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[54] **POROUS PLATE MADE OF METAL FIBERS**

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[52] **U.S. Cl.** **29/182.2**, 75/208, 75/226, 75/DIG. 1

[51] **Int. Cl.** **B22f 1/00**

[58] **Field of Search** 75/DIG. 1, 208, 226, 214; 29/182.2, 182

[56] **References Cited**

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[57] **ABSTRACT**

A porous plate substantially consisting of metal fibers which are formed in a layer, wherein said fibers which form the external circumferential area and/or a part of the internal area of the aforementioned layer are bonded, and such bonded part has a higher density as compared with the area other than the bonded part.

6 Claims, 2 Drawing Figures

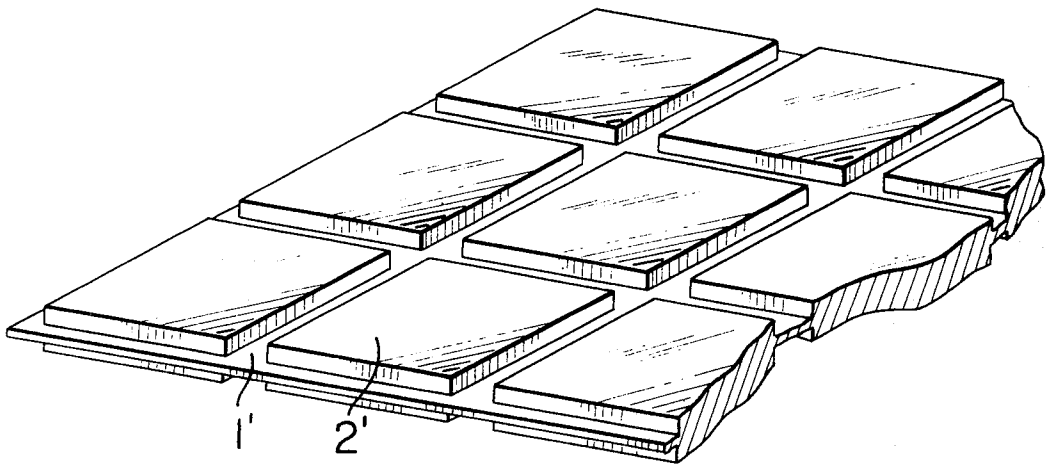


FIG. 1

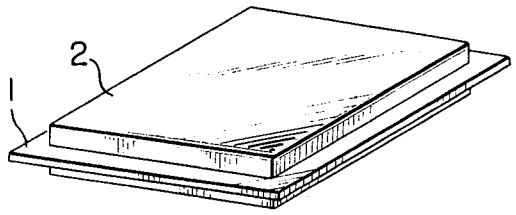
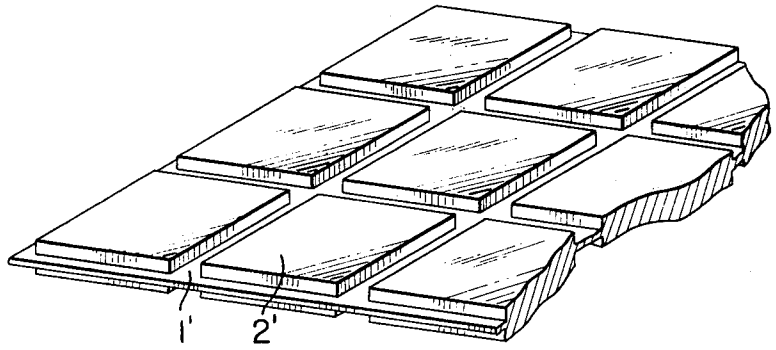


FIG. 2



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POROUS PLATE MADE OF METAL FIBERS

BACKGROUND OF THE INVENTION

a. Field of the Invention

The present invention relates to a porous plate made of metal fibers which is utilizable as a carrier material for catalyst in performing a chemical reaction, an electrode of an electric cell or battery, a sound absorbing material for use in building and construction, and a filter media to be used in a filter for liquids and gases.

b. Description of the Prior Art like. adhesive use catalyst, etco; while the plate which is sintering possesses

A plate made by felting metal fibers simply by a mechanical process does not have enough mechanical strength to be used for the aforementioned purposes though it has the advantages of having a larger surface area and being very porous. Since the shape of such a plate is maintained solely by an interlocking of metal fibers, it is apt to be changed when the plate is subjected to stresses such as bending stress, tensile stress and the like. For the purpose of preventing such felt-like plate from deforming in shape, the plate may be strengthened by the application of an adhesive or solder around it. The plate may be strengthened by sintering the interlocked metal fibers by the use of a proper heating furnace. The plate of metal fibers thus strengthened by the use of an adhesive or the like according to the first method has a tainted surface and is not good for use as a carrier material for use in catalyst, electrode, filter, etc.; while the plate which is strengthened by means of sintering according to the second method possesses the demerits of being subject to an extreme change in its dimension and a remarkable decrease of its effective surface area, thus losing much of its porosity. It is also known that when the plate is made of metal fibers such as lead, zinc and the like, the ordinary powder metallurgy method is hardly applicable for sintering such plate.

SUMMARY OF THE INVENTION

It is an object of this invention to provide a porous plate which is made of metal fibers and possesses high mechanical strength. According to the present invention, a porous plate, whose mechanical strength is remarkably increased without decreasing the porosity of the porous plate made of metal fibers and which is completely free from any kind of taint, is obtainable.

A porous plate according to the present invention is prepared by the method described hereunder:

Manufacturing method

Metal fibers are so arranged in layers as to have the shape of a plate, and the external area and/or a part of the internal area of the plate thus obtained is pressed and heated at one time so that there may be formed a sintered and bonded part of high density on the said external area and/or a part of the internal area. (Hot Press method)

According to the aforementioned method, it becomes possible to increase the mechanical strength of a porous plate, which is made of metal fibers such as lead, zinc, as well as copper and the like, to a great degree without tainting the aforementioned metal fibers or changing the dimensions of the plate.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 and FIG. 2 are perspective views respectively showing a preferred embodiment of the porous plate prepared according to the present invention.

Referring to the accompanying drawings, the details of the present invention will be explained further in the following.

FIG. 1 is a perspective view showing one of the embodiments described in the present invention, wherein the external surrounding area of a plate body which consists of metal fibers arranged in layers is processed according to the aforementioned method to bond the interlocking fibers to a high density.

FIG. 2 is a perspective view to show another embodiment of this invention wherein the external surrounding area and a part of the internal area of said plate body consisting of metal fibers arranged in layers are processed according to the aforementioned method to bond the interlocking fibers to a high density.

In these figures, 1 and 1′ show a bonded part of high density and 2 and 2′ show a porous part. More particularly, the parts of high density (1 and 1′) on the porous plate shown in these figures are not only high in density because their interlocking metal fibers are bonded physically and metallurgically but also are highly resistive to the external force such as bending stress, tensile stress, etc. While in the internal areas (2 and 2′) of the porous plate other than these bonded areas of high density, the metal fibers are interlocked to form layers and thus maintain a high porosity.

As for the manufacture of a porous plate as shown in FIG. 1 according to the present invention, a required plate can be obtained by pressing a plate body consisting of metal fibers arranged in layers placed in metal mold in such a way as to have its external area and a part of the internal area expected to be bonded put on the raised part of the metal mold and then heating it (at the temperature high enough to sinter the metal fibers under the pressure). A bonded plate may be obtained without heating the pressing mold, by pressing the plate body in a metal mold immediately after having been heated in a proper heating furnace. For obtaining a porous plate indicated in FIG. 2 according to the method of the present invention, the said metal mold should be designed to have its raised part in a latticework. It is difficult to set limits on the relations between the temperature to heat the plate body arranged in layers and the pressure of a metal mold; however, it may be said that the heating should be performed at the temperature not so high as to cause a dimensional change of the plate body arranged in layers and the pressure might be kept higher when the heating temperature is low and vice versa. It is advisable, however, to keep the pressure of the metallic molds higher in both cases.

Incidentally, the optimum relations between the temperature and pressure for processing the plate body are by kinds of metals in Table 1.

Table 1

Metal	Heating Temperature (°C)	Pressure (t/cm^2)
Pb or Pb-alloys	20–200	0.03–0.5
	(100–150)	(0.07–0.12)
Zn or Zn-alloys	180–300	0.05–0.8
	(200–250)	(0.1 –0.25)

Cu or Cu-alloys	350–500 (370–400)	0.3 –2.0 (0.7 –1.5)

The numerical values in the brackets indicate the most preferable ranges in the production of the porous plates according to the present invention.

The explanations of a porous plate made in the foregoing paragraphs are based on the embodiment of the present invention made with regard to a preparation of bonded part of high density in the shape of a quadrangle; however, the shape of said bonded part of high density is not necessarily limited to quadrangle, and it can be prepared in the shape of a circle, diamond, trapezium, etc. as a particular case may require. In case of a porous plate of metal fibers prepared in the shape of circle with a bonded part around its circumference, one or more than one circular parts of high density having a diameter smaller than the outer circle may be formed on the internal area of such circular plate. If a plate is prepared in the shape of a diamond, a part of high density may be formed along its diagonal lines in the internal area.

A porous plate of metal fibers prepared according to the present invention has the following distinctive features:

a. It has a remarkably large surface area and it is not tainted because it is not formed with the use of foreign materials.
b. It has a high mechanical strength.
c. The desired porosity can be freely obtained in its preparation stages.
d. Since the bonded part of high density which is necessary for worked maintenance of the mechanical strength of the porous plate occupies only a small portion of the plate, the shrinkage caused at the time of the forming process is small, and the dimensional change due to the heat expansion and chemical change is also small, causing no deformation.
e. When the porous plate is used as an electrode, its bonded part of high density serves as a lead wire.
f. The plate has a flexible structure and it is readily worked with the bending process.

By utilizing the aforementioned distinctive features, the plate can be used as a catalyst for use in chemical reaction, electrode for use in cells and batteries, sound absorbing materials for buildings, filters for liquids and gases, etc.

As for the metal fibers to be used for a plate according to the present invention, the plate can be bonded more easily and its porosity increases when the diameter of the metal fibers is smaller and the surface of the metal fibers is more clean; the metal fibers are not necessarily to be chosen according to such understandings. They may be used freely without any requirement as to the method of manufacturing metal fibers, whether they are continuous metal fibers or discontinuous ones, and whether they are thick or thin in diameter.

However, the best results are obtainable if the metal fibers range from 30 μ to 150 μ in diameter and their length ranges between 50 cm and 1 cm.

In order to maintain the predetermined mechanical strength of the porous plate according to the present invention, it will be most desirable to hold the density at the high density area of the porous plate above 70 percent based on the true density of the metal fibers composing the porous plate, whilst, with the low density area, to hold its density below 60 percent based on the true density of the metal fibers composing the porous plate, whilst, with the low density area, to hold its density below 60 percent based on the true density of the metal fibers composing the porous plate.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Continuous fibers of lead with a fiber diameter of 50 μ were arranged in layers in approximately 10 mm thickness and the plate body thus arranged in layers was accordingly heated. The plate body was then placed between a pair of metal molds which were 140 mm × 140 mm in dimension and had 4 mm wide raised parts at the intervals of 30 mm both longitudinally and transversely and the pressure of 10 tons was applied to the plate body at the temperature of 150° C. As the result of such preparation, a porous plate having a structure as indicated in FIG. 2 was obtained. The apparent density of the thus obtained porous plate arranged in layers other than the high density area ranged from 2 to 3 g/cm^3. In the bonding processes, it was possible to control at will the apparent density of the part arranged in layers ranging between 10 and 1.8 g/cm^3 by the adjustment of the initial thickness of the fiber layer, the shape of molds, and the pressure applied to the fiber layer. The tensile strength of the part bonded according to the hot press method (density approximately 10.5 g/cm^3) was 1.1 kg/mm^2.

EXAMPLE 2

Discontinuous fibers of zinc having a diameter of 70 μ and a length of 20 mm were arranged in layers of approximately 10 mm in thickness and the plate body thus arranged in layers was placed between a pair of square metal molds, 100 mm × 100 mm in size, having a raised part of 10 mm width and 0.5 mm height along the circumference, was then heated at the temperature of about 250° C. with the molds closed adiabatically, and was pressed under the pressure of 10 tons. As the result of these procedures, there was obtained a porous plate having a thickness of 1.5 mm along its edges and a thickness of 2.5 mm in its internal area. The apparent density of the internal area where the metallic fibers were arranged in layers was 5.1 g/cm^3 and the tensile strength of the sinter bonded part of high density (density approximately 6.8 g/cm^3) was 10.5 kg/mm^2.

EXAMPLE 3

Copper fibers of 90 μ in diameter was made into a plate body arranged in layers having 25 mm thickness and 100 mm length both lengthwise and crosswise. The plate body thus arranged in layers was placed between a pair of metal molds of 100 mm × 100 mm in size (having a raised part for pressing with 10 mm width and 3 mm height along the edges) and was pressed under the temperature of 400° C. and the pressure of 50 tons. After these procedures, a porous plate having a shape indicated in FIG. 1 was obtained. The thickness of the circumferential area of the porous plate was 2 mm and its apparent density was 7.5 g/cm^3. The thickness of the internal area arranged in layers was 6 mm and its apparent density was 2.5 g/cm^3. The tensile strength of the area along the edges subjected to the sinter bonding was 15 kg/mm^2.

What we claim is:

1. A method of preparing a porous plate of metal fibers, which consists essentially of the steps of forming a non-compressed, unsintered plate-like mass consisting of felted, non-oxidized, elongated, metal fibers free from bonding to each other, placing said mass into a mold, simultaneously compressing the mass in the mold by applying to a portion or portions of the mass a localized higher pressure than the pressure applied to the remainder of said mass and heating the mass to a temperature at which sintering takes place only under said localized higher pressure to form a plate in which the fibers of said portion or portions are bonded and sintered to each other and the fibers in the remainder of said mass are free from bonding to each other, the density of said portion or portions being at least 10% higher than the density of the remainder of said mass, and then removing the mass from the mold.

2. A method according to claim 1, wherein the metal fibers consist of a material selected from the group consisting of lead and lead-alloys, and a pressure in the range of from 0.03 to 0.5 t/cm^2 is applied to said portion or portions at a temperature in the range of from 20° to 200° C.

3. A method according to claim 1, wherein the metal fibers consist of a material selected from the group consisting of zinc and zinc-alloys, and a pressure in the range of from 0.05 to 0.8 t/cm^2 is applied to said portion or portions at a temperature in the range of from 180° to 300° C.

4. A method according to claim 1, wherein the metal fibers consist of a material selected from the group consisting of copper and copper-alloys, and a pressure in the range of from 0.3 to 2.0 t/cm^2 is applied to said portion or portions at a temperature in the range of from 350° to 500° C.

5. A porous plate made of non-oxidized metal fibers which consist essentially of a plate-like mass consisting of felted, non-oxidized, elongated, metal fibers having a diameter in the range of from about 30μ to about 150μ, said mass having compressed portion or portions of reduced thickness in which the fibers are bonded and sintered to each other, said compressed portions having a density in excess of 70 percent of the density of the metal fiber, the remainder of said mass being less compressed and having a density of less than 60 percent of the density of the metal fiber, the fibers in the remainder of said mass being mechanically interlocked but substantially free of bonding to each other.

6. A porous plate according to claim 5, in which the metal fibers are selected from the group consisting of lead, lead alloys, zinc, zinc alloys, copper and copper alloys.

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