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3,536,458

PLATED ALUMINUM POWDER METALLURGY SINTERED COMPACT

Samuel Storchheim, Forest Hills, N.Y., assignor to Alloys
Research & Manufacturing Corporation, Jamaica, N.Y.,
a corporation of Delaware
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ABSTRACT OF THE DISCLOSURE

A coherent smooth deposit of a plated metal on an aluminum powder metallurgy sintered compact is obtained by plating the metal on a sintered aluminum compact having at least about 90% theoretical density and having non-interconnecting pores and fine grains interconnected by a lattice of a minute amount of aluminum oxide.

This invention relates to powder metallurgy and, more particularly, to a metal-plated aluminum powder metallurgy sintered compact.

Sintered metal parts, made by powder metallurgy technique, have proven heretofore to be difficult to plate with the same or with any other metal. The sintered metal parts have generally been characterized by considerable porosity which must be filled, prior to plating, if a coherent smooth plate deposit is to be obtained. To fill these voids, various plastics have been used, and the presence of the plastic at the surface of the sintered metal compact, together with the large metal grain size promoted by the sintering temperature, has yielded non-coherent and non-adherent deposits when plated.

I have now found that a specific type of sintered aluminum compact does lend itself to being surface-plated and that the resulting article has many uses and advantages. This novel article of the invention consists essentially of (1) a sintered compact of aluminum powder, (a) having a density of at least 90% theoretical density, (b) having a grain size not significantly greater than that of the aluminum powder, and (c) the grain being substantially interconnected by a lattice of aluminum oxide in an amount not significantly in excess of 0.8% by weight of the aluminum; and (2) a coherent surface plate of a metal on at least a portion of the surface of the compact.

The sintered aluminum compact can be made from any aluminum powder having particle sizes of at least 3 microns in major dimension and generally are 100% minus 60 mesh Tyler Standard. Such powders can be any of those described in U.S. Pat. No. 3,366,479, whether air-atomized or helium-atomized, or the like. The aluminum may be substantially pure or it may contain one or more of the conventional alloying elements for aluminum powder metallurgy such as copper, zinc, magnesium, silicon, and the like, in amounts up to 45% by weight of the mixture. The additional element or elements can be present either in the form of an alloy with the aluminum or in the form of a mixture of elemental components, or a combination of these expedients. Whether the aluminum is used alone or in alloyage, it will be referred to herein and in the claims simply as aluminum.

The sintered aluminum powder compact is advantageously produced pursuant to the aforementioned Pat. No. 3,366,479. As described in the patent, the compact is formed under conditions which yield a shaped mass of interconnecting porosity prior to the sintering step. This interconnecting porosity is obtained by limiting the density of the shape to a maximum of 98% of theoretical

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density. This is done by using a conventional lubricant if the compaction pressure is about 3 t.s.i. or higher and by limiting the compaction pressure to a maximum of about 40 t.s.i. It is presently preferred to use a compaction pressure such that the sintered compact will have a density at least about 90% of theoretical density. When a low compaction pressure below 3 t.s.i. is used, interconnecting porosity is automatically obtained, but with a higher compaction pressures a lubricant is used so that volatilization of the lubricant as the compact temperature is being raised to a sintering level will leave behind the desired interconnecting pores. The resulting shaped mass of aluminum powder is then heated to sintering temperature in a moisture-containing atmosphere, to wit, an atmosphere containing water in amount corresponding to a dew point of -60° F. to -20° F. In the presence of this amount of oxidizing agent (the water) which is free to penetrate the pores of the shaped mass, the extent of oxidation of the pores is controlled by limiting the amount of time the porous metal shape is exposed to this atmosphere. Such control is obtained by using a minimum heating rate of about 20° C. per minute up to the sintering temperature.

As a result of this controlled oxidation of the walls of the pores, an internal skeleton of oxidized metal is formed which constitutes a supporting structure against the tendency of the compact to sag as it approaches the sintering temperature. Then, when the mass reaches the sintering temperature, thermal diffusion closes the pores to prevent further oxidation and forms a lattice of aluminum oxide interconnecting the grains. Not only does this controlled oxidation and diffusion substantially eliminate the initial interconnecting porosity of the compact, but the presence of the oxide film on the walls of the pores, advantageously limited to a maximum of about 0.8%, and preferably between about 0.2 and 0.5%, by weight of the aluminum, tends to act as a grain growth inhibitor and to insure in the sintered article a fine grain size generally not significantly larger than that of the aluminum powder.

The resulting sintered compact is sufficiently non-porous as to not require any filler, as in prior art practice, before the plated metal surface is applied. In addition, the absence of interconnecting porosity precludes entry of a plating solution in the compact and thus eliminates one of the causes of irregular plated surface characteristic of articles produced pursuant to prior art practice.

The plating of the sintered compact can be any conventional technique. When the compact is to be plated with aluminum or an aluminum alloy, conventional vacuum plating procedure is followed. When plating with nickel, zinc, tin, and the like, electroless plating can be used with advantage. Moreover, any metal such as gold, silver, brass, bronze, copper, tin, chromium, nickel, iron, cadmium, or the like, which can be electrodeposited from solution can be deposited effectively on the aforementioned sintered compact by any conventional electrodeposition operation. The plating can be applied over the entire surface of the sintered compact or on only one surface or on one or more portions of one or more surfaces of the compact, depending upon the purpose of the plating. When the plate is used for decorative purpose, the nature of the decoration will control its application. When the plate is used for mechanical or corrosion protection, other considerations will control the extent of the plated surface, and when the plate is used to facilitate soldering, brazing or welding, still other considerations will apply. In any event, it will be found that the plated surface is coherent, uninterrupted and as smooth as the plating technique makes possible.

The following specific example is illustrative but not limitative of the production of a plated sintered aluminum article pursuant to the invention:

An aluminum powder of -60 mesh and of the analysis and specification shown in Table I was mixed with 1% by weight of -325 mesh copper powder, plus 0.1% by weight of -325 mesh magnesium powder, plus 0.5% by weight of a conventional powder metallurgy organic lubricant known by its trade name as Nopcowax.

TABLE I.—ALUMINUM POWDER USED

Properties	Specification, percent		Typical analysis, percent
	Min.	Max.	
Chemical:			
Free metallic aluminum, percent by weight	98.75	---	99.4
Iron, percent by weight	---	0.25	0.14
Silicon, percent by weight	---	0.25	0.13
Physical, apparent density, g./cc.	1.00	1.30	1.25
Screen Analysis:			
+60 mesh	---	(1)	(1)
-60+200 mesh	35	60	42
-200+325 mesh	10	25	20
-325 mesh	30	45	38

¹ Trace.

The powder was mixed for one-half hour and was then compacted in the form of a number of small trays (3" in diameter and approximately 1/8" thick) which could be utilized as either a coaster for glasses or an ash tray. The green density of the trays was approximately 93% of theoretical and allowed easy handling of the compacts.

The compacts were then sintered in a continuous belt furnace which was maintained at 1220° F., and were passed through the furnace at a speed such as to give 5 minutes at the sintering temperature while in a hydrogen atmosphere having a dew point of about -35° F. After being sintered, the pieces had a metallic ring and were slightly shrunken (to approximately 95% of theoretical density). The sintered pieces were put back into the green pressing die and were coined. Some of the coined pieces were vacuum plated with aluminum by conventional technique and were lacquered, and some of the coined pieces were electroplated with bronze, brass, chrome, copper and 24 karat gold. All of the plates

were adherent and showed no pinhole porosity. The luster of the plates was very high and the adhesion was excellent, no spalling being observed when the pieces were cut or machined. No plating difficulties were encountered.

It will be seen, accordingly, that the plated sintered aluminum articles of the present invention make possible a quality of surface plate more adherent and useful than obtainable heretofore with sintered aluminum compacts. In addition, the plated compacts of the invention can be made more economically than heretofore because the sintered compact can be plated directly without intermediate treatment of the compact to close its pores or to otherwise prepare its surface for plating. The articles of the invention make possible the production of shapes having contoured surfaces which have the clarity of detail achievable previously with aluminum only by coining or by engraving.

I claim:

1. An article consisting essentially of:

(a) a sintered compact of aluminum powder, the sintered compact:

- (i) having a density of at least 90% theoretical density;
- (ii) having a grain size not significantly greater than that of the aluminum powder, and
- (iii) the grains being substantially interconnected by a lattice of aluminum oxide in an amount not significantly in excess of 0.8% by weight of the aluminum; and

(b) a coherent surface plate of a metal on at least a portion of the surface of the compact.

References Cited

UNITED STATES PATENTS

3,331,684 7/1967 Storchheim ----- 75-222 X
3,366,479 1/1968 Storchheim ----- 75-222 X

CARL D. QUARFORTH, Primary Examiner

A. J. STEINER, Assistant Examiner

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