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METHOD OF MANUFACTURING HARD
FACED METAL BODIES

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This invention relates to a method of manufacturing metal bodies having a hardened surface, such as e. g. dies, valve seats, guiding sleeves for threads or wires in weaving machines, and valve stems.

It is an object of the invention to provide such bodies with a hardened surface layer, containing or consisting of carbide, and to adjust the depth of such layer to any desired degree.

It is another object of the invention to simplify the production of such surface hardened bodies.

It is still another object of the invention to produce such bodies with a hardened surface layer containing or consisting of carbides ready for immediate use.

It has been suggested to manufacture bodies of the kind referred to by obtaining a body of the described shape and size from a suitable base metal, such as iron or tungsten, and to apply to its surface or surfaces, which during use are subjected to wear or corrosion, a layer consisting of or comprising carbide.

To this end a rod was prepared consisting of the selected carbide or carbides cemented with a sufficiently low melting metal, such as iron, and an end of this rod was melted, for instance by an electrical arc, or by heating by means of an oxygen-acetylene flame, and the melt was deposited on the surface to be covered. The thus obtained surface layers were comparatively uneven and of somewhat varying thickness. There was no possibility of meeting exact measurements.

It has further been suggested to produce such bodies from metal powders capable of forming a desired mass, such as tungsten, molybdenum, iron, nickel, chromium, platinum, singly or in suitable mixture, and to shape and consolidate the powder by pressing and heating. In particular it has been suggested to press and heat the powder in a neutral or protective atmosphere to a temperature at which presintering or fritting of the powder occurred, then to machine the body and afterwards to heat it up to high sintering temperature in a carbonaceous atmosphere. The carbon contained in that atmosphere combines superficially with the metal of the body at that temperature and carburises it. It is evident that with such a procedure only a very thin carbide containing surface layer can be obtained during heating at high sintering temperature, because the metal thus treated softens and the pores or interstices between the metal particles are closed. The carbon of the surrounding carbonaceous atmosphere is thereby soon prevented

from entering into the interior of the body, and from this results the very thin layer of carbide obtained.

According to my invention I also employ a two-step process, comprising a presintering or fritting and a subsequent final or high sintering step. However, instead of carburising the mass under treatment in the second step, I perform carburisation in a first step. Generally speaking my invention consists in that I compact a mass of metal powder in a first stage at fritting or sometimes slightly higher presintering temperature in the presence of a carbon containing or developing medium, and finish the body in a subsequent step by final or high sintering preferably in a neutral or protective atmosphere. In the second step a carbon containing medium may also be present. Furthermore, I keep the mass in the first step at fritting or sintering temperature for a controlled period of time in the presence of carbon containing or developing medium, in particular, gases or vapors of such concentration that a desired depth of penetration of the mass by the carbon is insured. In order to adjust the concentration of the gases or vapors I apply suitable pressure, in particular surpressure, and, if necessary, feed fresh gases or vapors into the space where the treatment takes place, in such amounts that the desired concentration of the carbon content of the medium, in particular gases or vapors is regulated or maintained.

Any suitable powder can be used for the purposes of my invention. It may consist of one or more metals and/or metalloids, or any mixture thereof. As a single metal e. g. tungsten, molybdenum, chromium, nickel, lithium, magnesium, aluminum or vanadium may be used. A suitable metalloid is represented by silicon. As a mixture of metals tungsten and titanium, or molybdenum and titanium, or tantalum and titanium, or iron and titanium, or tungsten and beryllium, or tungsten and boron, or lithium and aluminum, or iron and silicon may be referred to without limiting however my invention to any particular metal, metalloid or mixture thereof. I prefer a mixture containing at least one higher melting component capable of forming carbide and at least one component lower melting which is not capable of forming carbide or has a slighter affinity to carbon than the higher melting component.

There may also be used a mixture consisting of tungsten, titanium and iron, or molybdenum, titanium and iron, or tungsten, iron and beryllium, or aluminum, lithium and titanium, or tantalum,

titanium, cobalt, without limiting my invention to any composition comprising three different elements.

5 If titanium is added to any mixture it is preferably present as a minor portion in an amount of about 1% to 15%, preferably 1% to 6%.

If iron, cobalt or nickel are present, it preferably also forms a minor portion of the mass, between about 3% to 40%.

10 If tungsten or molybdenum are present they may be applied either as major or minor portion, as the case may be. If high temperature resistance is required besides hardness, then tungsten in amounts between about 50% to 80%
15 may be present besides e. g. titanium and/or silicon and iron and/or cobalt. If, however, only wear resistance of the surface is concerned, additions of tungsten in amounts by weight from about 15% to 40% are sufficient. Similar proportions are suitable if tungsten is entirely or partly replaced by molybdenum or tantalum.

20 If good heat conductivity is to be considered besides wear resistance, a substantial amount of iron group metal, particularly cobalt, should be used, e. g. about 10% to 50%.

25 If a low weight of the body is desirable, lithium and/or aluminum may be used as a substantial portion of the mass, in amounts from about 10% to 60% with iron, cobalt, zinc and/or tin as a
30 balance.

In particular, if a metallic state of one or more components of the mass is desirable, in order to render it either tough to a desired degree, or to adjust its heat conductivity, copper and/or cobalt are admixed in amounts from about 5% to
35 80%. Copper does not form any carbide and is therefore desirable as admixture, if it is to remain in its metallic state. However, copper has a relatively low melting point and in such a case the
40 other components to be carbided are to be chosen so that they are capable of being carbided at or below the melting temperature of copper.

I wish to point out that any sintering process is mostly a combination of a melting and plasticizing process insofar as the lower component
45 present in the mass is melting, whereas the higher melting component wetted by the lower melting component is somewhat plastified at least in its surface layers. Therefore with copper preferably
50 molybdenum is admixed which is capable of carbiding close to about 1000° C. without alloying with the copper present. Chromium in admixture with copper may also be used, because chromium is capable of being carbided close to
55 the melting temperature of copper and does not form a solid solution with copper. Iron in admixture with copper may also be used, because iron is capable of carbiding to a sufficient degree at the melting temperatures of copper and forms a
60 solid solution with it only to a very limited amount.

If very high resistance against wear is desired and therefore tungsten carbide wanted in the surface, it is suitably admixed with cobalt,
65 because tungsten forms carbide also below the melting temperature of cobalt, whereas cobalt does not easily form any carbide.

The mixture may also be composed so as to have one component protecting the other one
70 from carbidisation. Thus, for instance, titanium has a very high affinity to carbon and if titanium is admixed, e. g. to tungsten or iron, the titanium will be carbided at fritting temperature, whereas the tungsten or iron will remain substantially
75 metallic. In this case I conduct the treatment by

removing the body from the carbonaceous atmosphere after a period of time in which, according to experience, the titanium is substantially carbided, so that the admixture which is still substantially metallic retains this state.

5 In carrying out my process I heat the pressed and thereby shaped mass first to a temperature at which presintering or fritting occurs, and the lower melting component is heated close to its
10 melting point without being melted. At such temperature the lower melting component plastifies, but does not liquefy, and starts to fill the pores in the high melting component without being capable however of completely closing those
15 pores and interstices, so as to permit the surrounding carbonaceous atmosphere to enter the still open pores and interstices and to penetrate into the body. Such temperature close to but below the melting point of the lower melting component suffices for carbiding the properly chosen
20 higher melting component and, if desired, to some extent also the lower melting component. By suitable adjustment of the pressure in and time of application of the carbonaceous atmosphere, any depth of penetration of the carbonaceous
25 medium into the mass undergoing presintering or fritting is insured. I then remove the mass from the carbonaceous atmosphere. If desired, I machine the body so obtained, as it is well known in the art. Thereupon I subject the fritted or
30 presintered body to high sintering temperature in a neutral or protective atmosphere, such as hydrogen containing atmosphere.

Taking for instance a mixture consisting of a major portion of tungsten, a few percents of
35 titanium and a minor portion of cobalt, I press the mixture to a desired shape by applying pressure of between 2000 and 15000 lbs. per sq. inch, or higher. Then I put the loosely coherent body in a chamber in which a carbonaceous atmosphere of desired concentration is maintained. This
40 atmosphere may consist of carbon monoxide which decomposes at about 1000° C. under normal pressure or at somewhat higher temperature at increased pressure, and I heat the body within
45 the chamber to presintering temperature which lies between 900° to about 1100° C. At that temperature the carbon monoxide is decomposed and the carbon combined in statu nascendi with the titanium and, if the treatment is continued, with
50 the tungsten present, whereas cobalt does not undergo any substantial carbidisation. Thereupon I release the carbonaceous gases from the chamber, admit to it a washing gas, such as nitrogen, or even atmospheric air, and thereupon
55 I introduce hydrogen into said chamber. Now I again heat the body in the chamber up to sintering temperature which lies between about 1400 to 1600° C., until after the desired density of the body is obtained. The thus finished body
60 is removed from the chamber.

Instead of carbon monoxide an acetylene containing gas may be introduced into the chamber during the presintering stage, which either decomposes at the fritting or presintering
65 temperature or is being decomposed by an electric discharge sent through the chamber.

I may also introduce carbon containing gases such as methane.

Instead of creating a carbonaceous atmosphere
70 around the body under treatment by introducing a gas or vapor, I may use a mold to the surface of which carbon, preferably in the form of lamp black is applied as a rather thin layer. I use this mold for pressing the powdery mass and
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leave the mass therein during the subsequent fritting or presintering treatment. To this effect the mold is heated during or after pressing to the desired temperature sufficiently long to cause the carbon adhering to the inner surface of the mold to combine with suitable components of the mass and to infiltrate to a desired depth into it while undergoing fritting or presintering treatment. Thereupon I remove the mass which is compacted and provided with a carbidized surface layer from the mold and treat it in a chamber in a protective atmosphere at final sintering temperature.

I might also leave the mass in the mold during the entire treatment but raise the temperature so that presintering or fritting temperature is maintained for a period of time sufficient to carbidize the surface of the pressed body to a desired depth, whereupon the temperature is further raised, so as to finally sinter the body still in the mold and, if desired, under pressure. This latter process is advantageous in so far as the least handling of the mass is required, high density of the body and therefore strength is obtained, and the shortest period of time for finishing the treatment is required.

A preferred method according to my invention consists in the following—

I take the mixture of base metal powders desired for the body to be made, which may or may not contain elements capable of forming carbide, and press it into a mold under high pressure, as referred to above, or still higher. I may also heat it to fritting or sintering temperature. I may also use a cast body instead. Then I cover this coherent body with another powdery mixture, consisting of powdery metal containing elements capable of being carbidized and finely divided carbon, such as lamp black, and press the whole again under high pressure as referred to above preferably in the same mold. I thereby obtain a loosely coherent body comprising a core of the desired base metal and a layer consisting of a mixture of powdery metal and finely divided carbon. The metal present in that layer may be the same as the base metal or different from it. In any case, the layer has to contain the metal or metals intended to form the wear resisting carbide containing surface layer. It is obvious that the thickness of that layer and even the places where it is applied to the core can be selected at will. I can easily cover the entire core with said layer, or I may cover only those parts of it which are subject to wear during use. I may also apply a layer of even thickness or I may vary the latter.

After the second pressing I do not need to remove the body from the mold, but may immediately apply heat to the mold, so that presintering or fritting together with chemical combination between the carbon and the metal present in the layer occurs. After having remained at that temperature for a sufficient period of time, so as to secure thorough carbidisation, I raise the temperature of the body still in the mold until final sintering is performed.

If any machining of the body is necessary, this has to be done between the presintering and the final sintering step.

However, due to the use of metal powders shaped in molds or dies and due to the further fact that carbidisation occurs in the surface layer itself during pressing and heating, generally no such machining is necessary, and the final body has the exact measures.

Although the lastly described feature of my

invention offers its principal advantages, the carbidisation of the desired metal contained in the layer is substantially completed in the presintering stage, so that in the final sintering stage only compacting and densification of the surface layer occurs, the latter consisting of desired carbides and metal cementing the same, so that a uniform and extremely wear resisting cover of desired depth is obtained.

It is within the scope of my invention that also preformed carbides may be incorporated into the base metal or a covering layer thereof, such as tungsten carbide, titanium carbide, etc. in finely divided state, so that in the presintering stage only additional carbide is formed in the presence of carbon, and in the final sintering stage the whole is compacted and densified.

What I claim is:

1. A process of manufacturing shaped and surface hardened bodies comprising the steps of forming a surface layer on a body, said layer comprising components capable of carburising, exposing said body with said layer to a free carbon containing medium surrounding said components and raising the temperature to a range from fritting to presintering temperature, continuing said treatment within said temperature range during a controlled period of time until said components in the surface layer are substantially carburised, and thereupon solidifying said still hot body by highly sintering in a neutral atmosphere.

2. A process of manufacturing shaped and surface hardened bodies, comprising the steps of forming a powdery mixture consisting of about 1% to 15% titanium, about 10% to 50% metal selected from the iron group, and a balance selected from metal melting above said iron group metal, shaping and pressing a body containing said mixture at least in surface layers, exposing said body to a free carbon containing medium and heating it during a controlled period of time to a temperature between fritting and sintering temperature of said iron group metal until at least said titanium is substantially carburised, and thereupon solidifying said body by high sintering in a neutral atmosphere.

3. A process of manufacturing shaped and surface hardened bodies, comprising the steps of forming a powdery mixture consisting of about 1% to 15% titanium, about 5% to 50% metal selected from the iron group, the remainder substantially selected from a group of metal consisting of tungsten, molybdenum and tantalum, shaping and pressing a body containing said mixture at least in surface layers, and exposing said body during a controlled period of time to a free carbon containing medium at a temperature between about fritting and sintering temperature of said iron group metal until said titanium and the metal selected from said group are substantially carburised, and thereupon solidifying said body by high sintering at a temperature between about 1400° to 1600° C.

4. A process of manufacturing a shaped and surface hardened body, comprising the steps of forming a powdery mixture of about 1% to 15% of at least one element selected from a first group consisting of titanium and silicon, of about 10% to 50% of at least one metal selected from the iron group, the remainder substantially at least one metal selected from a third group consisting of tungsten, molybdenum and tantalum, shaping a body containing said mixture at least in surface layers, exposing said body during a

controlled period of time to a medium containing free carbon sufficient to substantially carburise the metal selected from said first and third group, at a temperature between about 700° to about 1200° C. until said metal is substantially carburised, and thereupon solidifying said body by heat treatment at temperatures between about 1400° to 1600° C.

5. A process of manufacturing shaped and surface hardened bodies comprising the steps of forming a powdery mixture containing at least one component in appreciable amount capable of being carburised, shaping a layer of said mixture as a cover on a solid body, exposing said covered body during a controlled period of time to a free carbon containing medium at a temperature between fritting and presintering temperature of said mixture until said component is

substantially carburised, and thereupon solidifying said body by high sintering in a neutral atmosphere.

6. A process of manufacturing shaped and surface hardened bodies, comprising the steps of forming a powdery mixture containing at least one component other than iron in appreciable amount capable of being carburised, and carbon in an amount substantially sufficient for carburising said component, shaping and pressing said mixture, treating the body thus obtained during a controlled period of time at a temperature between fritting and presintering temperature of said mixture until said component substantially combines with said carbon and thereupon solidifying said still hot body by high sintering in a neutral atmosphere.

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