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METHOD FOR PRODUCING ALLOY STEEL WOOL

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The present invention relates to a metallic corrosion-resistant and oxidation-resistant material and articles made therefrom, and relates especially to metallic materials and shaped articles which are of porous character. The said material is particularly suitable for use for filter and machine parts. The present invention relates also to a method for producing the new material.

Metallic porous materials are known and have found use in the most varied of industrial applications. These materials are usually manufactured by powder metallurgy methods. Materials which are based upon iron, copper or bronze cannot be considered to be corrosion-resistant. In order to obtain corrosion-resistant materials, a powder of a V2*a* material has been used. Materials made from V2*a* powder likewise do not fulfill the usual requirements as to corrosion-resistance, because rustless steels are only resistant to reactive gases, vapors and liquids, if they have completely smooth and polished surfaces, no corners or crevices are present in which residues can collect and the texture is completely homogeneous, in order to prevent the formation of local elements.

Known surface treatments with corrosion-resistant metals, for example, a diffusion treatment with chromium ("chromising" process) of, for example, workpieces formed by pressing non-corrosion-resistant metals in powder form, do not give the desired result. A very good corrosion-resistant surface layer can be applied to such workpieces, but this known method does not succeed in making corrosion-resistant the central zone of a workpiece or shaped article, which in many cases is necessary, particularly if such a workpiece is subsequently mechanically treated or worked.

It is an object of the invention to provide a metallic material avoiding the previous disadvantages. In carrying out the above object, it is another object to provide a material consisting of metal threads, particularly steel wool fibres, plated or coated with alloying constituents imparting temperature, corrosion and/or oxidation resistance to the basic metal of the threads, and then homogenised by diffusion annealing.

Another object of the invention is to provide a porous metallic material consisting of skeleton-like felted metal threads, particularly steel wool fibres, which form a network, which fibres or threads have first been gas phase plated with chromium imparting temperature, corrosion and/or oxidation resistance to the basic metal of said fibres or threads, and then have been homogenised by diffusion annealing.

A further object of the invention is to provide a porous metallic material for subsequent use as filter or machine parts, the material consisting of skeleton-like felted and pressed steel wool fibres which form a network, which steel wool fibres are homogeneously alloyed with chromium, and whereby the chromium content of the alloy may amount up to 40 percent by weight.

Yet another object of the invention is to provide a porous metallic material consisting of steel wool fibres in the form of a network, which steel wool fibres are homogeneously alloyed with aluminum and wherein the aluminum content of the alloy may amount up to 10 percent by weight.

Yet another object of the invention is to provide a porous metallic material consisting of steel wool fibres in the form of a network, which steel wool fibres are homogeneously alloyed with nickel, and wherein the nickel content of the alloy may amount up to 15 percent by weight.

Specifically the invention is directed to the method of producing the new material which consists in subjecting metal threads to a surface treatment of plating or coating with at least one metal which forms an alloy with the basic metal of the threads imparting temperature, corrosion and/or oxidation resistance, and then homogenising the material by diffusion annealing at high temperatures. The material may be finally compressed into shaped articles, but the metal threads can also be pressed and shaped in the untreated state ("green" state) and plated and homogenised as previously described as shaped articles.

Further objects and advantages of the present invention will be apparent from the following description.

The invention comprises using, as the base material, metal wool, particularly steel wool, and the separate threads are improved by an otherwise known process in such a way that not only is the surface altered, as is the case with the known method, but by subsequent annealing and homogenising, the shaped article as a whole receives the desired properties, even throughout its inner central regions.

It is possible firstly to shape the metal threads into plates or discs or other forms, if required, by sintering, before the surface plating with the improving or hardening metal is applied. In the shaping, the metal threads interpenetrate, so that an open network is produced, which nevertheless is quite resistant to deformation and has a certain mechanical strength, although it can contain up to 90% of voids. In applying coatings, deposition occurs not only on the outer surfaces of the metal thread article, but also the, for example, metal vapors, solutions, melts or powder mixtures containing the alloying constituents penetrate through the whole network so that a layer is deposited on the separate metal threads throughout the whole of the internal region. In the subsequent diffusion annealing at suitable temperatures, the alloying metal diffuses from the applied layer to establish an equilibrium in the separate threads and a completely homogeneously alloyed metal thread structure is formed which is suitable for preparation of completely corrosion-resistant articles.

All known methods can be employed for carrying out the metal plating step, such as, for example, metal vapor treatment, immersion in metal melts, immersion in alloying agent powders, immersion in salt baths (electroless metal deposition) and also immersion in aqueous salt solutions with subsequent reduction at high temperatures e.g. under hydrogen.

The diffusion annealing accompanying the plating is carried out at such a temperature and for such a duration that the separate metal threads become completely coated with for example, a high chromium content material, and finally become homogeneously alloyed. As a rule, temperatures of about or above 1,000° C. are used. Sufficient homogenising is usually obtained after up to three hours. According to certain circumstances, in which the velocity of diffusion of the plating layer is very slight, for example with nickel on steel wool, longer times of up to ten to twenty hours, for example are necessary.

Gas-phase plating of steel wool fibres with chromium is preferably carried out at temperatures of 1000° to 1100° C. for two to three hours and annealing advantageously proceeds for 0.5 to 3 hours at 1100° to 1400° C. The diffusion and annealing treatment can take place in

one stage, preferably at 1100° to 1200° C. for one to three hours, together with the gas-phase plating step.

Chromium is preferred in many cases as the metal used in gas-phase plating. Other metals, such as nickel or aluminum, can also be used in the process of the invention.

In the manufacture according to the invention of a material using, for example, steel fibres and chromium as the improving agent, a chromium content in the steel wool of about 40% is obtained. This provides an assurance of a satisfactory oxidation and corrosion resistance of the material in subsequent mechanical treatment. The surface character of the metal fibres remains virtually unaltered by this treatment. The ductility and elasticity of the metal fibers likewise remain substantially the same. These properties are of great importance for the later working and use of these materials.

The material used according to the invention as the basic material is advantageously obtained by cutting from metal wire or strip and is used in the form of fibres ranging in size from one thousandth to several tenths of a millimetre in width, one thousandth to several millimeters in breadth and up to several metres in length. Steel wool fibres which undergo substantially no alteration of form on being chromised, for instance, are particularly suitable.

The material according to the invention can be mechanically worked with comparatively little wastage because of its good ductility and elasticity and thus always retains its corrosion-resistance. For example, a steel wool material homogenised and diffusion-treated with chromium was wound on a roller, which has an angle-iron frame, and after being covered with a linen or felt cloth, is used in ironing machines and wringing apparatus. Hot water vapor is led to the inside of the roller and the roller covering must therefore be absolutely corrosion-resistant and also permeable to steam. These requirements are met in an ideal way by the material according to the invention. Similar roller arrangements are required in the ceramic industry for the dewatering of slip materials. The roller dips into the slip at the underside and takes up a thin layer of it. Inside the roller filter, a vacuum is produced, whereby the excess water is filtered off. In this particular kind of use, stringent conditions are imposed as regards resistance. The high porosity of e.g. chromised steel wool produced according to the process of the invention is very well suited to the uses of such a device made from the material according to the invention.

Together with such machine parts filters themselves can advantageously be manufactured with the material according to the invention. Such filters are especially well suited for dust filtering in SO_2-containing, moist hot atmospheres.

The material according to the invention is particularly suitably, because of its high oxidation and corrosion-resistance and low specific gravity with high porosity, for the manufacture of turbine blades for so-called sweat cooling at high temperatures.

In the following, various embodiments of the method of the invention are described in detail. These embodiments, in which temperatures are given on the centigrade scale, serve as illustrations, only, and are not intended to limit the present invention in scope.

Example 1

Steel wool hanks consisting of numerous separate threads which were obtained from a special steel wire of the following analysis, 0.13% C, 1.06% Mn, 0.042% P, 0.009% S, 0.05% Cr and traces of Si by cutting, were laid out in parallel form and introduced into an upright chromising retort. Chromium and ceramic pieces were packed into the retort so that no pressure or tension could be exerted on the steel wool yarn. A mixture of nitrogen and hydrogen as a protective gas was introduced through the closed retort. Simultaneously, small amounts of hydrogen chloride were introduced which, by reaction with the chromium pieces and the steel wool, effected the chromising process. The diffusion and annealing treatment was carried out in one stage for two hours at temperatures between 1150° and 1180° C. After cooling, the original appearance of the material was substantially unaltered. A porous steel wool yarn only slightly altered in external volume was produced which had considerable corrosion-resistance and was capable of being used as a constructional material for a variety of purposes.

Example 2

A steel wool hank about 1 m. long with an average thread cross-section of 0.05 x 0.5 mm. was immersed in a suspension consisting of methyl alcohol and 10 parts by weight of lamelliform aluminum powder. Because of the high pore volume of more than 90%, the aluminum suspension penetrated into the inside of the steel wool material. After a steeping process at about 80° C. for two hours, the separate steel wool threads were covered with a thin layer of aluminum powder. By an annealing under a protective gas (nitrogen) at 600° to 660° C. for five to ten hours, the aluminum was diffused into the steel wool fibres, so that the fibres consisted homogeneously of a steel containing about 6–10% of aluminum.

This material is very oxidation-resistant and can be made into a high temperature filter which can be used in an oxidizing atmosphere.

Example 3

A steel wool yarn corresponding to Example 2 was immersed in an aqueous saturated nickel nitrate solution. Because of the extensive capillary action, the steel wool material took up the solution completely. By careful drying at 120° C. the solution was evaporated and, on the surface of the steel wool fibres, a thin salt crust remained. The steel wool material was then subjected to diffusion annealing at 1200° to 1400° C. By heating in the temperature range of 800° to 1000° C. the nickel nitrate was first reduced to metallic nickel and, in the further annealing treatment, this nickel was diffused into the steel wool. Because of the low diffusion velocity of nickel, the annealing process was carried out for 10 to 20 hours. After the annealing treatment, a thread was obtained which consisted of a high nickel content steel containing about 15% nickel.

By means of compressing in a steel matrix comprising about 5 tons per square cm., a pore volumn of about 80% was reduced to only 10%. Such a part is ideally suited as a turbine blade for "sweat" cooling.

If necessary the shaped article of steel wall can be immersed, before being compressed, in a ceramic slip and, after drying, can then be pressed as has been described. In this case, sintering at 1400° to 1500° C. is necessary, in order to give the part the desired strength. Such a part is most suitable for use in combustion turbines.

While the embodiments of the present invention as herein disclosed constitute preferred examples, it is to be understood that other compositions and forms might be adopted.

We claim:

1. A method of producing metal alloys, comprising applying to a multiplicity of steel fibers oriented at random as a body of steel wool a coating of a metal selected from the class consisting of chromium, aluminum and nickel with the surface of the fibers coated with the coating metal throughout the body of steel wool, and maintaining the body of steel wool at elevated temperature to diffuse the coating metal through the thickness of each fiber until the concentration of the coating metal is substantially uniform throughout the thickness of each fiber.

2. A method as claimed in claim 1, in which the coating metal is chromium.

3. A method as claimed in claim 1, in which the coating metal is aluminium.

4. A method as claimed in claim 1, in which the coating metal is nickel.

5. A method as claimed in claim 1, and compressing the body of steel wool to a desired shape prior to said coating step.

6. A method as claimed in claim 5, and sintering the body of steel wool to weld the fibers together at their points of contact, said sintering step being performed after said compression step and before said coating step.

7. A method as claimed in claim 1, and compressing the body of steel wool to a desired shape after said diffusion step.

References Cited by the Examiner

UNITED STATES PATENTS

1,243,654	10/1917	Clark	117—50
2,415,078	2/1947	Mecker et al.	148—16
2,616,165	11/1952	Brennon	117—107
2,798,140	7/1957	Kohring	117—107
2,836,513	5/1958	Samuel	117—107.2
2,851,375	9/1958	Samuel	148—16
2,862,783	12/1958	Drummond	117—107.2
2,875,112	2/1959	Becker et al.	117—107.2
2,959,494	11/1960	Shepard	117—107
2,980,532	4/1961	Martenson et al.	148—16
3,139,359	6/1964	Morgan	148—12.1

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