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PRODUCTION OF HEAVY METAL OBJECTS BY POWDER METALLURGY

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This invention relates to improvements for the production of heavy metal objects by powder metallurgy. The invention more particularly relates to improvements in the process of forming metal objects from titanium, zirconium, tantalum, tungsten, molybdenum and chromium powders, to a novel powder composition used in such process, and to the objects formed by the process.

It is known to produce metal objects of titanium, zirconium, tantalum, tungsten, molybdenum and chromium by the powder metallurgy process. In accordance with this process, a powder of a metal of the aforementioned group is first compacted into the desired shape of the object to be formed, as for example by pressing in a die at pressures between 10 and 50 tons per square inch. The compacting solidifies the powder into what is referred to as a "green briquette," which has sufficient structural strength to withstand the further treatment. After the compacting the green briquette may be trimmed or cut, as necessary, or otherwise finished. It is then sintered into the final object, preferably in a vacuum furnace.

One object of this invention is to improve the mechanical properties, as well as the chemical and wear-resistant characteristics of objects produced by the aforementioned process.

These and still further objects will become apparent from the following description:

In accordance with the invention I have discovered that the properties, such as the mechanical, chemical, and wear-resistant characteristics of the articles produced by the above mentioned process, may be improved if an alkali metal borohydride is admixed with the metal powder in an amount of about 1–5%, and preferably 1–3%, by weight, calculated as boron, prior to the compacting of the powder into the green briquette.

Any of the known alkali metal borohydrides may be used, including sodium, potassium, lithium, cesium, and rubidium borohydrides, but sodium, potassium or lithium borohydrides are preferred due to their greater availability and lesser cost.

The starting metal powder used in the process is the conventional powder used for the production of titanium, zirconium, tantalum, tungsten, molybdenum, or chromium objects by powder metallurgy. The powder, however, should have a mesh size of above 325 mesh, U.S. standard screen size, and should preferably have a mesh size between −100 and +200 mesh, though still coarser powder may be used. The use of the relatively coarser powder, as indicated above, assures the escape of the gas evolved from the alkali borohydride during the sintering, and thus prevents an eruption or even explosion of the piece, which could occur if the same were compacted with too high a density to allow such gas to escape.

The starting metal powder should preferably have an oxygen content of 0.5% or less. The alkali metal borohydride is thoroughly incorporated and mixed with this powder, as for example by milling.

The powder is then compacted into the form of a green briquette in the conventional manner, preferably using pressures to produce a density of about 60–80% of the theoretical, as for example pressures between 10 and 50 tons per square inch. The green briquettes are then trimmed or cut, as necessary, in the conventional manner and sintered in a high vacuum furnace at a temperature

of at least 1600° F. In connection with chromium, molybdenum, tantalum and tungsten, temperatures of between 1800 and 2000° F. are preferably used, and in connection with titanium and zirconium, temperatures between about 2000 and 2500° F. are preferably used. The vacuum in the furnace is preferably maintained at 1 to 2 microns Hg. The preferable sintering time is about 4 hours, but as high as 24 hours or longer may be employed. Generally, as a rule of thumb, the heating time in hours may be calculated by multiplying the percentage of boron, added as borohydride, by 1½ to 2.

Apparently the alkali metal borohydride decomposes and reacts during the sintering, liberating the alkali metal, which combines with the oxygen, carrying the same off and thus acting as a deoxidizing agent while the boron combines with the metal to form a stable boride. The hydrogen is apparently liberated, and furthermore the overall hydrogen content of the metal is reduced because of the heating in a high vacuum. The objects formed in accordance with the invention have improved mechanical properties, as well as chemical and wear-resistant characteristics.

The following examples are given by way of illustration and not limitation:

Example 1

A quantity of sodium borohydride, sufficient to add about 2% by weight of boron, was mixed with zirconium metal powder having an oxygen content of 0.3%, and a mesh size between −100 and +200 mesh. The powder was compacted in a die, at a pressure of about 20 tons per square inch, into the form of a small crucible having a density of about 70% of the theoretical. The crucible was trimmed to remove any jagged edges remaining after the compacting, and the green briquette was sintered in a vacuum furnace for about 4 hours at a temperature of about 2100° F. The crucible formed showed improved tensile strength and chemical resistance, as well as increased wear-resistance because of an increase in hardness. The metal of the crucible showed a reduced oxygen content of 0.07%.

Example 2

Titanium metal powder of a mesh size between −200 and +200 mesh, and with an oxygen content of 0.25%, and a hydrogen content of 0.018% was milled with potassium borohydride in an amount supplying about 3% boron, based on the titanium. The powder was then compacted by pressing in a die with punches into the form of a rocket nozzle. The pressure was sufficient to produce a density of about 70% of the theoretical. The green briquette was then trimmed to remove rough edges and imperfections, and was sintered in a vacuum furnace at a temperature of about 2200° F. for about 4 hours. The finished product showed an oxygen content of 0.05% and a hydrogen content of 0.009%. As compared with an identical object produced without the potassium borohydride, it showed marked improvement (22%) in tensile strength.

Example 3

The above examples are repeated using, in turn, chromium, molybdenum, tantalum and tungsten powder, and lithium, cesium and rubidium borohydride, with the sintering being effected at a temperature between about 2000 and 2200° F. Improved products are obtained in each case as compared with the product produced in the identical manner but without the alkali metal borohydride.

The invention is particularly applicable for producing, for example, gears, bearings, cams, pump parts, turbine blades, valve parts, hydraulic equipment, jet engine parts, etc.

While the invention has been described in detail with

reference to certain specific embodiments, various changes and modifications which fall within the spirit of the invention and scope of the appended claims will become apparent to the skilled artisan. The invention is therefore only intended to be limited by the appended claims or their equivalents, wherein I have endeavored to claim all inherent novelty.

I claim:

1. In the process for producing metal objects by powder metallurgy, in which a powder of a metal selected from the group consisting of titanium, zirconium, tantalum, tungsten, molybdenum and chromium, is compacted into shape and thereafter sintered, the improvement which comprises admixing an alkali metal borohydride with the powder in an amount of about 1–5% by weight boron prior to said compacting.

2. Improvement according to claim 1 in which said alkali metal borohydride is admixed in an amount of about 1–3% by weight boron.

3. Improvement according to claim 1 in which said powder has a mesh size above about 325 mesh.

4. Improvement according to claim 3 in which said powder has a mesh size between about 100 and 200 mesh.

5. Improvement according to claim 1 in which said compacting is effected to about 60–80% of the theoretical density.

6. Improvement according to claim 1 in which said sintering is effected at a temperature between about 1800 and 2200° F. in a vacuum furnace.

7. A powder material for powder metallurgy comprising a powder of a metal selected from the group consisting of titanium, zirconium, tantalum, tungsten, molybdenum and chromium, having a particle size above about 325 mesh and containing an alkali metal borohydride intimately admixed therewith in an amount of about 1–5% by weight boron.

8. A powder according to claim 7 in which said alkali metal borohydride is present in an amount of about 1–3% boron.

9. A powder according to claim 8 having a mesh size between about 100 and 200 mesh.

10. An article sintered from a compacted metal powder selected from the group consisting of titanium, zirconium, tantalum, tungsten, molybdenum and chromium, said powder containing an alkali metal borohydride in an amount of about 1–5% by weight boron.

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