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H. VOGT ET AL

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PRODUCTION OF SINTERED ARTICLES

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Fig. 1

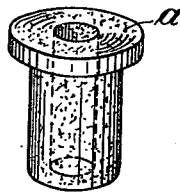


Fig. 2

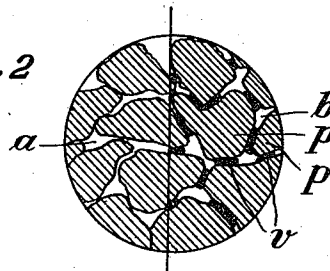
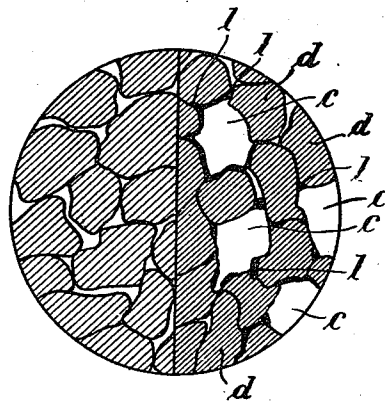


Fig. 3



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PRODUCTION OF SINTERED ARTICLES

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14 Claims. (Cl. 75—22)

This invention relates to methods of producing sintered porous metal articles and to the products of such methods.

It is an object of the invention to facilitate the production of such sintered articles and to increase their mechanical strength.

Another object of the invention is to provide means by which the porosity of the product can be controlled in any desired manner, within wide limits and, more particularly, to provide relatively larger cavities evenly distributed over the sintered article, besides the normal small pores of the material. Still another object of the invention is to reduce the shrinking of such porous articles in the sintering operation.

Still another object is to prevent corrosion in the inner structure of porous metal articles.

A special object of the invention is to provide a method of producing porous anti-friction metal, especially from iron, having a substantial oil absorbing capacity and great mechanical strength.

A further object is to improve the "running in" characteristics of such porous bearings and to reduce the coefficient of friction thereof.

A still further object is to produce metal wicks, packing rings and the like of high porosity and mechanical strength.

With these and further objects in view which will be apparent from the within disclosure, our invention comprises broadly the addition of metal compounds, more particularly metal oxide and metal salts to the metal which forms the porous sintered body and the reduction to metal of said metal compound additions.

It is to be understood, of course, that the present invention is not to be limited to production of the sintered bodies from the particular sources of raw material and additions referred to herein.

Further features and advantages of our invention will appear from the following detailed description taken in connection with the accompanying drawing in which:

Fig. 1 is a perspective view of a bearing bushing made in accordance with the invention.

Fig. 2 is a sectional view, made up after the manner of a photomicrograph, showing on the left hand side (a) a sintered structure obtained by a normal sintering operation and, on the right hand side (b), a sintered structure obtained by the addition of metal salts in dissolved form in accordance with our novel process.

Fig. 3 is a similar view as Fig. 2, but showing on the right hand side a sintered structure ob-

tained by the addition of metal compounds in the form of solid particles.

We give the following examples of our process, but it will be understood that while in said examples we refer to certain materials and to certain articles produced by the process of the present invention, other materials may also be used and the particular structure may be used in other articles. It will be understood further that the analysis of the product will vary according to the raw materials used in its manufacture, and that the characteristics of the resulting product and the steps in the process may be varied considerably.

Where it is mainly intended to enhance the mechanical strength of the sintered body, we prefer to add the metal compounds in the form of a metal salt solution to the metal powder before or after it is briquetted, and preferably before it is sintered; in this case the solvent is first evaporated and the briquetted article is then sintered in such a manner that the metal salt is reduced to metal which forms bonds *v*, Fig. 2, portion *b*, between the adjacent particles *p* of the sintered metal. Various compounds of metals which can be diffused and reduced may be used for this purpose, for example, sulfates, hydrates, chlorides, organic acid salts and carbonates of the heavy metals, more particularly of the group comprising iron, nickel, chromium, cobalt, manganese or copper. The impregnation of the porous metal particles with the metal salt solution may be carried out repeatedly and a reducing operation may be inserted after each impregnating operation. The metal salts may be dissolved in water, glycerine or the like and preferably in high-boiling solvents, for example, polyvalent alcohols. It is also possible to impregnate the sintered body with the metal salt solution, in this case the body must be subjected to a further heat treating, sintering or reducing operation.

Example 1

Relatively coarse spongy iron particles (sponge iron) are compressed or briquetted to a bearing bushing or the like, for example, in the form shown in Fig. 1. In this compressed state, the material has a specific gravity of 5 and a percentage by volume of pores of about 33%. The briquette is then impregnated with a saturated aqueous solution of sulfate of iron, under vacuum, and dried by action of a hot air current, until the water has been evaporated completely. The briquette which now shows the sea-green colour of the iron sulfate deposit is then sintered

at a temperature of 1050° C., for a period of 30 minutes.

The increase of the weight due to the impregnation and sintering is only 0.45% while the strength is increased to the 2.5 fold amount. This value has been found by a crushing test to which a bearing bushing made according to the invention was subjected, together with a second bearing bushing made in the same manner, but without impregnation. The latter piece was crushed after 14 shocks while the bushing made according to the example was crushed after 34 shocks. The shrinking which generally amounts to 0.35 percent, was found to be unchanged by the impregnation.

It is also contemplated that the sintered article may be rendered more corrosion-proof by the use of certain salts for the impregnation. For example, nickel salts or chromium salts may be used to increase the resistance of the surface of porous iron structures. Also, where the base metal shows undesirable catalytic features, for example, with respect to the decomposition of the lubricant, such catalytic effects may be prevented in this manner. For instance, self-lubricating bearing materials in which copper which tends to accelerate said decomposition represents a substantial component may thus be provided with an interior protective coating of a metal, for instance, iron, which has no catalytic or other detrimental effect.

The improved mechanical strength attained by our novel process is probably due to the fact that by a capillary effect the metal salt solution is drawn into the narrow spaces at the points of contact between adjacent particles whereby the respective metal is deposited in these narrow spaces and in the melting or sintering operation, enlarges the point-shaped contact points to larger areas thus producing a greater mechanical strength.

It is also contemplated that the metal salt shall be dissolved in a solvent of high boiling point, for example, a polyvalent alcohol, in order to prevent the solvent from evaporating already during the mixing phase of the metal powder.

The impregnating and reducing operations may be repeated several times, and different metal salt solutions may be used in the successive operations, depending on the special use for which the sintered article is intended. In the same manner, non-metallic porous articles, for instance of a ceramic nature, may be provided with a metallic coating of their pores.

Where it is primarily intended to produce additional cavities in the porous sintered body, we add the metal compounds advantageously in the form of solid particles, substantially of a size of 0.1 to 1 mm., to the loose metal powder, and preferably we use a metal compound comprising the same metal as the base metal powder. In this case, the size and shape of the hollow spaces produced in the sintered body by the said solid additions can be controlled by the size and shape of the metal compound particles which are added to the metal particles to be briquetted and sintered together. For example, the said metal compound particles may be round or angular, with a diameter of 0.2 to 0.5 mm., and they may be added in quantities of up to 10, but preferably 2 to 4 percent by volume. Very fine, dust-like material is not generally suitable because it tends to reduce the strength and to increase the shrinkage. Any reducible metal compounds, for example, chlorides, sulfates, hydrates and organic acid

salts of various metals may be used provided that they are capable of withstanding the pressures exerted in the briquetting operation.

Example 2

Sponge iron powder substantially of a particle size of about 0.05 to 0.2 mm. is mixed with 2 to 3 percent by weight of iron sulfate particles substantially of a size of about 0.3 to 0.5 mm., obtained by crushing crystals of $\text{Fe}_2(\text{SO}_4)_3$ and sieving and rounding same, for example in a ball mill. After intimate mixture, advantageously with additions of about 1% oil which prevents demixing and facilitates the pressing operation, the mixture is briquetted under suitable pressure and reduced and sintered in the presence of hydrogen, at a temperature of about 1050° C. The structure thus obtained is shown in Fig. 3, right hand portion; the sponge iron particles are designated *d* while *c* are the spaces between the sponge iron particles which are at first filled with the iron sulfate particles, after the pressing and before the sintering operation and afterwards form hollow spaces or cavities for the reception of oil or other purposes. The iron reduced from the iron sulfate in the sintering operation is designated *l*. As will be seen, the said reduced iron is especially deposited at the portion adjacent to the points where the iron particles *d* contact each other, whereby an additional bond is formed between the particles and the mechanical strength of the material is improved.

Example 3

A sintered article is made in the manner stated under Example 2 and, when cooled down, is impregnated with a saturated iron sulfate solution, dried in a heated air current and once more subjected to the reducing and sintering operation at the same temperature of about 1050° C., whereby its mechanical strength can be further increased.

It is thus possible to increase the porosity of porous metal articles by 30 to 50 percent, without any reduction of the mechanical strength of the article and without any increase of the shrinkage. The oil-absorbing capacity is thus substantially increased and the running-in characteristics and the coefficient of friction are improved. In view of the larger size of the cavities or pores formed by the metal compound additions the decomposition products occurring by oxidation and polymerisation of the lubricants e. g. bitumen, asphalt and the like, can be easily deposited and prevented from exerting a detrimental effect upon the lubrication.

It will be understood that it is also possible, and of special advantage, to combine steps of the kind specified in Examples 1 and 2 and the base metal may be impregnated with the metal salt solution before the briquetting operation and/or thereafter and/or after the sintering operation, with a subsequent repeated sintering operation. Sintered bodies of a porosity up to 50% may be made which at the same time have good mechanical properties.

The products obtained by our novel process may be used as anti-friction material, as metal wicks for petroleum lamps or burners, filters, catalyzators, resistances, damping plates for sound mufflers in autocars and the like.

Porous self-lubricating bearings may be made e. g. of iron or bronze powder and in the second case, a copper salt, for example, copper sulfate is advantageously used instead of iron sulfate mentioned in the above examples.

We claim:

1. Process for the production of porous metal bodies which comprises forming a body of the finely divided metal, introducing a metal salt into the formed body in the form of a solution thereof and reducing the metal salt to metal in situ.
2. Process as defined in claim 1 in which the finely divided metal is formed into a body, sintered and then impregnated with metal salt solution.
3. Process as defined in claim 1 in which the metal powder mixed with finely divided metal compound is briquetted and sintered with reduction of the metal compound and the sintered briquette is impregnated with a solution of metal salt, dried and sintered.
4. Process as defined in claim 1 in which metal powder is wetted with metal salt solution, briquetted, dried, sintered and reduced and then impregnated with metal salt solution dried, sintered and reduced.
5. Process as defined in claim 1 in which the finely divided metal is sponge iron.
6. Process as defined in claim 1 in which the finely divided metal is sponge iron and in which it is formed into a body, sintered and then impregnated with metal salt solution.
7. Process as defined in claim 1 in which the finely divided metal is sponge iron and in which it, mixed with finely divided metal compound is briquetted and sintered with reduction of the metal compound and the sintered briquette is impregnated with a solution of metal salt, dried and sintered.
8. Process as defined in claim 1 in which the finely divided metal is sponge iron and in which it is wetted with metal salt solution, briquetted, dried, sintered and reduced and then impregnated with metal salt solution dried, sintered and reduced.
9. Process for the production of porous metal bodies which comprises mixing porous sponge iron powder with a relatively small proportion of a metal compound, compressing the mixture to a coherent body, relieving the pressure, and sintering said body under reduction of said metal compound in situ whereby an additional bond is formed between the particles of the sponge iron powder and the mechanical strength of the body is increased.
10. Process as defined in claim 9 in which the metal compound is a metal salt.
11. Process as defined in claim 9 in which the metal compound is in solid form.
12. Process as defined in claim 9 in which the metal compound is an iron salt.
13. Process as defined in claim 9 in which the metal compound is in solid form and has a particle size from 0.1 to 1 mm.
14. Process as defined in claim 9 in which the sponge iron powder is wetted with a solution of a metal salt.

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