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METHOD FOR MANUFACTURING POROUS METAL FIBER FELTS

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6 Claims

ABSTRACT OF THE DISCLOSURE

A method is described for manufacturing porous metal fiber materials of uniform constitution by screening comminuted metal fibers on to a carrier support and thereby distributing the comminuted metal fibers using a rotary movement and the one or more layers distributed on to a support are then coated with an adhesive or binding agent applied to this first layer, whereupon one or more subsequent fiber layers are applied and these processes are continued until the desired thickness of the resultant mat on the support has been obtained, whereupon the mat so formed is then dried and the solvent present in the adhesive or binding agent is driven off, and then the products are subjected to heat treatment if required after compacting. Very uniform distribution is achieved if the comminuted metal fibers are distributed using a rotary movement and subsequent vibratory treatment, and the comminuted metal fibers may be classified before the distribution step, for purpose of more reliable control of the desired properties of the material to be produced.

SUMMARY OF THE INVENTION

The invention relates to a method for the simple manufacture of metal fiber felts already having a particularly satisfactory strength before sintering, which is particularly suitable for a continuous method of operation.

Metal fiber felts or metal fiber materials have been known for a long time. The special properties of such felts are high porosity and large surface coupled with good strength and flexibility. Such materials are used with advantage particularly for heat exchangers, in battery electrodes and in catalyst units because of their large surface. Because of their high porosity, they can be used advantageously in filter plates and in sound damping materials. By variation of the composition of the material and the treatment of the fibers, the physical and chemical properties of such materials can be modified over wide limits and in accordance with the most varied technical requirements.

Despite these particular advantages, metal fiber felts or metal fiber materials have only found use in technology rarely and in special cases, since the manufacture of such materials is expensive particularly if uniform material constitution is required.

Metal fiber felts or metal fiber materials are made by various known methods which have been taken from the textile and paper industries. As the starting material for the fibers, various fine wires, turnings, electrolytically manufactured thin sheets and metal yarns made by the lost wax process and the like can be used. These yarns are felted into long fibers by crimping, carding and similar processes and devices known in the textile industry. Short metal fibers made by comminution are treated according to the aerodynamic principle or also the other methods used in the paper industries. In the latter method, a suspension of fibers in a suitable liquid is made, the fibers are deposited upon a wire or textile web and the suspension liquid is then extracted. For technical reasons manufacture of metal fibers has previously been made, however, by the spinning method. This produces in essence

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only short fiber lengths so that the sedimentation method for metal fiber felting has attained practical importance. Since metal fibers in contrast to paper or textile fibers have a relatively high specific weight only special fluids can be used as the suspension liquid as otherwise a separation of the small and coarse fibers would be unavoidable. There is frequently the disadvantage that such suspension liquids in the subsequent sintering process leave residues on the metal fiber material. Even the slightest residue of suspension liquid or reaction products such as corrosion or decomposition products can affect the sintering of the fibers in an undesirable way so that the disadvantages are connected with the use of these known methods. Moreover, because of the rough and coarse fiber surfaces the formation of lumps and flocks is favored so that metal felts obtained according to this known method are frequently very uneven as regards their properties and appearance. These difficulties can be overcome if at all only with considerable expense, as the method is technically very complicated.

Furthermore, a method is already known in which metal fiber felts are made from short metal fibers by screening a mass of such short fibers over a vibratory screen on to a support. The fibers which pass through the screen openings are deposited by falling freely on to the support. This method does not operate entirely satisfactorily however, since with small screen openings practically only the very short and thin fibers are screened which do not felt together satisfactorily on the support. The longer and coarser fibers thus remain on the screen and the formation of lumps and flocks is facilitated by the vibratory movement on the screen surface. If a screen with relatively coarse screen openings is used in this known method, the screening process then proceeds very rapidly but the deposition on to the support is then uneven. This disadvantage cannot be alleviated by delaying the speed of fall by using an additional supply of air as a gaseous suspension medium since then the disadvantages previously mentioned in connection with liquid suspension media become evident.

The invention is based upon the problem of avoiding the disadvantages of previously known methods and providing a new simple and effective method for the manufacture of porous uniform materials from metal fibers.

This problem is solved in accordance with the method of the invention for the manufacture of porous materials of uniform constitution by screening comminuted metal fibers on to a carrier support and the sintering them, if required after compacting, which is characterized in that the comminuted metal fibers are distributed on to a carrier support using a rotary movement and first of all a fiber layer is produced, a layer of a binding agent is applied to this first layer and then a second metal fiber layer is distributed and this process is repeated alternately until the desired thickness of mat has been obtained, whereupon the material so obtained is dried, the solvent contained in the binding material is removed and finally the material is then sintered, if required after being compacted. A particularly uniform distribution and an exceedingly even material is thus obtained with the method of the invention particularly if the distribution of the comminuted metal fibers proceeds using a rotary movement and a subsequent vibratory treatment.

For the purpose of more reliable control of the desired properties of the material to be produced, it is advantageous if the comminuted metal fibers are classified before the distribution step. This can be carried out in any suitable manner known to the expert.

The useful properties of the material being made can be varied in any desirable way by adding to the binding agent pigments in the form of fine metal powders, metal oxide powders and/or metal compounds reducible in the

subsequent sintering step. Additional metal powder can be sprayed on to one or more of the metal fiber layers during the distribution.

The materials made according to the method of the invention have an extremely good uniformity and they can be prepared with any desired porosity and any desired properties.

In carrying out the method according to the invention, the metal fibers manufactured for example by spinning are first comminuted in a mill or other suitable apparatus used for the comminution of metal fibers and are advantageously classified in a special operation according to length and cross-section. Classification of the fibers is not entirely necessary for the subsequent felting process, but effects a reliable control of the desired properties of the metal felt to be produced.

The fibers so treated and classified are then subjected to a rotary movement in a suitable device and are uniformly distributed by a screen device onto a correspondingly arranged carrier support. The distribution step can be carried out and controlled in any desired way during the subsequent vibration. The screening device is effectively a distribution drum which has a cover of perforated sheet or wire cloth or punched screen.

If a mass of fibers is introduced into such a distribution drum device and the drum is rotated, the fibers are carried along and raised up from the drum wall in the direction of rotation until the weight of the amount of fibers is greater than the adhesion of the fibers to the drum wall. Individual fibers are then released from the fiber blocks and fall through the openings in the drum wall, if required above a vibratory screen device and then onto the underlying carrier sheet.

The perforation of the drum cover is effectively not too coarse. It is advantageous if a screen drum is used whose cover surface does not consist of more than 50% of free spaces. If the spaces in the drum body are greater than the largest fiber diameter, preferably 2 to 100 times larger, then a particularly even and satisfactory distribution effect is obtained. The perforations also are important as to their shape. Preferably the thinner, shorter and straighter fibers are selected for usage, which have a smooth surface with small apertures, whereas for the thick long curved fibers with rough surface apertures of large cross-section are preferable. In the extreme case, the apertures can have a rectangular cross-section or be constructed as longitudinal slots. In distribution tests it has been shown that aperture plates are better than wire cloths or punched screens. Distribution drums with screens and a given screen-opening diameter distribute very rapidly but unevenly and if the screen opening cross-sections are reduced then the openings of the screen become too narrow so that the distribution process comes to a stop.

As already described, the starting material is raised inside the drum during the rotation process and, then falls again whereupon the natural distribution process takes place. The step of raising and dropping does not proceed uniformly and continuously but instead layers are formed which are released at regular time intervals from the highest part of the drum wall. Upon the impact on the inner cover, lying below as a base, the layer-like fall is retarded so that the actual distribution process proceeds more or less continuously. Very uniform distribution is achieved if the time interval is kept as small as possible. By introducing a particular kind of fiber the time sequence, in which the fiber layers are separated, is dependent upon the drum diameter and the speed of rotation of the drum. If the drum diameter is large and the speed of rotation low, then the fibers are carried up very high and the fiber layers roll out at relatively large time intervals. With increasing number of revolutions the time intervals become smaller but the number of revolutions cannot be raised excessively since otherwise the centrifugal forces would become excessive and the fibers would then substantially not be released from the inner wall of

the drum so that the distribution process would then not take place. If stationary guide plates or brushes mounted within the drum are provided, the speed of rotation can be kept higher than would otherwise be the case with the same conditions.

A further very advantageous method of operation can be achieved if below the distribution drum device in the path of fall of the fibers a vibration screen device is inserted or located. A relatively low rate of rotation of the distribution drum can then be used satisfactorily and if required the distribution width can be varied over certain limits with a given drum construction, which is particularly advantageous if only small amounts of materials of different diameters are to be processed.

The distribution drum device is required in connection with the vibratory screen device and the support carrier are moved relatively, which can be effected either by reciprocal movement of these devices with a stationary support or by continuous movement of the support for example in the form of a conveyor belt beneath one or more stationary distribution drums and, if required, vibratory screen devices. Metal fiber layers are formed in this way, which, after a certain time, have a more or less thick fiber depth. In order that such an unsintered mat has some strength, which makes it possible to be used before the sintering, a suitable adhesive or binding agent is applied according to the invention, to the fiber layers which are distributed repeatedly on top of one another to form a mat, as already described. Bonds between the individual fibers are thus provided in the manufacture of the mat which is of particular value in the subsequent process because of the combined insensitivity to external mechanical effects.

If a sufficient number of layers have been distributed together and the mat is thus sufficiently thick, a drying process is then carried out which can be accelerated for example by infra-red heating. The solvent is thus driven off from the adhesive or binding agent. After this drying, the mat has sufficient strength to undergo a careful mechanical treatment such as separation with shears for example.

Which adhesive or binding agent is used in any particular case depends upon the strength desired and upon the particular kind of metal fibers used, and can be determined by simple tests by the expert or from information supplied by the manufacturer of the adhesive or the binding agent. The kind of adhesive or binding agent used is not material to the present invention.

In the method of the invention, the adhesive or binding agent can advantageously include additional pigments in the form of fine metal powders, metal oxides or other metal compounds which are reduced in the subsequent sintering step. In those cases where the metal compounds cannot be reduced in a hydrogen atmosphere, an addition of carbon can be made in the form of lamp black, active charcoal or graphite powder to the binding agent in order to have the desired reducing effect. By the last-mentioned measure, the subsequent sintering process is facilitated considerably and the strength resulting after sintering is considerably higher than if sintering is carried out without these additions. Moreover, in certain cases, it is possible to keep a sintering temperature more than 100° C. lower than normal or to shorten the sintering time without adversely affecting the properties of the fiber mat. Both these features lead to considerable economy in the process. A special effect in the addition of pigments to the applied adhesive agent is given in that suitable alloying constituents are applied to the fiber material and this is then correspondingly modified, for in the subsequent sintering process these metals diffuse into the fibers on the fiber surface and thus modify their constitution over wide limits. At the beginning of the sintering process, temporary low-melting alloys are formed upon the surface of the fibers in many cases so that these fibers are welded and soldered together at the points where they cross, which

partly explains the sinter and harnessing effect of the added pigments.

Ceramic pigments can also be applied by spraying which are not reduced during the subsequent sintering step. It is possible according to the invention to apply to the surface of the fibers an oxidic or glass-like or enamel-like layer, which binds the individual fiber particles together.

It is also possible to spray a natural or synthetic resin as an adhesive or binding agent on to the metal fiber layers distributed on the support. Generally, the subsequent sintering step must then be dispensed with because the mat so formed will then merely be subjected to a heat treatment to harden the resin binder. Since the binder remains in the finished fiber material, its mechanical, physical and chemical properties are very different from those of the sintered form of material which are made according to the invention.

After the sintering, adhesion, enamelling or other subsequent treatment the metal fiber materials manufactured according to the invention, such as fiber mats or fiber felts and the like can have a whole series of special properties which are not noticeable with other materials. It is particularly to be noted that there the specific weight is very small due to the very high pore volume. Depending upon the kind of fiber used, pore volumes of up to 98% can be produced whereby the specific weight is reduced to about 2% of the specific weight of the material used initially. Moreover, by oxides applied to the fibers surfaces, catalytic effects can be achieved.

The method according to the invention can be carried out continuously or discontinuously. Materials of any desired form can be obtained either by cutting or otherwise mechanically treating blanks manufactured in the form of mats or by disposing moulds of any desired shape on the support and carrying out the distribution in these molds. In this way, complicated porous fiber materials can be manufactured in the simplest way.

EXAMPLE

Fibers of an 18/8 chrome nickel steel (material No. 14300) with an average diameter of 0.1 to 0.2 mm. and an average length of 5 mm. were charged into a distribution drum. The distribution drum had a cover provided with 1 mm. openings and its surface consisted of about 30% of free space. The drum diameter was 200 mm. The drum was filled with fibers and then rotated at 50 r.p.m. The drum was guided back and forth over a carrier sheet located below. During this movement, new fibers were continuously fed into the drum so that it was kept in the full state. The carrier sheet had a length of 500 mm. and a width of 500 mm. After 4 fiber layers had been distributed a solution of copolymers of acrylic resins, which is marketed under the trademark "Plexisol" by Messrs. Röhm & Haas, Darmstadt, Germany, was sprayed on. After obtaining a mat thickness of approximately 5 mm. on the support the distribution was continued and the support with the applied mat which had a size of approximately 500 x 500 mm. was introduced into a drying chamber. After drying for about 1 hour at approximately

100° C. the solvent was vaporized and the mat had a sufficiently high strength for it to be conveyed to a second supporting plate coated with a parting agent. On this plate, the mat was introduced into a sinter furnace. Sintering took place in a protective gas furnace under a hydrogen atmosphere at approximately 1250° C. The residence time at the nominal temperature was about 2 hours. The contents were then cooled to approximately 100° C. Finally, the mat was removed from the furnace. It had a silvery white appearance and an ultimate strength of approximately 50 kg./cm.². The pore volume amounted to approximately 85%.

By interposing a corresponding vibratory screen between the distribution drum and the support the mat dimensions can be varied as required over the limits from 400 x 500 mm. to 600 x 500 mm.

We claim:

1. In a method for manufacturing porous metal fiber materials of uniform constitution by screening comminuted metal fibers onto a carrier support; the improvement comprising

(a) distributing said metal fibers on said carrier support by tumbling said metal fibers in a rotating multi-perforate drum through the perforations of which said metal fibers fall,

(b) thereafter coating the layer of metal fibers thus formed with an adhesive,

(c) repeating steps (a) and (b) until a mat of metal fibers of a desired thickness is formed, and

(d) heating said mat to dryness.

2. A method as claimed in claim 1, and thereafter sintering said mat at about the sintering temperature of said metal fibers.

3. A method as claimed in claim 2, and compressing said mat to reduce its thickness.

4. A method as claimed in claim 1, and passing said fibers through a vibratory screen between said drum and said support.

5. A method as claimed in claim 1, in which the total area of openings through said drum is no more than 50% of the area of the drum.

6. A method as claimed in claim 1, in which said drum has a cover of perforated sheet through which said fibers fall.

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