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Description

The present invention relates to a vane for a rotary type compressor, and more particularly relates to such a compressor vane, made of a metallic material reinforced with short fiber material, which is improved so as to be outstanding in its strength and durability.

As is per se known, a rotary type compressor that includes vanes typically is basically composed of a hollow right cylindrical member that defines a compressor chamber with its inner right cylindrical surface (which often, typically, may not be circular cylindrical), a rotor member that rotates within said cylindrical compressor chamber about an axis parallel to the generators thereof (said axis being located either at the axial center of said compressor chamber, or not, depending upon constructional layout) and is formed with a plurality of generally radially extending vane receiving slots, and a plurality of vanes, each one of which is slidingly fitted in a one of said vane receiving slots with its outer edge extending generally parallel to the generators of the inner cylindrical surface defining the compressor chamber and in contact therewith. As the rotor member is rotated within the compressor chamber, the vanes of course rotate along therewith, and their outer edges, which stay in contact with said inner cylindrical surface defining the compressor chamber by said vanes sliding to an fro along the rotor member vane receiving slots in which they are fitted, define in cooperation with said cylindrical surface and said rotor member a plurality of pumping chambers which expand and contract in volume as the rotor member and the vanes thus rotate. In detail, considering a one of said pumping chambers, it expands in volume as it passes a portion of said cylindrical surface in which there is formed an intake port, and at this time said pumping chamber sucks a fluid which is to be pumped and compressed into itself through said intake port. Subsequently said one of said pumping chambers passes away from said portion of said cylindrical surface with said intake port and becomes isolated, and next said one of said pumping chambers contracts in volume and thereby compresses the quantity of said fluid entrapped therein. Finally, said one of said pumping chambers passes to a portion of said cylindrical surface in which there is formed an exhaust port, and at this time said pumping chamber squirts the compressed fluid within itself through said exhaust port. Thereby, as a whole, fluid is sucked into the compressor through said intake port, is compressed, and is then expelled in compressed form through said exhaust port; and thereby compression action for said fluid is maintained.

During the operation of such a vane type compressor, each of the vanes rotates at high speed with its outer edge portion in sliding contact with the compressor chamber inner cylindrical surface, which creates severe conditions of sliding friction; and at the same time said vane slides to and fro in the generally radially direction along the vane receiving slot in the rotor member in which it is fitted, and this sliding contact motion similarly creates severe conditions of sliding friction. This means that both the outer edges of the vanes and also the side surfaces thereof are all subjected to high friction operational regimes, and are liable to severe wear. For these reasons, conventional design practice has aimed at making such vanes light in weight, and, with the objective of ensuring the adequacy of the anti seizure characteristics, the anti scuffing characteristics, and the anti wear characteristics of the vanes, they have been conventionally manufactured from a high silicon type aluminum alloy such as the type AA standard A390. However, such aluminum alloy type vanes have been decidedly deficient with regard to anti wear characteristics, anti scuffing characteristics, and anti seizure characteristics, especially in view of the constantly more severe demands in terms of operational conditions and performance and also operating life made upon such a vane type compressor, and accordingly other solutions have been desired.

In order to meet this problem, in Japanese Patent Laying Open Publications Serial Nos. 58-91141 (1983) and 59-34496 (1984), neither of which is it intended hereby to admit as prior art to the present patent application except to the extent in any case required by applicable law, there was described a fiber reinforced metal compressor vane, in which the main or matrix metal was an alloy of aluminum and the reinforcing material was short carbon fiber material, and the concepts were further discussed that in such a compressor vane (a) the short carbon reinforcing fibers should be oriented substantially randomly in three dimensions; and (b) said short carbon reinforcing fibers should all be oriented substantially in the same direction, said direction being substantially perpendicular to the surfaces of the vane.

However, in the course of enhancing the performance of such compressors and making such compressors more and more compact, in the case of utilizing such high silicon alloy compressor vanes, or such fiber reinforced metal compressor vanes, the performance has been discovered to be currently inadequate with regard to anti wear characteristics and anti scuffing characteristics. Moreover, in making such vane type compressors more and more compact, the requirement has arisen for the vanes to be made extremely thin, and a further problem has developed with regard to the bending strength of the vanes. In detail, the outer edges and the inner edges of the vanes act as fulcrums with regard to stresses imposed on the vanes, and it is accordingly necessary that said outer edges and said inner edges of the vanes should be not only superior with regard to anti wear characteristics and anti scuffing characteristics, but also should be superior with regard to bending strength, in order to be able to withstand the bending stress imposed by the rotor member and so on. These demands upon the characteristics of such vanes for vane type compressors have become exceedingly severe, especially when considered together as a whole rather than each in isolation.

GB-A-1,324,443 describes a compressor vane made of a suitable material incorporating carbon fibres.

Summary of the invention

The inventors of the present invention have considered the various problems detailed above in the case of a vane for a vane type compressor, from the point of view of the desirability of increasing the operational performance of the compressor while decreasing its size and making it more compact and light in weight.

Accordingly, it is the primary object of the present invention to provide a fiber reinforced metal compressor vane, which avoids the problems detailed above.

It is a further object of the present invention to provide such a fiber reinforced metal compressor vane, which is endowed with superior frictional wear resistance characteristics.

It is a further object of the present invention to provide such a fiber reinforced metal compressor vane, which is endowed with such superior frictional wear resistance characteristics, in particular on its outer edge portion.

It is a further object of the present invention to provide such a fiber reinforced metal compressor vane, which is endowed with such superior frictional wear resistance characteristics in particular on its side surface portions, and especially upon the parts of said side surface portions thereof which slide in vane receiving grooves formed in the rotor member of the compressor.

It is a further object of the present invention to provide such a fiber reinforced metal compressor vane, which is endowed with superior scuffing resistance characteristics.

It is a further object of the present invention to provide such a fiber reinforced metal compressor vane, which is endowed with such superior scuffing resistance characteristics, in particular on its outer edge portion.

It is a further object of the present invention to provide such a fiber reinforced metal compressor vane, which is endowed with such superior scuffing resistance characteristics in particular on its side surface portions, and especially upon the parts of said side surface portions thereof which slide in vane receiving grooves formed in the rotor member of the compressor.

It is a further object of the present invention to provide such a fiber reinforced metal compressor vane, which is endowed with superior anti seizure characteristics.

It is a further object of the present invention to provide such a fiber reinforced metal compressor vane, which is endowed with such superior anti seizure characteristics, in particular on its outer edge portion.

It is a further object of the present invention to provide such a fiber reinforced metal compressor vane, which is endowed with such superior ainti seizure characteristics in particular on its side surface portions, especially upon the parts of said side surface portions thereof which slide in vane receiving grooves formed in the rotor member of the compressor.

It is a further object of the present invention to provide such a fiber reinforced metal compressor vane, which has particularly good bending strength.

It is a further object of the present invention to provide such a fiber reinforced metal compressor vane, which has such particularly good bending strength especially at its portions which are subjected with high bending stress during use.

It is a yet further object of the present invention to provide such a fiber reinforced metal compressor vane, which allows for a compressor incorporating it to have good durability.

It is a yet further object of the present invention to provide such a fiber reinforced metal compressor vane, which allows the compactness of a compressor incorporating it to be enhanced.

It is a yet further object of the present invention to provide such a fiber reinforced metal compressor vane, which allows the pumping capacity of a compressor incorporating it to be enhanced, without particularly requiring said compressor to be increased in size or weight.

It is a yet further object of the present invention to provide such a fiber reinforced metal compressor vane, which is itself light in weight.

The invention provides a vane of a vane-type compressor having the features of the characterising clause of Claim 1.

According to such a fiber reinforced metal compressor vane as specified above, since the orientation of the fibers of said reinforcing short fiber material, when said vane is fitted to said rotor of said compressor, is generally two dimensionally random and isotropic in planes perpendicular both to said opposite side surfaces thereof and also to said edge portion thereof and thus substantially perpendicular to the longitudinal direction of said rotor, thereby these reinforcing short fibers, where they meet said opposite side surfaces and said edge portion of said rotor, are overall on average angled at the maximum amount with respect to said surfaces of said vane, which are the surfaces of said vane which particularly undergo sliding friction during use of the compressor. By « overall » it is meant that other orientations for the reinforcing short fibers might increase the average angle which said reinforcing short fibers might make at one of these surfaces, but only at the expense of the average angle which said reinforcing short fibers might make at the other of said surfaces ; the specified orientation for the reinforcing short fiber

material is the one which maximizes the minimum average angle which said reinforcing short fibers make at both of these surfaces. Consequently, the anti wear characteristics and the anti scuffing and anti seizure characteristics of this vane and the compressor incorporating it are significantly enhanced. Further, since the reinforcing short fibers are generally oriented on planes which are perpendicular to the direction (taken as a vector) of the bending stress to which the vane is subjected by the rotor during use of the compressor, thereby there is made possible a significant improvement in the bending strength of the vane, which further increases its durability.

Thereby, as a whole, the durability of a compressor including this vane is notably enhanced, and, further, since it becomes possible to reduce the thickness of the vane in accordance with the improved characteristics thereof, thereby the swept volume of the compression or pumping chambers of the compressor can be significantly increased, without making the compressor as a whole more bulky or heavier. As a result, the pumping capacity of the compressor can be desirably enhanced to a significant extent.

According to a particular specialization of the present invention, the above and other objects may more particularly be accomplished by a fiber reinforced metal compressor vane of either of the types specified above, wherein said matrix metal is magnesium alloy, or alternatively is aluminum alloy. This facilitates making the vanes as light as possible. Further, the reinforcing fiber material may be alumina short fiber material, or alumina-silica short fiber material (possibly including a substantial crystalline content, which may be mullite crystalline content), or silicon carbide whisker material, or silicon nitride whisker material. An the volume proportion of said reinforcing fiber material may be from about 5 % to about 50 %.

Brief description of the drawings

The present invention will now be described with respect to the preferred embodiments thereof, and with reference to the illustrative drawings appended hereto, which however are provided for the purposes of explanation and exemplification only, and are not intended to be limitative of the scope of the present invention in any way, since this scope is to be delimited solely by the accompanying claims. With relation to the figures, spatial terms are to be understood as referring only to the orientation on the drawing paper of the illustrations of the relevant elements, unless otherwise specified ; like reference numerals, unless otherwise so specified, denote the same elements and so on in the various figures relating to one preferred embodiment, and like elements and so on in figures relating to different preferred embodiments ; and :

Fig. 1 is a schematic longitudinal skeleton view of a vane type compressor suitable for incorporating any one of the preferred embodiments of the fiber reinforced metal compressor vane of the present invention ;

Fig. 2 is a schematic enlarged perspective view showing a fiber reinforced metal compressor vane for said Fig. 1 compressor, said compressor vane being according to any on of the preferred embodiments of the present invention ;

Fig. 3 is a perspective view showing a preform made of short reinforcing fiber material, suitable for being used for making a fiber reinforced metal compressor vane according to the present invention, with the orientation of the short fibers of which said fiber preform is composed being generally two dimensionally isotropically random in planes perpendicular to the axis thereof designated as « Y » ;

Fig. 4 is similar to Fig. 3, being a perspective view showing a preform made of short reinforcing fiber material, suitable for being used for making a first comparison fiber reinforced metal compressor vane not according to the present invention, with the orientation of the short fibers of which said fiber preform is composed being generally two dimensionally isotropically random in planes perpendicular to the axis thereof designated as « X » ;

Fig. 5 is similar to Figs. 3 and 4, being a perspective view showing a preform made of short reinforcing fiber material, suitable for being used for making a second comparison fiber reinforced metal compressor vane also not according to the present invention, with the orientation of the short fibers of which said fiber preform is composed being generally two dimensionally isotropically random in planes perpendicular to the axis thereof designated as « Z » ; and :

Fig. 6 is similar to Figs. 3 through 5, being a perspective view showing a preform made of short reinforcing fiber material, suitable for being used for making a third comparison fiber reinforced metal compressor vane also not according to the present invention, with the orientation of the short fibers of which said fiber preform is composed being generally isotropically random in three dimensions.

Description of the preferred embodiments

The present invention will now be described with reference to the preferred embodiments thereof, and with reference to the figures.

General Construction of a Vane Type Compressor

In Fig. 1, there is shown a schematic longitudinal skeleton view of a vane type compressor, which is of the type discussed earlier in this specification, and which is suitable for incorporating any one of the preferred embodiments of the fiber reinforced metal compressor vane of the present invention which will be described hereinafter; and Fig. 2 shows a vane incorporated therein in enlarged perspective view. Therefore, before description of any of the preferred embodiment compressor vanes, a general description of the construction and the functioning of such a vane type compressor will be given, in order to place into context the requirements upon the fiber reinforced metal compressor vane of the present invention with regard to bending strength, wear resistance, scuffing resistance, and the like.

Referring to Fig. 1, the reference numeral 2 denotes a hollow cylinder member of the compressor, and this hollow cylinder member 2 is received in the central cavity of an outer casing member 4. This hollow cylinder member 2 is formed as a right cylindrical body which has a right cylindrical inner surface 8 which defines within it a cylinder chamber space. This inner surface 8, which extends in a direction perpendicular to the drawing paper in Fig. 1, however is not a circular cylinder, but rather its cross sectional shape is generally formed as approximately elliptical. The central axis of symmetry 6 of the inner surface 8 of the hollow cylinder member 2 is denoted as 6 in the drawing, and this axis of symmetry 6 also extends in a direction perpendicular to the drawing paper in Fig. 1, since the entire construction is right cylindrical.

Through the inner surface 8 of the hollow cylinder member 2, at diametrically opposite sides thereof with respect to the axis of symmetry 6 of said cylindrical inner surface 8, there open a pair of inlet ports 10 and 12. The inlet port 10 communicates to an inlet plenum 14, and similarly the other inlet port 12 communicates to another inlet plenum 16. Although such arrangements are not particularly shown in the figure, the two inlet plenums 14 and 16 may typically be communicated together and then may be connected to an inlet side of the compressor as a whole, for sucking fluid to be compressed from a source thereof. Similarly, through said inner surface 8 of the hollow cylinder member 2, at diametrically opposite sides thereof with respect to said axis of symmetry 6 of said cylindrical inner surface 8, there open a pair of outlet ports 18 and 20. The outlet port 18 communicates to an outlet plenum 22, and similarly the other outlet port 20 communicates to another outlet plenum 24. Although such arrangements are not particularly shown in the figure, the two outlet plenums 22 and 24 may typically be communicated together and then may be connected to an outlet side of the compressor as a whole, for expelling fluid which has been compressed towards a device for receipt thereof. In fact, a pair of one way valves are provided, one to each of said outlet ports 18 and 20, for allowing flow of fluid therethrough only in the direction from the cylinder chamber space defined within the inner surface 8 of the hollow cylinder member 2 towards the respective outlet plenums 22 and 24, and not in the reverse directions; however, such arrangements also are not particularly shown in the figure.

A substantially circular cylindrical rotor member 26 is mounted within said cylinder chamber space defined in said hollow cylinder member 2, so as to be rotatable about the axis of symmetry 6 of the inner surface 8 of said hollow cylinder member 2. This rotor member 26 is formed with four vane receiving slots designated as 28a through 28d, each of which extends substantially longitudinally along the rotor member 26 and thus in a plane also substantially perpendicular to the drawing paper in Fig. 1 and substantially parallel to the axis of symmetry 6 of the construction although in fact not actually including said axis of symmetry 6. The planes of the two vane receiving slots 28a and 28c are parallel to one another and are set at an angle of 90° with respect to the planes of the other two vane receiving slots 28b and 28d which also are parallel to one another. Thus, the four vane receiving slots 28a through 28d extend in the longitudinal direction of the rotor member 26 and also generally in the radial direction of said rotor member 26 although in fact somewhat offset therefrom. In each of said four vane receiving slots 28a through 28d there is slidably fitted a corresponding one of four vanes 36a through 36d, each of which is formed as a slab member, i.e. generally as a rectangular parallelopiped or cuboid whose dimension in the circumferential direction of the construction is relatively small, whose dimension in the radial direction of the construction is intermediate, and whose dimension in the longitudinal direction of the construction is relatively large. The outer edges of these four vanes 36a through 36d are respectively denoted by the reference symbols 40a through 40d; the trailing sides (with respect to the preferred direction of rotation of the rotor member 26 and the vanes 36a through 36d as shown by an arrow in Fig. 1) of the four vanes 36a through 36d are respectively denoted by the reference symbols 42a through 42d; and the leading sides with respect to said preferred direction of rotation of the four vanes 36a through 36d are respectively denoted by the reference symbols 44a through 44d. This nomenclature and these relative dimensions are best appreciated by consideration of Fig. 2, which shows such a vane, particularly one according to the present invention as will be described later, in enlarged perspective view.

Operation of this Vane type Compressor

Thus, as the rotor member 26 rotates, it naturally carries the four vanes 36a through 36d around with it, since they are slidably fitted into the four vane receiving slots 28a through 28d formed in said rotor member 26. The action of centrifugal force therefore keeps said four vanes 36a through 36d biased in the

respective radially outward directions, so that their outer edges 40a through 40d are kept pressed against the inner surface 8 of the hollow cylinder member 2 and form relatively good seals thereagainst, while said one of said four vanes 36a through 36d slides to and fro in its one of the four vane receiving slots 28a through 28d, its sides 42 and 44 at this time performing rubbing action each on its side of said one of said four vane receiving slots 28a through 28d. Thus, four variable volume pumping chambers 38 are defined around the rotor member 26 between adjacent pairs of said four vanes 36a through 36d, the rotor member 26, and said inner surface 8 of said hollow cylinder member 2. To consider the action in detail, as the rotor member 26 and the four vanes 36a through 36d rotate, and considering an exemplary one of these variable volume pumping chambers 38 : said variable volume pumping chamber 38 moves around the inner surface 8 of the hollow cylinder member 2 in the counterclockwise direction as seen in the figure, and first at the start of its pumping cycle its leading edge portion comes to correspond to one of the inlet ports 10 and 12 — here let us assume that that one is the inlet port 10 — and thereafter said variable volume pumping chamber 38 expands in volume as it passes past said inlet port 10, to reach a substantially maximum volume as its trailing edge portion comes to pass said inlet port 10 ; thereby a quantity of fluid to be compressed is sucked into said variable volume pumping chamber 38 through the inlet plenum 14 and said inlet port 10. Next, this variable volume pumping chamber 38 is reduced in volume, thus compressing the fluid just inducted thereinto, and then the leading edge portion thereof comes to correspond to one of the outlet ports 18 and 20 — actually the outlet port 20 in this case — and thereafter said variable volume pumping chamber 38 further reduces in volume as it passes past said outlet port 20. At an appropriate time point the one way valve not shown in the figure for said outlet port 20 is opened by an appropriate means therefor, so as to allow the compressed fluid in the variable volume pumping chamber 38 to be expelled therefrom through said outlet port 20 and the outlet plenum 24. And the variable volume pumping chamber 38 reaches a substantially minimum volume as its trailing edge portion comes to pass said outlet port 20. And then this cycle is repeated. Thereby, fluid is sucked in from the inlet plenums 14 and 16, is compressed, and is expelled at relatively high pressure via the outlet plenums 22 and 24.

During this action, the four vanes 36a through 36d are subjected to very severe conditions of frictional wear, both due to the rubbing of their outer edges 40a through 40d against the inner surface 8 of the hollow cylinder member 2, and also due to the sliding of their sides 42a through 42d and 44a through 44d against the sides of the four vane receiving slots 28a through 28d. Such severe frictional wear conditions can cause scuffing of the relevant surfaces against one another, or, in the worst case, mutual seizure thereof. And, furthermore, the outer and inner edges of each such vane 36a through 36d function as fulcrums to receive the bending stress imparted from the outer edge of the respective one of the four vane receiving slots 28a through 28d, and this subjects the four vanes 36a through 36d to very severe conditions of bending strain. Because of these various severe conditions to which the four vanes 36a through 36d are subjected, the requirements for their endurance have been made more and more demanding, which has given rise to the particular composition for said four vanes 36a through 36d according to the present invention, now to be explained.

The Vane of the Present Invention

Fig. 2 is a schematic enlarged perspective view showing a fiber reinforced metal compressor vane for said Fig. 1 compressor, said compressor vane being according to any one of the preferred embodiments of the present invention. This vane, denoted as 36, is manufactured from a composite material which is made up from a matrix of metal such as for example aluminum alloy or magnesium alloy, reinforced by short fiber material such as for example alumina-silica fibers or the like, with the particular feature, according to the concept of the present invention, that the orientation of the short fibers (denoted by the reference symbol 46) of said reinforcing short fiber material is such that they are oriented substantially randomly and isotropically in two dimensions, and substantially lie in planes perpendicular to the axial line 6 of the compressor to which they are to be fitted. In other words, according to the nomenclature shown in the figure, the outer edge portion of the vane 36 which slides against the inner surface 8 of the hollow cylinder member 2 is designated as 40 and the two sides of said vane 36 which slide against the sides of the vane receiving slot 28 formed in the rotor member 26 for this vane 36 are designated as 42 and 44, and the axes as shown in the figure are as follows : the X axis is in the direction perpendicular to said two sides 42 and 44 of said vane 36, i.e. is in the direction circumferential to the rotor member 26 of the compressor when this vane 36 is fitted to said compressor ; the Y axis is in the direction parallel to said outer edge 40 of said vane 36, i.e. is in the direction longitudinal to the rotor member 26 of the compressor when this vane 36 is fitted to said compressor · and the Z axis is in the direction parallel to said two sides 42 and 44 and perpendicular to said outer edge 40 of said vane 36, i.e. is in the direction radial to the rotor member 26 of the compressor when this vane 36 is fitted to said compressor. And, according to the particular concept of the present invention, the orientation of the short fibers 46 of the reinforcing short fiber material is such that they are oriented substantially two dimensionally randomly and isotropically in planes parallel to the X-Z plane, and however substantially all extend perpendicular to the Y axis.

As a result of this orientation of the short fibers 46, the average orientation of said short fibers 46 where they reach the surface of the vane 36, both at the outer edge 40 of said vane 36 and at the two side

surfaces 42 and 44 of said vane 36, is maximized : i.e. the average angle at which said short fibers 46 meet said various surfaces 40, 42 and 44 is maximized. Thereby, the anti wear characteristics of said outer edge 40 and said two side surfaces 42 and 44 of said vane 36 are as a whole maximized, as are their anti scuffing characteristics and their anti seizure characteristics. Further, according to this orientation of the short fibers 46 of the fiber reinforcing material according to the present invention, since said short fibers are substantially oriented to lie in planes which are extended in the direction of the bending stress which the vane 36 receives from the rotor member 26, the bending strength characteristics of this vane 36 are also notably excellent. That is to say, speaking in vector and/or tensor terms, the twisting stress to which the vane 36 is subjected as the compressor rotor member 26 rotates can be represented by a vector field whose elements all extend substantially longitudinally to said rotor member 26, i.e. in the direction of the Y axis as seen in Fig. 2, and therefore, because the short fibers 46 of the reinforcing short fiber material all lie so as to extend perpendicular to the Y axis, i.e. all extend substantially two dimensionally randomly and isotropically in planes parallel to the X-Z plane, therefore the resistance which they offer to said bending stress is substantially maximal.

The First Preferred Embodiment, and Comparison Examples

Now, the first preferred embodiment of the fiber reinforced metal compressor vane of the present invention will be described in concrete terms, along with comparison examples, with reference to Figs. 3 through 6.

First, a quantity of crystalline alumina-silica short fiber material was prepared in the following manner. The starting material was a quantity of non-crystalline (amorphous) short fiber material of the type « Kaowool » (this is a trade mark) made by Isolite Babcock Taika K.K., which had average fiber length of approximately 1 mm and average fiber diameter of approximately 3 microns, and which was composed of approximately 48 % by weight Al_2O_3 and balance substantially SiO_2. This starting material was then subjected to heat treatment, so that approximately 60 % by weight of it was converted to the mullite crystalline form.

Then, from this crystalline alumina-silica short fiber material, there were prepared, using colloidal silica as a binder, four different short fiber material preforms, shown in Figs. 3 through 6 and designated as 50, 52, 54, and 56. Each of these preforms 50, 52, 54, and 56 had approximate dimensions 98 mm × 50 mm × 200 mm, and had fiber volume proportion of approximately 15 %, and the orientations of the short fibers in each preform were as will now be described, taking the X axis as the 50 mm axis, the Y axis as the 98 mm axis, and the Z axis as the 200 mm axis (these axes correspond to the axes of the finished vanes made from these preforms as shown in Fig. 2). The first such preform 50 had the short fibers 46 of the short fiber reinforcing material thereof lying generally two dimensionally randomly and isotropically in planes perpendicular to the Y axis, i.e. extending parellel to the X-Z plane (hereinafter referred to as orientation A) ; the second such preform 52 had the short fibers 46 of the short fiber reinforcing material thereof lying generally two dimensionally randomly and isotropically in planes perpendicular to the X axis, i.e. extending parallel to the Y-Z plane (hereinafter referred to as orientation B) ; the third such preform 54 had the short fibers 46 of the short fiber reinforcing material thereof lying generally two dimensionally randomly and isotropically in planes perpendicular to the Z axis, i.e. extending parallel to the X-Y plane (hereinafter referred to as orientation C) ; and the fourth such preform 56 had the short fibers 46 of the short fiber reinforcing material thereof lying generally three dimensionally randomly and completely isotropically in all directions (hereinafter referred to as orientation D). These preforms were manufactured by per se conventional methods which will not be particularly discussed herein.

Next, each of these four preforms 50, 52, 54, and 56 was subjected to a high pressure casting process, which is not shown in any illustration because it is also per se conventionally known, as follows. First, the preform was heated up to a temperature of approximately 600 °C, and then it was placed in a cavity of a casting mold, which itself was maintained at a temperature of approximately 250 °C. Then a quantity of molten aluminium alloy of type JIS standard AC1A, at a temperature of approximately 710 °C, for serving as a matrix metal, was poured into said mold cavity over and around the preform, to substantially completely cover it, and then a pressure plunger, itself heated up to a temperature of approximately 200 °C, was slidingly inserted into said mold cavity so as closely to cooperate therewith, and was pressed strongly downwards on the surface of the molten aluminium alloy, so as to pressurize said molten aluminium alloy matrix metal to a pressure of approximately 1000 kg/cm^2. Thereby the molten aluminium alloy matrix metal was pressed into the interstices of the preform, so as thoroughly to infiltrate between all of the short fibers 46 thereof. And the pressure plunger was maintained in this condition until the aluminium alloy matrix metal had completely solidified. After said aluminium alloy matrix metal had thus completely solidified, the resultant cast form was removed from the casting mold, and was cut down so as to produce a piece of composite material, with the peripheral portions consisting substantially only of the original aluminum alloy matrix material without any admixture of reinforcing fibers having been machined away.

Next, each of these pieces of composite material was processed, first by liquidization processing for a time period of approximately six hours at a temperature of approximately 500 °C, and then by artificial

aging processing for a time period of approximately six hours at a temperature of approximately 180 °C. Then, the resulting material pieces were machined using per se conventional processes such as shaving and the like, so as to form a set of four vanes such as shown in Fig. 2, and particularly each with X, Y, and Z axes as shown in Fig. 2 corresponding to the X, Y, and Z axes respectively of the preform used as shown in the appropriate one of Figs. 3 through 6. In fact, as will be easily understood based upon the above explanations and the claims of the present patent application, the one of these vanes, the reinforcing fibers of which had orientation A, was an embodiment — the first preferred embodiment — of the present invention, while on the other hand the three of these vanes, the reinforcing fibers of which had orientations B, C, and D respectively, were not embodiments of the present invention, but on the contrary were comparison samples.

Each of these vanes 36 in turn was fitted to a compressor of the general type shown in Fig. 1, and assessment tests were conducted to evaluate the bending strength characteristic, the wear resistance characteristic, and the scuffing and seizure resistance characteristics thereof. In detail, the material which was used for the rotor member 26 and for the hollow cylinder member 2 of the compressor was a high silicon type aluminium alloy of type JIS A390, and the assessment of the bending strength characteristic of each of the vanes 36 was performed by rapidly compressing a liquidized coolant substance and thus conducting liquid compression tests to establish the durability of the vanes 36 under these conditions. Further, the assessment of the wear resistance characteristic of each of the vanes 36 was performed by operating the compressor for a prescribed relatively long time period at a prescribed relatively high rotational speed, and by under these operational conditions checking the wear amount of the outer edge portion 40 of the vane 36 which had slid against the inner cylindrical surface 8 of the cylinder member 2 of the compressor, thus establishing the wear resistance characteristics of the vanes 36 under these conditions. Moreover, in these same tests, the sides 42 and 44 of the vanes 36, which had slid against the sides of the vane receiving grooves 28 in which said vanes 36 were fitted, were also checked, thereby not only further to establish the wear resistance characteristics of the vanes 36 under these conditions, but also to evaluate the anti scuffing characteristics and the anti seizure characteristics of said vanes 36.

The results of these tests are shown in the following Table. In this Table, the columns « Anti wear characteristic I » and « Anti wear characteristic II » refer to the anti wear characteristics of the two sides 42 and 44 of the vanes 36, and to the anti wear characteristics of the edge portions 40 of the vanes 36, respectively ; and an « O » indicates that the corresponding characteristic was at an outstanding and acceptable level, while on the other hand an « X » indicates that the corresponding characteristic was at an unsatisfactory level.

Table

Fiber Orientation	Bending Strength	Anti-wear Characteristic I	Anti-wear Characteristic II
A	O	O	O
B	O	X	O
C	X	O	X
D	X	X	X

As will be clear from the above Table, the vane whose constituent short reinforcing fibers had fiber orientation A, i.e. the first preferred embodiment of the fiber reinforced metal compressor vane of the present invention, was clearly superior in overall characteristics to the other three vanes, whose constituent short reinforcing fibers had fiber orientations B, C, and D, i.e. the first through the third comparison example vanes. In other words, each of these first through third comparison example vanes was deficient in one or more required performance characteristics, and only the first preferred embodiment of the fiber reinforced metal compressor vane of the present invention was satisfactory with regard to all of : bending strength characteristic, anti wear characteristics of its two sides 42 and 44, and anti wear characteristic of its edge portion 40, as well as being satisfactory with regard to the scuffing and seizure resistance characteristics thereof.

The Second preferred Embodiment, and Comparison Examples

Now, the second preferred embodiment of the fiber reinforces metal compressor vane of the present invention will be described in concrete terms, along with other comparison examples. In this second preferred embodiment and its comparison samples, the reinforcing material used was a quantity of alumina short fiber material of a type made by ICI K.K., which had average fiber length of approximately

1 mm and average fiber diameter of approximately 3 microns, and which was composed of approximately 95 % by weight Al_2O_3 and balance substantially SiO_2. From this alumina short fiber material there were prepared, substantially as before except that the fiber volume proportions were now approximately 7 % in each case, four different short fiber material preforms, again as shown in Figs. 3 through 6 with the same approximate dimensions as before, and with the same orientations of the short fibers in each preform. Again, these four preforms were manufactured by per se conventional methods which will not be particularly discussed herein.

Next, each of these four preforms 50, 52, 54, and 56 was subjected to a high pressure casting process, substantially as before except that the matrix metal utilized was a magnesium alloy of type JIS standard MC2. The particular details of this casting process, and of the subsequent processing steps for the resultant pieces of composite material, will not be particularly discussed herein, since they are similar or identical to those practiced for the first preferred embodiment and for its comparison samples, and in any case are per se conventional. The resulting material pieces were, as before, machined using per se conventional processes such as shaving and the like, so as to form four vanes such as shown in Fig. 2, corresponding to the preforms as shown in the appropriate ones of Figs. 3 through 6. Again, the one of these vanes, the reinforcing fibers of which had orientation A, was an embodiment — the second preferred embodiment — of the present invention, while on the other hand the other three of these vanes, the reinforcing fibers of which had orientations B, C, and D respectively, were not embodiments of the present invention, but on the contrary were a second set of comparison samples.

Each of these vanes 36 in turn was subjected to assessment tests to evaluate the bending strength characteristic, the wear resistance characteristic, and the scuffing and seizure resistance characteristics thereof, of the same general nature as in the case of the first preferred embodiment and of its comparison examples, detailed above. In this case, the materials which were used for the rotor member 26 and for the hollow cylinder member 2 of the compressor were, respectively, a high silicon type aluminium alloy of type JIS A390, and a tempered chromium steel of type JIS standard SCr20.

The results of these tests will not be detailed at length herein, in view of the desirability of conciseness of disclosure ; suffice it to say as a summary that the vane whose constituent short reinforcing fibers had fiber orientation A, i.e. the second preferred embodiment of the fiber reinforced metal compressor vane of the present invention, was clearly superior in overall characteristics to the other three vanes, whose constituent short reinforcing fibers had fiber orientations B, C, and D, i.e. these first through third comparison example vanes. In other words, each of these first through third comparison example vanes was deficient in one or more required performance characteristics, and only the second preferred embodiment of the fiber reinforced metal compressor vane of the present invention was satisfactory with regard to all of : bending strength characteristic, anti wear characteristics of its two sides 42 and 44, and anti wear characteristic of its edge portion 40, as well as being satisfactory with regard to the scuffing and seizure resistance characteristics thereof.

The Third preferred Embodiment, and Comparison Examples

Now, the third preferred embodiment of the fiber reinforced metal compressor vane of the present invention will be described in concrete terms, along with other comparison examples. In this third preferred embodiment and its comparison samples, the reinforcing material used was a quantity of silicon carbide whisker material of a type made by Tokai Carbon K.K., which had average fiber length of approximately 100 microns and average fiber diameter of approximately 0.3 microns. From this silicon carbide whisker material there were prepared, substantially as before except that the fiber volume proportions were now approximately 25 % in each case, four different whisker material preforms, again as shown in Figs. 3 through 6 with the same approximate dimensions as before, and with the same orientations of the whiskers in each preform. Again, these four preforms were manufactured by per se conventional methods which will not be particularly discussed herein.

Next, each of these four preforms 50, 52, 54, and 56 was subjected to a high pressure casting process, substantially as before except that the matrix metal utilized was now an aluminium alloy of type JIS standard AC7A. The particular details of this casting process, and of the subsequent processing steps for the resultant pieces of composite material, will not be particularly discussed herein, since they are similar or identical to those practiced for the first and second preferred embodiments and for their comparison samples, and in any case are per se conventional. The resulting material pieces were, as before, machined using per se conventional processes such as shaving and the like, so as to form four vanes such as shown in Fig. 2, corresponding to the preforms as shown in the appropriate ones of Figs. 3 through 6. Again, the one of these vanes, the reinforcing fibers of which had orientation A, was an embodiment — the third preferred embodiment — of the present invention, while on the other hand the other three of these vanes, the reinforcing fibers of which had orientations B, C, and D respectively, were not embodiments of the present invention, but on the contrary were a second set of comparison samples.

Each of these vanes 36 in turn was subjected to assessment tests to evaluate the bending strength characteristic, the wear resistance characteristic, and the scuffing and seizure resistance characteristics thereof, of the same general nature as in the case of the first preferred embodiment and of its comparison examples, detailed above. In this case, the material which was used for the rotor member 26 and for the

hollow cylinder member 2 of the compressor was in both cases a high silicon type aluminium alloy of type JIS A390.

The results of these tests again will not be detailed at length herein, in view of the desirability of conciseness of disclosure ; suffice it to say again as a summary that the vane whose constituent short reinforcing fibers had fiber orientation A, i.e. the third preferred embodiment of the fiber reinforced metal compressor vane of the present invention, was clearly superior in overall characteristics to the other three vanes, whose constituent short reinforcing fibers had fiber orientations B, C, and D, i.e. these first through third comparison example vanes. In other words, each of these first through third comparison example vanes was deficient in one or more required performance characteristics, and only the third preferred embodiment of the fiber reinforced metal compressor vane of the present invention was satisfactory with regard to all of : bending strength characteristic, anti wear characteristics of its two sides 42 and 44, and anti wear characteristic of its edge portion 40, as well as being satisfactory with regard to the scuffing and seizure resistance characteristics thereof.

The Fourth preferred Embodiment, and Comparison Examples

Now, the fourth preferred embodiment of the fiber reinforced metal compressor vane of the present invention will be described in concrete terms, along with other comparison examples. In this fourth preferred embodiment and its comparison samples, the reinforcing material used was a quantity of silicon nitride whisker material of a type made by Tateho Chemical K.K., which had average fiber length of approximately 100 microns and average fiber diameter of approximately 1 micron. From this silicon nitride whisker material there were prepared, substantially as before except that the fiber volume proportions were now approximately 40 % in each case, four different whisker material preforms, again as shown in Figs. 3 through 6 with the same approximate dimensions as before, and with the same orientations of the whiskers in each preform. Again, these four preforms were manufactured by per se conventional methods which will not be particularly discussed herein.

Next, each of these four preforms 50, 52, 54, and 56 was subjected to a high pressure casting process, substantially as before except that the matrix metal utilized was now an aluminium alloy of type JIS standard AC8A. The particular details of this casting process, and of the subsequent processing steps for the resultant pieces of composite material, will not be particularly discussed herein, since they are similar or identical to those practiced for the first through the third preferred embodiments and for their comparison samples, and in any case are per se conventional. The resulting material pieces were, as before, machined using per se conventional processes such as shaving and the like, so as to form four vanes such as shown in Fig. 2, corresponding to the preforms as shown in the appropriate ones of Figs. 3 through 6. Again, the one of these vanes, the reinforcing fibers of which had orientation A, was an embodiment — the fourth preferred embodiment — of the present invention, while on the other hand the other three of these vanes, the reinforcing fibers of which had orientations B, C, and D respectively, were not embodiments of the present invention, but on the contrary were a second set of comparison samples.

Each of these vanes 36 in turn was subjected to assessment tests to evaluate the bending strength characteristic, the wear resistance characteristic, and the scuffing and seizure resistance characteristics thereof, of the same general nature as in the case of the first preferred embodiment and of its comparison examples, detailed above. In this case, again, the material which was used for the rotor member 26 and for the hollow cylinder member 2 of the compressor was in both cases a high silicon type aluminium alloy of type JIS A390.

The results of these tests again will not be detailed at length herein, in view of the desirability of conciseness of disclosure ; suffice it to say again as a summary that the vane whose constituent short reinforcing fibers had fiber orientation A, i.e. the fourth preferred embodiment of the fiber reinforced metal compressor vane of the present invention, was clearly superior in overall characteristics to the other three vanes, whose constituent short reinforcing fibers had fiber orientations B, C, and D, i.e. these first through third comparison example vanes. In other words, each of these first through third comparison example vanes was deficient in one or more required performance characteristics, and only the fourth preferred embodiment of the fiber reinforced metal compressor vane of the present invention was satisfactory with regard to all of : bending strength characteristic, anti wear characteristics of its two sides 42 and 44, and anti wear characteristic of its edge portion 40, as well as being satisfactory with regard to the scuffing and seizure resistance characteristics thereof.

Conclusion

This fiber reinforced metal compressor vane according to the present invention, in its various preferred embodiments, was thus shown to have superior performance characteristics with regard to bending strength characteristic, anti wear characteristics of its two sides, anti wear characteristic of its edge portion, and also anti scuffing characteristic and anti seizure characteristic. It is considered to have been amply demonstrated, in the light of the various comparison examples, that this overall improvement in performance characteristics is due to the choice of orientation for the reinforcing fibers incorporated in the material of said compressor vanes. This is thought to be because, according to such a fiber reinforced

metal compressor vane as specified in the claims to this patent application, since the orientation of the fibers of said reinforcing short fiber material, when said vane is fitted to the compressor rotor, is generally two dimensionally random and isotropic in planes perpendicular both to the opposite side surfaces thereof and also to the edge portion thereof and thus substantially perpendicular to the longitudinal direction of said rotor, thereby these reinforcing short fibers, where they meet said opposide side surfaces and said edge portion of said rotor, are overall on average angled at the maximum amount with respect to said surfaces of said vane, which are the surfaces of said vane which particularly undergo sliding friction during use of the compressor. That is to say, other orientations for the reinforcing short fibers might increase the average angle which said reinforcing short fibers might make at one of these surfaces, but only at the expense of the average angle which said reinforcing short fibers might make at the other of said surfaces ; the specified orientation for the reinforcing short fiber material is the one which maximizes the minimum average angle which said reinforcing short fibers make at both of these surfaces. It is considered to be a consequence for the anti wear characteristics and the anti scuffing and anti seizure characteristics of this vane and the compressor incorporating it to have been significantly enhanced ; and this was verified by the experimental tests detailed above. Further, since the reinforcing short fibers are generally oriented on planes which are perpendicular to the direction (taken as a vector) of the bending stress to which the vane is subjected by the rotor during use of the compressor, it is considered that this is the reason for the demonstrated significant improvement in the bending strength of the vane, which as a matter of course further increases its durability. Thereby, as a whole, the durability of a compressor including this vane is notably enhanced, and, since further it becomes possible to reduce the thickness of the vane in accordance with the improved characteristics thereof, thereby the swept volume of the compression or pumping chambers of the compressor can be significantly increased, without making the compressor as a whole more bulky or heavier. As a result, the pumping capacity of the compressor can be desirably enhanced to a significant extent.

Claims

1. A vane of a vane-type compressor in which a rotor (26) formed with a slot (28a-28d) extending generally in radial and longitudinal directions thereof to have opposite substantially mutually parallel side surfaces and bearing a generally rectangular parallelopipedal slab shaped vane (36, 36a-36d) having substantially mutually parallel opposite side surfaces (42, 44, 42a-42d, 44a-44d) as received in said slot to be slidable at said opposite side surfaces thereof against said side surfaces of said slot as the rotor rotates about a longitudinal axis thereof in a housing (2) with an outer edge (40, 40a-40d) of said vane extending substantially in parallel with said longitudinal axis of said rotor being in sliding contact with a curved inner surface (8) of said housing so that said vane moves in radial directions in said slot when said rotor rotates about said longitudinal axis thereof in said housing, said vane being made of a matrix of metal reinforced with short fibers (46), characterised in that said short fibers are generally orientated to be two dimensionally randomly isotropic in planes substantially perpendicular to said opposite side surfaces (42, 44, 42a-42d, 44a-44d) and said outer edge (40, 40a-40d) of said vane.

2. A fiber reinforced metal compressor vane according to Claim 1, wherein said matrix metal is magnesium alloy.

3. A fiber reinforced metal compressor vane according to Claim 1, wherein said matrix metal is aluminium alloy.

4. A fiber reinforced metal compressor vane according to Claim 2, wherein said reinforcing fiber material is alumina short fiber material.

5. A fiber reinforced metal compressor vane according to Claim 3, wherein said reinforcing fiber material is alumina-silica short fiber material.

6. A fiber reinforced metal compressor vane according to Claim 5, wherein said reinforcing alumina-silica short fiber material has a substantial percentage of crystalline content.

7. A fiber reinforced metal compressor vane according to Claim 6, wherein said reinforcing alumina-silica short fiber material has a substantial percentage of the mullite crystalline content.

8. A fiber reinforced metal compressor vane according to Claim 3, wherein said reinforcing fiber material is silicon carbide whisker material.

9. A fiber reinforced metal compressor vane according to Claim 3, wherein said reinforcing fiber material is silicon nitride whisker material.

10. A fiber reinforced metal compressor vane according to any one of Claims 1-9, wherein the volume proportion of said reinforcing fiber material is from about 5 % to about 50 %.

Patentansprüche

1. Schieber eines Drehschieberverdichters, in dem ein Rotor (26) vorgesehen ist, der mit sich im allgemeinen in dessen radialen und Längsrichtungen erstreckenden Schlitzen (28a-28d) ausgebildet ist, die gegenüberliegende, im wesentlichen zueinander parallele Seitenflächen aufweisen, und der im

allgemeinen rechteckige, parallelopipede, plattenförmige Schieber (36, 36a-36d) trägt, die im wesentlichen zueinander parallele, gegenüberliegende Seitenflächen (42, 44, 42a-42d, 44a-44d) aufweisen, um in jenen Schlitzen so aufgenommen zu werden, daß sie mit ihren gegenüberliegenden Seitenflächen an jenen Seitenflächen jener Schlitze entlanggleiten können, wenn der Rotor sich um seine Längsachse in einem Gehäuse (2) dreht, wobei sich äußere Kanten (40, 40a-40d) jener Schieber im wesentlichen parallel zu jener Längsachse jenes Rotors erstrecken, der eine gekrümmte innere Fläche (88) jenes Gehäuses in der Weise gleitend berührt, daß jene Schieber sich in radialen Richtungen in jenen Schlitzen bewegen, wenn sich jener Rotor um seine Längsachse in jenem Gehäuse dreht, wobei die Schieber aus einer mit kurzen Fasern (46) verstärkten Metallmatrix bestehen, dadurch gekennzeichnet, daß jene kurzen Fasern im allgemeinen so ausgerichtet sind, daß sie in zu jenen gegenüberliegenden Seitenflächen (42, 44, 42a-42d, 44a-44d) und jenen äußeren Kanten (40, 40a-40d) jener Schieber im wesentlichen senkrechten Ebenen zweidimensional statistisch isotrop sind.

2. Verdichterschieber aus faserverstärktem Metall nach Anspruch 1, in dem jenes Matrixmetall eine Magnesiumlegierung ist.

3. Verdichterschieber aus faserverstärktem Metall nach Anspruch 1, in dem jenes Matrixmetall eine Aluminiumlegierung ist.

4. Verdichterschieber aus faserverstärktem Metall nach Anspruch 2, in dem es sich bei jenem Verstärkungsfasermaterial um Aluminiumoxidkurzfasermaterial handelt.

5. Verdichterschieber aus faserverstärktem Metall nach Anspruch 3, in dem es sich bei jenem Verstärkungsfasermaterial um Aluminium/Siliciumoxidkurzfasermaterial handelt.

6. Verdichterschieber aus faserverstärktem Metall nach Anspruch 5, in dem der Gehalt jenes Aluminium/Siliciumoxidkurzfaserverstärkungsmaterials zu einem wesentlichen Prozentsatz aus kristallinem Material besteht.

7. Verdichterschieber aus faserverstärktem Metall nach Anspruch 6, in dem der Gehalt jenes Aluminium/Siliciumoxidkurzfaserverstärkungsmaterials zu einem wesentlichen Prozentsatz aus kristallinem Mullit besteht.

8. Verdichterschieber aus faserverstärktem Metall nach Anspruch 3, in dem es sich bei jenem Verstärkungsfasermaterial um Siliciumcarbid-Whiskermaterial handelt.

9. Verdichterschieber aus faserverstärktem Metall nach Anspruch 3, in dem es sich bei jenem Verstärkungsfasermaterial um Siliciumnitrid-Whiskermaterial handelt.

10. Verdichterschieber aus faserverstärktem Metall nach einem der Ansprüche 1-9, in dem der Volumenanteil jenes Verstärkungsfasermaterials etwa 5 % bis etwa 50 % beträgt.

Revendications

1. Une palette pour compresseur à palettes dans lequel un rotor (26) comporte une fente (28a-28d) et a en général des directions radiale et longitudinale de façon à présenter des surfaces de côté opposées sensiblement parallèles, et dans lequel ledit rotor supporte une palette (36, 36a-36d) en forme de plaque comme un parallélépipède rectangle dont les faces de côté opposées (42, 44, 42a-42d, 44a-44d) sont sensiblement parallèles, la palettes étant logée dans ladite fente pour que coulissent lesdites surfaces de côté opposées contre lesdites surfaces de côté de ladite fente lorsque le rotor tourne autour d'un axe longitudinal dans un carter (2), et un bord externe (40, 40a-40d) de ladite palette étant sensiblement parallèle audit axe longitudinal dudit rotor tout en glissant avec une surface intérieure courbe (8) dudit carter si bien que ladite palette se déplace radialement dans ladite fente lorsque ledit rotor tourne autour dudit axe longitudinal dans ledit carter, ladite palette étant faite en métal matriciel ou métal de matrice renforcé de fibres courtes (46), caractérisé en ce que lesdites fibres courtes ont des origines distribuées de manière aléatoire mais ont des directions qui sont isotropes lorsqu'on considère ces directions selon deux axes situés dans des plans sensiblement perpendiculaires respectivement auxdites surfaces de côté opposées (42, 44, 42a-42d, 44a-44d) et audit bord externe (40, 40a-40d) de ladite palette.

2. Une palette de compresseur en métal renforcé par des fibres selon la revendication 1, dans laquelle ledit métal matriciel ou métal de matrice est un alliage de magnésium.

3. Une palette de compresseur en métal renforcé par des fibres selon la revendication 1, dans lequelle ledit métal matriciel ou métal de matrice est un alliage d'aluminium.

4. Une palette de compresseur en métal renforcé par des fibres selon la revendication 2, dans laquelle ledit matériau à fibre de renforcement est un matériau à fibres courtes en oxyde d'aluminium.

5. Une palette de compresseur en métal renforcé par des fibres selon la revendication 3, dans laquelle ledit matériau à fibres de renforcement est un matériau à fibres courtes en oxyde d'aluminium-dioxyde de silicium.

6. Une palette de compresseur en métal renforcé par des fibres selon la revendication 5, dans laquelle ledit matériau à fibres de renforcement à fibres courtes en oxyde d'aluminium-dioxyde de silicium présente un pourcentage important d'éléments à l'état cristallin.

7. Une palette de compresseur en métal renforcé par des fibres selon la revendication 6, dans laquelle ledit matériau à fibres de renforcement à fibres courtes en oxyde d'aluminium-dioxyde de silicium présente un pourcentage important de cristaux de mullite.

8. Une palette de compresseur en métal renforcé par des fibres selon la revendication 3, dans laquelle ledit matériau à fibres de renforcement est un matériau à barbes de carbure de silicium.

9. Une palette de compresseur en métal renforcé par des fibres selon la revendication 3, dans laquelle ledit matériau à fibres de renforcement est un matériau à barbes de nitrure de silicium.

10. Une palette de compresseur en métal renforcé par des fibres selon une quelconque des revendications 1 à 9, dans laquelle la proportion en volume dudit matériau à fibre de renforcement est comprise entre approximativement 5 % et approximativement 50 %.

FIG. 1

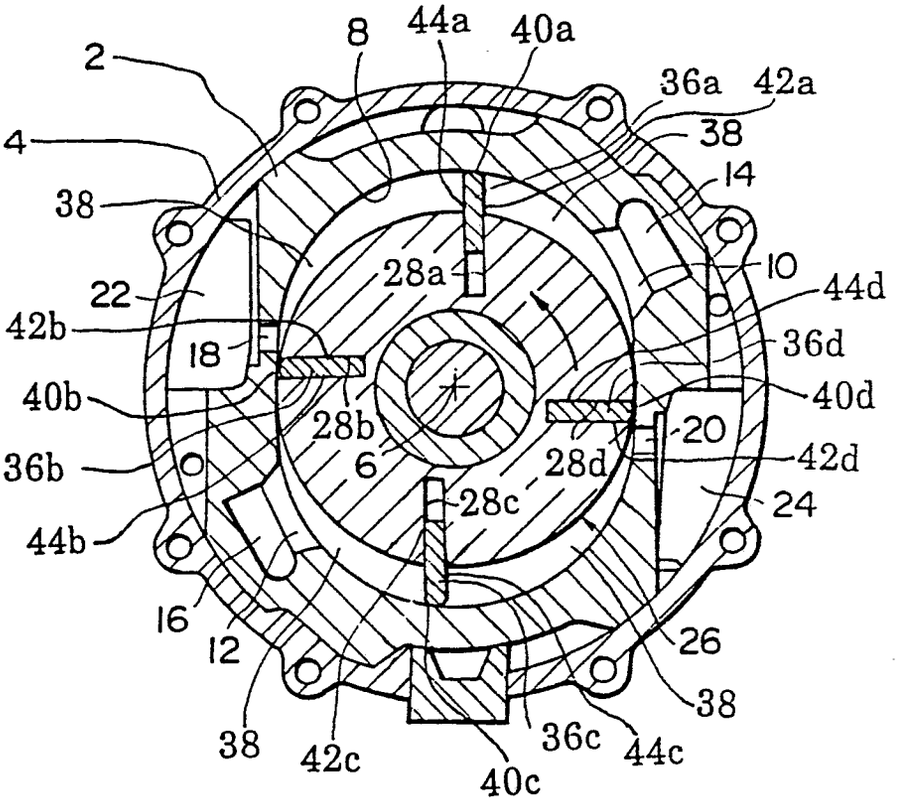

8
44a
40a
2
36a
42a
4
38
14
38
10
28a
44d
22
42b
18
36d
40b
40d
28b
20
36b
6
28d
42d
28c
24
44b
16
12
26
38
38
42c
36c
44c
40c

FIG. 2

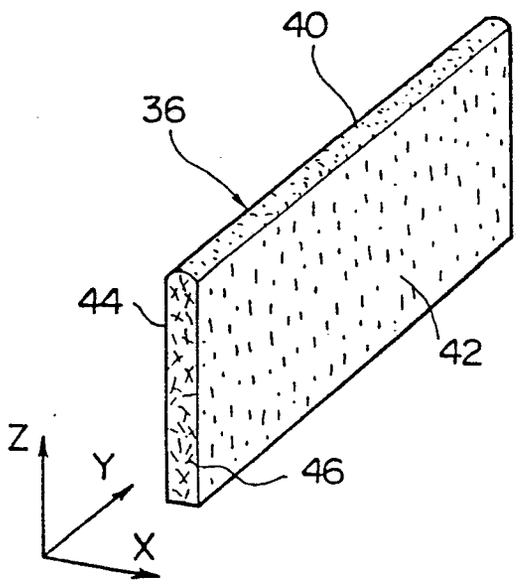

40
36
44
42
Z
Y
46
X

FIG. 3

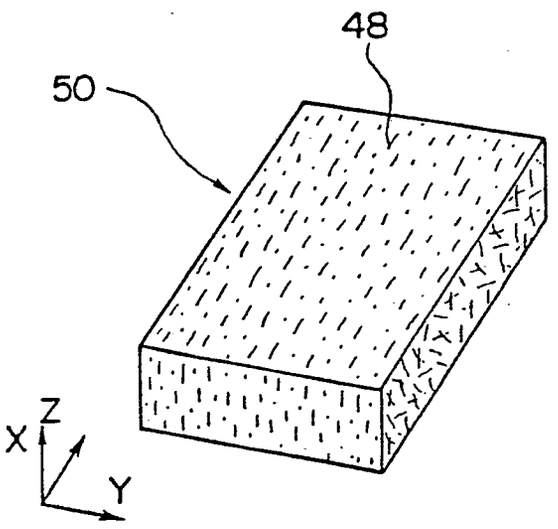


FIG. 4

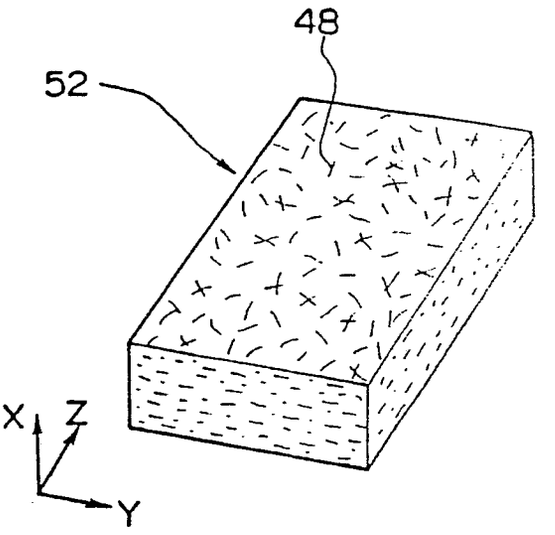


FIG. 5

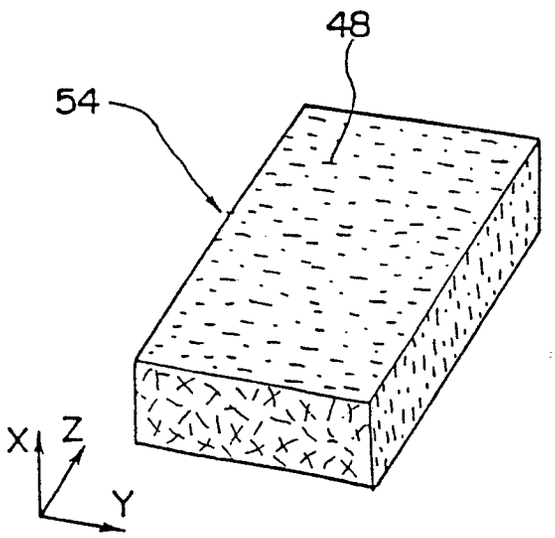


FIG. 6

