular application lies in the field of aviation, in particular for controlling the angular pitch of the air inlet guide vanes in turbomachine compressors.

[0002] In a turbomachine, the high pressure compressor is typically made up of a plurality of variable-pitch vane stages that serve to modify the flow characteristics of the gas depending on the operating speed of the turbomachine.

[0003] The variable-pitch vanes in a given stage have respective head control pivots and root guide pivots, the control pivot passing through a stator casing of the turbomachine and co-operating with a member for controlling the pitch angle of the vanes, and the guide pivot being mounted to pivot in a bushing housed in a recess in an inside ring of the turbomachine casing. By acting on the control member, it is possible to vary the pitch angle of the vanes in the stage in question.

[0004] The variable-pitch vanes are thus positioned with only one degree of freedom by being pivoted about their guide pivot in the bushings. The bushings must therefore transmit to the inside ring of the casing, forces that act on the vane, and they must withstand friction against the guide pivot of the vane, i.e. they must provide both a low coefficient of friction and great resistance to wear.

[0005] In order to satisfy those requirements, when the guide pivots of variable-pitch vanes are made of steel, it is known to make the bushings out of a graphite-based material. In modern turbomachines, variable-pitch vanes are subjected to high levels of mechanical stress that lead to premature wear of their guide pivots. The vanes then need to be replaced after only a few thousand hours of operation, and that is becoming unacceptable in terms of cost.

OBJECT AND SUMMARY OF THE INVENTION

[0006] A main object of the present invention is thus to mitigate such drawbacks by proposing a vane and a bushing that enable a low coefficient of friction to be obtained together with high resistance to wear.

[0007] This object is achieved by a variable-pitch vane for a turbomachine compressor, the vane including a bushing mounted to pivot about a guide pivot of the vane and for mounting in a casing of the turbomachine, and in which, in accordance with the invention, the pivoting contact between the bushing and the guide pivot is of the nickel-graphite on titanium type.

[0008] The Applicant has found that the graphite acts as a solid lubricant during continuous friction, thereby providing a coefficient of friction that is relatively low, and that the friction between graphite and titanium leads to titanium carbide being formed on the roughness peaks, thereby ensuring good wear resistance between the bushing and the guide pivot of the vane. Thus, the lifetime of vanes, and in particular of their roots, is increased.

[0009] Several variant embodiments can be envisaged. In one embodiment of the invention, when the guide pivot is made of a titanium-based material, the bushing is constituted by a material based on nickel and on graphite. Under such circumstances, the bushing can be obtained by sintering a powder based on nickel and on graphite in a mold.

[0010] In another embodiment of the invention, when the guide pivot is not constituted by a titanium-based metal material, said guide pivot is covered in a nickel-graphite deposit and the bushing is made of a titanium-based material.

[0011] Alternatively, when the guide pivot is not constituted by a titanium-based metallic material, the vane may also include a metal ferrule covered in a nickel-graphite deposit and heat-shrunk onto the guide pivot, the bushing then being made of a titanium-based material.

[0012] In another alternative, still for a the guide pivot that is not made of a titanium-based metallic material, the vane may also include a ferrule made of a material based on nickel and on graphite, and heat-shrunk onto the guide pivot, the bushing then being made of a titanium-based material.

[0013] Whatever the embodiment selected, while nickel-graphite is being deposited, that can be done by thermally spraying a powder based on nickel and on graphite.

[0014] The invention also provides a turbomachine compressor and a turbomachine including a plurality of variable-pitch vanes as defined above.

BRIEF DESCRIPTION OF THE DRAWING

[0015] Other characteristics and advantages of the present invention appear from the following description made with reference to the accompanying drawings that show an embodiment having no limiting character. In the figures:

[0016] FIG. **1** is a section view of a variable-pitch vane of the invention; and

[0017] FIG. **2** is a fragmentary section view of a variable-pitch vane in a variant embodiment of the invention.

DETAILED DESCRIPTION OF EMBODIMENTS

[0018] With reference to FIG. **1**, the variable-pitch vanes **2** of the high pressure compressor of the turbomachine are distributed in circular stages disposed between stages of moving blades (not shown) that are secured to a rotor (not shown) of the turbomachine.

[0019] Each variable-pitch vane **2** of a circular stage is in the form of an airfoil **4** terminating at a radially outer end (or vane head) in a control pivot **6** (or top pivot), and at a radially inner end (or blade root) by a guide pivot **8** (or bottom pivot).

[0020] The control pivot **6** passes through a stator casing **10** of the turbomachine and co-operates with a member for controlling vane pitch. For this purpose, the control pivot **6** is terminated by a head **12** having engaged thereon one end of a control link **14** whose other end co-operates with a control ring **16**.

[0021] The links **14** and the control ring **16** form the member for controlling the pitch of the vanes. Turning the control ring **16** about the axis of the turbomachine serves to turn the control links **14** and thus modify simultaneously the pitch angle of all of the variable-pitch blades **2** in a given stage of the high pressure compressor.

[0022] The guide pivot **8** of the vane is designed to pivot inside a substantially cylindrical hollow bushing **8** forming a pivot support. Each bushing **18** is received in a recess **20** formed in an inside ring **22** of the turbomachine casing, the bushing and the recess being substantially complementary in shape.

[0023] According to the invention, the pivoting contact between the bushing **18** and the guide pivot **8** for the vane is of the nickel-graphite on titanium type.

[0024] A contact is said to be of the nickel-graphite on titanium type when the pivoting contact between the bushing **18** and the guide pivot **8** for the vane comprises a first contact surface and a second contact surface adjacent to the first, the first contact surface being constituted by a material based on nickel and on graphite, and the second contact surface being constituted by a material based on titanium.

[0025] In the conditions of use of continued pivoting contact between the bushing and the guide pivot, the pair of materials constituted by nickel-graphite and titanium presents performance that is extraordinary in terms of great resistance to wear and low coefficient of friction.

[0026] The pivoting contact between the bushing and the guide pivot goes through a running-in period characterized by initial friction between peaks of roughness on the NiGr and Ti surfaces. This friction leads to very high local heating, in particular of the titanium (which possesses a low coefficient of conductivity for heat). The very high temperature of the titanium associated with NiGr then leads to titanium carbide (TiC) forming, which becomes deposited on the contact surfaces between the bushing and the guide pivot, thus ensuring locally high hardness which limits the wear of the surfaces in contact.

[0027] Comparative tests have been performed for various pairs of materials under the same friction conditions and for the same durations. The table below summarizes the results obtained (the unit of measurement for the observed wear is arbitrary).

	NiGr wear	Opposing wear
NiGr and Waspalloy ®	0.9	1
NiGr and Ta6V	0.1	0.1

[0028] The Waspalloy® used for the first pair of materials in this test is a known alloy based on nickel. The titanium TA6V used in the second pair of materials in this test is a known alloy based on titanium and including aluminum and vanadium.

[0029] During testing, it was thus observed that the contacting surfaces of the bushing and the guide pivot of the vane became worn very little (nine to ten times less wear than for the NiGr on waspalloy® pair of materials).

[0030] Various implementations of such a nickel-graphite and titanium pair of materials can be envisaged in the invention, depending on the material used for making the vane and its guide pivot.

[0031] Thus, when the guide pivot **8** of the vane is constituted by a titanium-based material, the bushing **18** is constituted, in accordance with the invention, of a material based on nickel and graphite.

[0032] In this embodiment, the bushing can be obtained by sintering a powder based on nickel and graphite in a mold. One example of such a sintering method is known as metal-injection molding (MIM): it consists in injecting a powder based on nickel and graphite, and associated with an organic binder, into a mold, and then in chemically eliminating the organic binder once the bushing has been formed. Another example of such a sintering method is known as spark plasma sintering (SPS): compared with other sintering methods, the source of heat used in this method comes from an electric current passing through the presser enclosure (thus enabling fast temperature rise speeds to be obtained).

[0033] When the guide pivot **8** of the vane is not made of a titanium-based material (e.g. because it is made of a steel-based alloy), then, in accordance with the invention, the guide pivot can be covered in a deposit of nickel-graphite, in which case the bushing **18** is made of a titanium-based material.

[0034] Nickel-graphite can be deposited on the guide pivot of the vane by thermally spraying a powder based on nickel and graphite. For this purpose, a screen should preferably be used so that the angle between the trajectory of the sprayed powder and the tangent to the pivot at the point of impact is less than about 45°, in order to ensure proper adhesion of the powder on the pivot.

[0035] In an alternative shown in FIG. **2**, still for a guide pivot **8** that is not made of a titanium-based metallic material, the vane of the invention further includes a metal ferrule **24** that is covered in a deposit of nickel-graphite and heat-shrunk onto the guide pivot, the bushing **18** then being constituted by a titanium-based material.

[0036] In this embodiment, the nickel-graphite can be deposited on the ferrule **24** of the vane by thermally spraying a powder based on nickel and on graphite. For this purpose, a screen should preferably be used to ensure that the angle between the trajectory of the sprayed powder and the tangent to the ferrule at the point of impact is less than about 45°, in order to ensure proper adhesion of the powder on the ferrule.

[0037] In yet another alternative, that is not shown in the figures, and still for a guide pivot that is not constituted by a titanium-based metallic material, the vane of the invention further includes a ferrule that is made of a material based on nickel and on graphite and that is heat-shrunk onto the guide pivot, the bushing then being made of a titanium-based material.

[0038] Under such circumstances, the ferrule is advantageously obtained by sintering a powder based on nickel and on graphite in a mold using the above-described MIM or SPS methods.

What is claimed is:

1. A variable-pitch vane for a turbomachine compressor, the vane including a bushing mounted to pivot about a guide pivot of the vane and for mounting in a casing of the turbomachine, wherein the pivoting contact between the bushing and the guide pivot is of the nickel-graphite and titanium type.

2. A vane according to claim **1**, in which the guide pivot is made of a titanium-based material, wherein the bushing is constituted by a material based on nickel and on graphite.

3. A vane according to claim **2**, in which the bushing is obtained by sintering a powder based on nickel and on graphite in a mold.

4. A vane according to claim **1**, in which the guide pivot is not constituted by a titanium-based metallic material, wherein said guide pivot is covered by a deposit of nickel-graphite, and the bushing is constituted by a titanium-based material.

5. A vane according to claim **1**, in which the guide pivot is not constituted by a titanium-based metallic material, the vane further including a metal ferrule covered in a deposit of nickel-graphite and heat-shrunk on the guide pivot, the bushing being constituted by a titanium-based material.

6. A vane according to claim 1, in which the guide pivot is not constituted by a titanium-based metallic material, the vane further including a ferrule constituted by a material based on nickel and on graphite, and heat-shrunk onto the guide pivot, the bushing being constituted by a titanium-based material.

7. A vane according to claim 6, wherein the ferrule is obtained by sintering a powder based on nickel and on graphite in a mold.

8. A vane according to claim 4, wherein the nickel-graphite is deposited by thermally spraying a powder based on nickel and on graphite.

9. A turbomachine compressor, including a plurality of variable-pitch vanes according to claim 1.

10. A turbomachine, including a plurality of variable-pitch vanes according to claim 1.

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