United States Patent

Kondo

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[54] **HONEYCOMB ROTOR-SEALING DEVICE AND METHOD OF MANUFACTURE**

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[51] **Int. Cl.**.....**F16j 15/28**, F16j 15/44

[58] **Field of Search**.....277/95, 96; 29/400 D, 418, 29/445, 481; 156/250, 209; 161/68, 69

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[57] **ABSTRACT**

A method of manufacturing a honeycomb rotor-sealing device, which is to be applied to a space between a rotor means and a stationary casing means surrounding said rotor means and open cells of which are adapted to face on the periphery of said rotor means for preventing fluid from passing therethrough, including steps of forming a thin sheet of metal or the like into an embossed sheet as to provide a plurality of cells adjacently arranged and open at each side thereof, fixing said embossed sheet on to a supporting plate at one side thereof and cutting a surface portion thereof away from said embossed sheet for providing an increased number of open cells over at the side opposite to that at which said embossed sheet is fixed on to said supporting plate.

7 Claims, 8 Drawing Figures

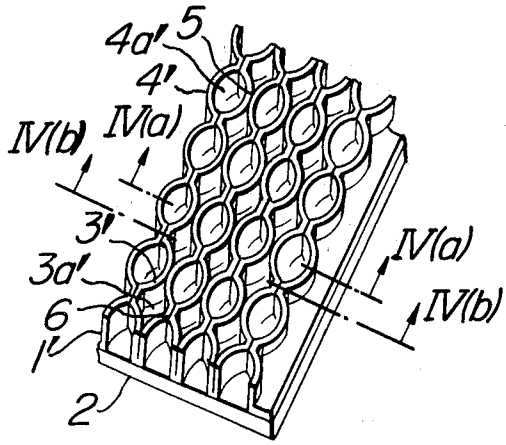


FIG. 1

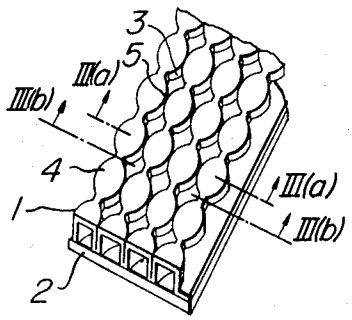


FIG. 2

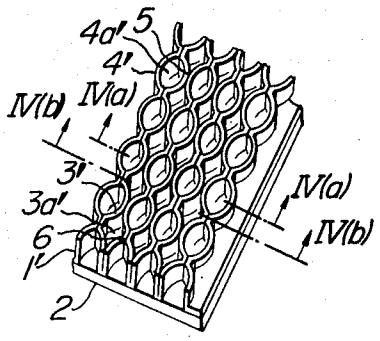


FIG. 3(a)

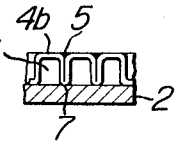


FIG. 3(b)

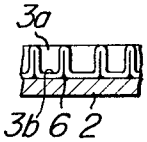


FIG. 4(a)

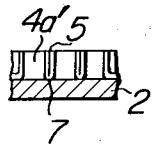


FIG. 4(b)

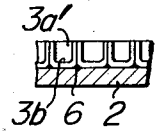


FIG. 5

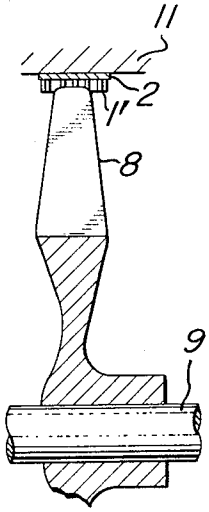
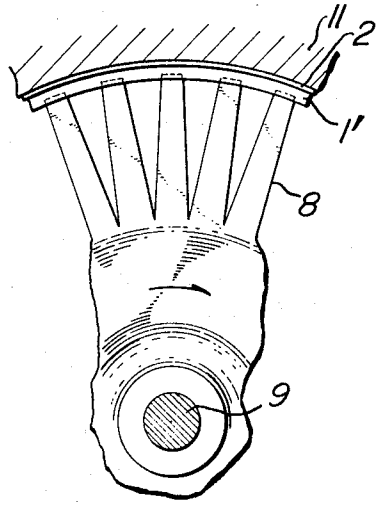


FIG. 6



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HONEYCOMB ROTOR-SEALING DEVICE AND METHOD OF MANUFACTURE

BACKGROUND OF THE INVENTION

In view of improving a rotating machine such as a gas-turbine, a vane pump or the like to be provided with higher efficiency, it is very important to reduce fluid leakage taking place through a gap between periphery of a rotor and inside wall of a casing surrounding said rotor as much as possible.

In the prior arts, some kinds of sealing devices have been practiced for preventing said fluid leakage and as well a honeycomb rotor-sealing device has been also practiced.

But the honeycomb rotor-sealing device of the prior art comprises such a honeycomb structure that is provided with a number of cells which are independently formed and adjacently joined together with each other, and that is fixed to a ringlike supporting plate. Accordingly, the steps of forming said independent cells and of fixing each of said cells on to the supporting plate requires so much labor to be processed.

Moreover, the honeycomb structure thus manufactured is inevitably so stiffened due to the cells independently arranged and fixed with each other in face to face contacts that there is a fear that said stiffness of the cells causes the rotor to be damaged while said rotor is being rotated, especially while being operative at high speed and of high temperature and then being expanded or deformed by heat and/or centrifugal force.

According to the invention of this application, there is provided a method of manufacturing an improved honeycomb rotor-sealing device in which these disadvantages of the prior arts as above mentioned are effectively eliminated.

SUMMARY OF THE INVENTION

This invention relates to a method of manufacturing a honeycomb rotor-sealing device, which is to be applied to a space between a rotor means and a stationary casing means surrounding said rotor means and open cells of which, that is so call a honeycomb structure, are adapted to face on the periphery of said rotor means for preventing fluid from passing therethrough, including steps of forming a thin sheet of metal or the like into an embossed sheet as to provide a plurality of cells adjacently arranged and open at each side thereof, fixing said embossed sheet on to a supporting plate at one side thereof and cutting a surface portion thereof away from said embossed sheet for providing an increased number of open cells over at the side opposite to that at which said embossed sheet is fixed on to said supporting plate.

According to this invention there can be obtained a much more improved and efficient rotor-sealing device as compared with the prior arts in the following points.

A primary advantage of the device of this invention resides in that fluid flow through a narrow gap, that is so called fluid leakage, between a rotor and a stationary casing due to a great pressure differential between the front and rear sides of said rotor may be extremely reduced, so that a rotor-sealing device of this invention may be improved to be as much high efficient.

Another advantage of this invention resides in that, since the honeycomb structure is formed of an unitary sheet and is in face to face contact with a supporting plate, fixation of said honeycomb structure to said supporting plate is easily processed with increased strength, so that such a fear that the rotor would be damaged or broken on account of said honeycomb structure separated from said supporting plate is effectively eliminated.

Further advantage of this invention resides in that, since the cells formed over the honeycomb structure are substantially in line contact (not in face to face contact) with each another and may be provided with appropriate flexibility, resistant force due to stiffness of said honeycomb structure which acts against rotation of said rotor may be extremely reduced and also said rotor is prevented from being damaged.

Still further advantage of this invention resides in that, since the honeycomb structure is formed of a sheet and continuously processed by embossing step, said process is made much more efficient and the manufacturing cost is as much lowered.

As a result of these advantages as above mentioned, a honeycomb rotor-sealing device of this invention may be practically provided with such a dimension that the narrow gap between the honeycomb structure and the rotor is determined at an extremely smaller amount, so that as much high efficiency of having the fluid prevented from leaking can be brought out.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a partial perspective view of a honeycomb structure semiprocessed according to the invention,

FIG. 2 is a partial perspective view of a honeycomb structure fully processed according to the invention,

FIG. 3(a) is a section taken along line III*a*—III*a* in FIG. 1,

FIG. 3(b) is a section taken along line III*b*—III*b* in FIG. 1,

FIG. 4(a) is a section taken along line IV*a*—IV*a* in FIG. 2,

FIG. 4(b) is a section taken along line IV*b*—IV*b* in FIG. 2,

FIG. 5 is a section of a rotor wherein a honeycomb rotor-sealing device of the invention is practiced and

FIG. 6 is an elevation of FIG. 5.

DESCRIPTION OF PREFERRED EMBODIMENT

With reference to the drawings, a preferred embodiment of this invention will be described hereinafter.

A general structure of a honeycomb rotor-sealing device of this invention is shown in FIG. 2, in which a honeycomb structure 1′ and a supporting plate 2, which is to be formed into a cylindrical ring or a flat plate for being adapted to support said honeycomb structure, are fixed together with by brazing, soldering, binding agents or the like.

In FIGS. 1, 3*a* and 3*b*, a semiprocessed honeycomb structure made of a thin sheet of metal or the like is indicated by the reference numeral 1, which has been processed only by embossing step and is provided with a number of cells 3 and 4 open at one end thereof. Said cells consist of two kinds 3 and 4 of groups of the cells, wherein each of the cells 3 being provided with a closure wall 3*b* and a hollow 3*a* having a cylindrical, hexagonal, or polygonal section, and each of the cells 4 being provided with a closure wall 4*b* and a hollow 4*a* having a cylindrical, hexagonal or polygonal section, each of said cells 3 and 4 being respectively open at the opposite sides of the semiprocessed honeycomb structure 1.

As seen from FIGS. 3(a) and 3(b), a series of the same cells 3 or 4 are continuously arranged along one direction III*a*—III*a* or III*b*—III*b* of the honeycomb structure, but along the other direction normal to the line III*a*—III*a* or III—III*b* said two kinds of cells 3 and 4 are alternatively arranged.

Each of the respective cells 3 and 4 are adjacently fixed to each another at the respective conjunctions 5 and 6 by means of brazing soldering, binding agent or the like, and the semiprocessed honeycomb structure 1 is fixed to the supporting plate 2 at the conjunctions 7 provided between each of the adjacent cell 4 and also at the closure walls 3*b* of the cells 3.

Though the series of the cells 4 in the section III*a*—III*a* are closed by the closure walls 4*a* as seen in FIG. 3(a), it is necessary to cut said closure walls 4*b* away from said cells and to provide much more number of open cells for the honeycomb rotor-sealing device of this invention to be provided with higher faculty of sealing the working fluid, as this being described in detail hereinafter.

In FIG. 2, there is shown a honeycomb rotor-sealing device which has been fully processed, wherein said closure walls 4*b* has been cut away by machinery such as grinding or the like, consequently the closed hollows 4*a* are processed to be open as hollows 4′*a* and the open hollows 3*a* are also consequently processed to be shallower hollows 3′*a*, so that the honeycomb structure is finished as indicated by the reference number 1′. Therefore, the honeycomb rotor-sealing device thus fully

processed is formed with such opposite sides that over one side thereof the cells 3' and 4' are entirely closed by the supporting plate 2, though the cells 3' being closed also by the closure walls 3*b* thereof, and that over the other side thereof all of the cells 3' and 4' are open as the hollows 3'*a* and 4'*a*.

As seen from FIGS. 4(a) and 4(b), the thickness of the honeycomb structure 1' is as much decreased as the the thickness of the surface portion cut away from the honeycomb structure.

The side of the device which is thus provided with a number of open hollows 3'*a* and 4'*a* is adapted to be faced on a rotor or the like for sealing a working fluid and the other side which is the supporting plate 2 is adapted to be secured to a stationary casing surrounding said rotor.

The operations of the honeycomb rotor-sealing device according to the invention are as follows.

In a space provided between a rotor and a casing surrounding said rotor, the honeycomb rotor-sealing device is arranged in the manner that the open hollow 3'*a* and 4'*a* are faced on the periphery of the rotor and the device itself is fixedly secured to the inside wall of the stationary casing through the ringlike supporting plate 2.

Though the working fluid is forced to flow through the narrow gap provided between the periphery of the rotor and the inside wall of the honeycomb structure 1' due to pressure differential provided between the front and the rear of the rotor, and though this flow of the working fluid, that is so called leakage, effectively causes the lowering of efficiency, since according to this invention there can be obtained much more resistance to reduce said leakage, said leakage of the working fluid may be effectively as much decreased, as compared with the sealing devices of the prior arts.

The principle of generation of this great resistance may be analytically explained as follows. While the working fluid continuously passing through the honeycomb structure 1', said fluid is alternatively and repeatedly subjected to expansions and compressions in the open hollow 3' and 4' and then there can be obtained the great fluid flow resistance in the direction opposite to the leakage flow, and moreover frictional resistance due to the fluid flow along over the surface of the honeycomb structure is also added to said fluid flow resistance.

Therefore, an account of these resistances the fluid leakage through the sealing device may be decreased so much extent.

The amount of said fluid flow resistance is to be determined by the following equation.

$$H=V^2/2g\times n\times C$$

where

H: fluid flow resistance

V: flowing velocity

n: number of opened cells over which the fluid is to pass

C: constant

From this equation, it is obvious that the more in number the open cells 3' and 4' are provided to the predetermined length of sealing device, the more effectively fluid is sealed.

In FIG. 5, there is shown a practical application of the honeycomb rotor-sealing device of this invention, wherein said device is applied to moving vanes of a gas-turbine for sealing the working gases thereof.

By arranging a honeycomb rotor-sealing device which comprises a honeycomb structure 1' and a supporting plate 2 in the space formed between the rotor, that is the moving vanes 8 which is secured to an output shaft 9, and a stationary casing 11 surrounding said rotor, the working gases is effectively prevented from flowing through said space according to the principle as above mentioned.

In this practice, if the honeycomb structure bears such appropriate stiffness that the moving vanes are not caused to be damaged even when the honeycomb structure 1' comes into contact with said moving vanes 8, the narrow gap between said honeycomb structure and the periphery of said moving vanes may be extremely decreased for much more reducing the gas-leakage.

Though thickness of the metal sheet material of the honeycomb structure is desired to be extremely thin, said sheet may not be unrestrictedly thinned in practice for reason of the increasing of manufacturing cost. Simultaneously, the connection of the honeycomb structure 1' to the supporting plate 2 is required to be strong and reliable, if not so, it is feared that, while being operative, said honeycomb structure is possibly separated from said supporting plate and this causes a fatal damage of the moving vanes 8 being broken.

The practical application of this invention is not limited to the application to gas-turbine as above mentioned, and may be further effectively applied to such a bearing means that is operative at relatively high speed and is required to be perfectly sealed, to a sealing device provided at a narrow gap between vanes and a housing in a vane compressor, and to a sealing device provided at a narrow gap between a rotor and a housing in a Roots compressor.

According to the honeycomb rotor-sealing device of this invention, since the honeycomb structure 1' is in face to face contact with the supporting plate 2, the fixation of the honeycomb structure to the supporting plate may be easily processed with increased strength, namely with higher efficiency, so that there may be eliminated the fear of the honeycomb structure being separated from the supporting plate and consequently the rotor being caused to be damaged.

Moreover, since the open cells 3' and 4' are substantially in line contact (not in face to face contact) with each other and may be made appropriately flexible, resistant force due to stiffness of said honeycomb structure which acts against rotation of said rotor may be extremely decreased and also said rotor is prevented from being damaged. In keeping with this advantage of the invention, it is unnecessary to use an extremely thinned sheet of metal or the like to form honeycomb structure, so that the manufacturing cost may be as much lowered.

Further, since the honeycomb structure of this invention is formed of a sheet and continuously processed by embossing step, said process is made much more efficient and the manufacturing cost is as much lowered.

Still further, since the surface of the honeycomb structure which is adapted to be faced on the periphery of the rotor is finished by machinery, the open cells thus finished are increased in number and the measure of said surface is given much more precision, then fluid leakage therethrough may be effectively reduced to the extent as the gap originally set between the honeycomb rotor-sealing device and the periphery of the rotor possibly being determined at extremely small amount.

I claim:

1. A method of manufacturing a honeycomb rotor-sealing device, which is to be applied to a space between a rotor means and a stationary casing means surrounding said rotor means and open cells of which are adapted to face on the periphery of said rotor means for preventing fluid from passing therethrough, including steps of forming a thin sheet of metal or the like into an embossed sheet as to provide a plurality of cells adjacently arranged and open at each side thereof, fixing said embossed sheet on to a supporting plate at one side thereof and cutting a surface portion thereof away from said embossed sheet for providing an increased number of open cells over at the side opposite to that at which said embossed sheet is fixed on to said supporting plate.

2. A honeycomb rotor-sealing device, which is to be applied to a space between a rotor means and a stationary casing means surrounding said rotor means and open cells of which are adapted to face on the periphery of said rotor means for preventing fluid from passing therethrough, manufactured by steps of forming a thin sheet of metal or the like into an embossed sheet as to provide a plurality of cells adjacently arranged and open at each side thereof, fixing said embossed sheet on to a supporting plate at one side thereof and cutting a surface portion thereof away from said embossed sheet for providing an increased number of open cells over at the side

opposite to that at which said embossed sheet is fixed on to said supporting plate.

3. A honeycomb rotor-sealing device as defined in claim 2 wherein said plurality of cells provided on said embossed sheet are shaped into circular cylinder.

4. A honeycomb rotor-sealing device as defined in claim 2 wherein said plurality of cells provided on said embossed sheet are shaped into hexagonal.

5. A honeycomb rotor-sealing device as defined in claim 2 wherein said embossed sheet is fixed on to said supporting plate by means of brazing.

6. A honeycomb rotor-sealing device as defined in claim 2 wherein said embossed sheet is fixed on to said supporting plate by means of soldering.

7. A honeycomb rotor-sealing device as defined in claim 2 wherein said embossed sheet is fixed on to said supporting plate by means of a binding agent.

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