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PROCESS OF HARDENING ALLOYS BY INDIFFUSION OF A METALLOID

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It is known to harden a metal and more particularly an iron alloy by making diffuse into it at increased temperature a metalloid such as nitrogen, for example by heating in an atmosphere, or a molten mass containing a compound of nitrogen. Reaction of nitrogen diffused in the metal with one or more constituents of the metal to be hardened has the effect of producing nitrides, resulting in hardening. Such a nitride hardening is utilised for obtaining a hardened superficial layer of a metal.

The Belgian Patent Specification 454,567 describes an alloy, more particularly of silver, copper or nickel, which is to be hardened by making oxygen diffuse into it at increased temperature, which leads to the production of sub-microscopic oxides in the alloy, which bring about the hardening effect. This so-called oxidation hardening may serve for a superficial hardening as well as for a hardening through the whole of the alloy.

The alloys hardened by indiffusion of a metalloid are frequently brittle, due to which their use is in definite cases rendered impossible.

According to the invention, for reducing the brittleness the alloy is hardened in the monocrystalline state.

The invention is particularly of importance for alloys, such as copper and silver alloys, which are hardened by indiffusion of oxygen. The brittleness is in this case suppressed so strongly that the monocrystalline alloy, after being hardened, may be readily formed into rods, supports, strips, etc. by rolling, drawing or a similar operation, even at room temperature. It is thus possible to obtain products which are hard, ductile and have a high electrical conductivity and which, for example, lend themselves very well to the manufacture of components in thermionic tubes, such as grid backbones and wires. Also with indiffusion of nitrogen, alloys of considerable less brittleness are obtained by utilising the invention.

If with the use of the invention the alloy, after being hardened, is not rolled or deformed in another manner, it remains in the monocrystalline state, although one cannot say that in the above-mentioned embodiment of the invention, in which the hardening process is followed by a deformation, the alloy becomes polycrystalline in the usual sense of the word.

In the latter case the monocrystalline structure is broken, however, by shearings of crystal parts relatively to one another, resulting in slide lines. The monocrystalline alloy deformed subsequent to the hardening process has a very particular structure which becomes manifest in the fact that the deformation does not bring about any further appreciable increase of hardness and that upon annealing, the deformed alloy neither recrystallises, nor does there occur a decrease in hardness. We mean here an annealing process under conditions in which the same deformed alloy in which only no metalloid is indiffused, does recrystallise. For the practical use it is of the utmost importance that the hardness is retained after annealing.

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During the annealing the alloy does not reach the very soft state which recrystallizing alloys usually pass at the time of their recrystallization and which, when deformed alloys are being annealed, cause variations of shape if these alloys are exposed to any stress during the annealing process.

The improvement in brittleness obtained by the invention is probably connected with the fact that the nitrides and oxides which are formed during the hardening process also separate out at the surfaces where the crystals adjoin one another. When such crystal boundaries are not present in the alloy, in the case of a monocrystal for instance, brittleness is considerably smaller. Small inclusions and pores in a monocrystal are, of course, not detrimental to the hardness and the expression "monocrystalline state," consequently comprises monocrystals having such inclusions and pores.

In manufacturing an object or constructional part according to the invention it will sometimes not be necessary that the whole of the object or constructional part has minimum brittleness. In such a case it suffices if the portion of the object which is exposed to a mechanic load and whose brittleness should be decreased is in the monocrystalline state during the hardening process.

Examples

I. A monocrystal in the form of a circular rod of 3.5 mm. in diameter and 60 mms. in length, consisting of silver containing 0.3% by weight of magnesium, was completely hardened by annealing it in air for 27 hours at 800° C. The hardness was 122 kgs./mm.^{2}, measured according to the method by Vickers. Subsequently, the monocrystal was rolled cold into a plate of 0.5 mm. thick, during which treatment the hardness raised to 146 kgs./mm.^{2}. This plate was entirely free from cracks. After annealing in nitrogen for half an hour the hardness was 122 kgs./mm.^{2}.

Any recrystallisation did not occur during this process. The slide lines produced during rolling were still clearly visible.

II. A monocrystal of copper containing 0.2% by weight of beryllium of same dimensions as in Example I was completely hardened by heating it in air for 26 hours at 950° C. After removal of the oxide film, the diameter of the monocrystal was 1.6 mms. The Vickers hardness was 120 kgs./mm.^{2}. Subsequently, the monocrystal was rolled cold into a plate of 0.5 mm. thick, during which treatment the hardness remained unvaried. Annealing for half an hour at 800° C. in nitrogen did not vary the hardness and any recrystallisation did not occur during this process.

When the monocrystal was annealed in air for 17.5 hours only, a core of about 0.5 mm. in diameter remained unhardened. This core did recrystallise during annealing in nitrogen. The crystals produced during this process did not grow through the boundary of the unhardened core and the hardened superficial layer.

III. A rod-like monocrystal of 3 mms. in diameter and consisting of iron containing 2% by weight of aluminum was heated in ammonia for 120 hours at 525° C. Whereas a polycrystalline rod treated in this way is very brittle and cracks and breaks during cooling at the crystal boundaries, the hardened monocrystal was very resistant.

What we claim is:

1. The method of manufacturing a hardened body, comprising the steps of heating a monocrystalline alloy body to an elevated temperature, diffusing a metalloid selected from the group consisting of oxygen and nitrogen into said alloy body while the said alloy body is maintained at the said elevated temperature, and thereafter deforming the said alloy body.

2. The method of manufacturing a hardened body, comprising the steps of heating a monocrystalline silver magnesium alloy body to a temperature of about 800° C., diffusing oxygen into said alloy body while the said alloy body is maintained at the said temperature, cooling the so-treated alloy body, and thereafter deforming the said alloy body.

3. The method of manufacturing a hardened body, comprising the steps of heating a monocrystalline copper-beryllium alloy body to a temperature of about 950° C., diffusing oxygen into said alloy body while the said alloy body is maintained at the said temperature, cooling the so-treated alloy body, and thereafter deforming the said alloy body.

4. The method of manufacturing a hardened body having hardened surface portions, comprising the steps of heating a monocrystalline copper-beryllium alloy body to a temperature of about 950° C., diffusing oxygen into said alloy body while the alloy body is maintained at the said temperature, deforming the so-treated alloy body, and annealing the deformed alloy body at a temperature of about 800° C. in a nitrogen atmosphere.

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