

1

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COHERENT DISPERSION HARDENED COMPOSITES

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2 Claims

ABSTRACT OF THE DISCLOSURE

A composite material having a bundle of tubular hardening films and consisting of a single body formed of parallel fine wires diffusion welded to one another with interposition of substantially uniform layers of metals or compounds thereof capable of preventing the dislocation movement of the basic material, the diameter of said wires having a magnitude of 1 micron.

The present invention relates to composites having a bundle of tubular hardening films.

It is known that both deformation and rupture of crystalline materials are caused by lattice defects and particularly by the formation and movement of dislocations in the case of plastic deformation, by the increase of microcracks in the case of rupture. Also the microcracks can be formed and moved by dislocations. The dislocations cause the materials to plastically deform and break under stresses, which can be of some orders of magnitude lower than the stresses obtainable for perfect material, without such lattice defects.

In order to increase the yield point and consequently the strength in materials, it is theoretically possible to use two methods: trying to obtain perfect crystals without defects, or stopping the dislocation movement. Both methods have been used and have given good results. But perfect crystals can be obtained only in the form of fine fibers, or whiskers, with a difficult and expensive technique, so that the possibility of application is very limited.

To prevent the dislocation movements, advantage has been taken of the fact that fine particles included in a crystal lattice, anchor the dislocations in contact with them; and in this way the techniques of dispersion hardening have been developed. A typical example of the application of such techniques is aluminium hardened by dispersion of alumina particles, known under the name of SAP. The conditions under which anchoring of dislocations and reduction of plasticity by the dispersed particles can be obtained are: sufficient mechanical resistance of the particles, their rather small diameter, and average small distance therebetween. However, particles randomly distributed in the matrix, if they withstand the dislocation movements particularly at high temperature, are incapable of preventing it. If the stress increases, the dislocations separate from the particles and bypass them.

It can be theoretically demonstrated that dislocation movements are rigorously stopped in one direction, in principle, if the hardening materials are present not as dispersed particles, but as a compact bundle of tubular films, the diameter of the single tube being sufficiently small and on the order of one micron. Until now this has never been realized.

The objects of the present invention are the coherent dispersion hardened composite materials having the above-mentioned bundle of tubular hardening films and embodying the structure already shortly described.

By mere example and not limitation, some processes for obtaining the materials will now be described.

2

According to a process, we start from a basic material (which can be a metal or an alloy) under the form of fine wires. On the surface of the wires a small layer of the material constituting the barrier against dislocation movements, is deposited or is formed by oxidation. Then a bundle is formed with a group of the coated wires; should oxidation appear, the bundle is protected by a tight container. The assembly is drawn, or milled several times at the right temperature for plastic working and for sintering the basic material. During the last operations, due to the high hardening of the basic material, the temperature will be increased up to approximately the melting point. The plastic deformation will be continued until the section of each wire is reduced to the dimensions calculated in order to prevent the dislocation movements in the axial direction. During working, the cross sections of the wires, pressed all together, become approximately square or hexagonal, in accordance with the configuration of the bundle. As a consequence of the high deformation, the coating material forming the wall boundaries between the individual wires, breaks in many points allowing the basic material to weld discontinuously through the boundaries, forming a continuous matrix. Since the walls also are interconnected, a true "biskeleton" or "composite" is obtained. In this manner rods and wires and other profiles can be obtained if a swaging machine is used instead of a drawbank; cylindrical tubes can also be directly fabricated by placing the wires around a bar and drawing it with the bar; the composite sheets and bands can also be made by arranging many layers of wires side by side and milling them together. To give the sheet good properties, in a direction perpendicular to the rolling direction, the wires must be disposed in layers each at 90° to the direction of the previous layers. In order to obtain tubes able to withstand not only axial stresses, but also to internal pressure, it will be convenient to dispose around a bar alternating layers of axially directed wires and spiral wound wires; this being finished, the assembly is then submitted to a hot diffusion treatment in which the wires weld together. The composites so fabricated show a yield point much higher than the basic material, in the direction of the component wires. To reduce the elastic deformation, the basic material must be hardened with the normal methods.

The critical part of the material described is the external surface. In fact, the surface material is not sustained by a wall and can plastically deform because of dislocation movements that enter or disappear on surface.

To avoid this inconvenience it is necessary, in the assembling of the bundle, to select wires having different mechanical properties, more precisely, the external wires having a much longer elongation and a lower modulus of elasticity than the internal wires; so the external wires contribute to the strength, but being always in an elastic state they avoid dislocations entering from the surface into the composite bulk.

For more details, two particular examples will now be described.

EXAMPLE 1

Aluminium wires are taken—the finest that can be found on the market—having a 0.04 mm. diameter. The wires are oxidized passing through a furnace with controlled temperature and atmosphere, so that a homogeneous surface oxide layer 2μ thick is formed. On the oxidized wires aluminium is plasmasprayed to form a second layer 5μ thick. With the coated wires a compact bundle is assembled having 2 cm. diameter; the bundle is introduced in an aluminium tube having the right diameter, 1 mm. thick, previously oxidized inside. The assembly is rolled at nearly 600° C., in a round roller, reducing

3

the diameter in successive operations to the value of 2 mm. The remaining reduction from 2 to 0.5 mm. is obtained in ten passages at the drawbank. The container formed by the external layer of the piece, is removed by chemical etching; the oxide layer formed inside has the double action of hindering welding by diffusion between the bundle external surface and the container and stopping the chemical etching as soon as the container is eliminated.

EXAMPLE 2

The process is the same as in the previous example except that care will be taken in selecting two different aluminium alloys for the wires and for the container, so that the tube has elastic elongation much higher and Young's modulus much lower than the wires. The tube is so little oxidized on the internal surface that a partial welding with the external bundle wires during rolling is allowed.

The container is not removed, because it protects the composite against the formation and migration in the bulk of dislocations, as it is always in elastic state. To this purpose after drawing the wire is submitted to a thermal treatment for the elimination of working stresses in the external layer.

What I claim is:

1. A single composite dispersion hardened body comprising a basic material comprising parallel fine aluminium wires diffusion welded discontinuously to one another at portions along their length and substantially uniform layers interposed between said wires for preventing dislocation movement of the basic material, the assembly of wires and layers having been drawn several times at a temperature suitable for plastic working and for sintering

4

the basic material, thereby resulting in high hardening of the basic material, said layers comprising an aluminium oxide surface layer coating the wires and an aluminium layer coating the surface oxide layer, the diameter of said wires having a magnitude on the order of 1 micron, said layers having a thickness substantially less than the diameter of said wires and said layers closely surrounding said diffusion welded portions of said wires so that said diffusion welded wires and said layers form interlocked networks.

2. A material according to claim 1, characterized in that said parallel wires are spaced by layers of similar wires arranged at right angles thereto.

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