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[54] **MACHINING SINTERED POWDER METAL**

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[51] **Int. Cl.**.....**B22f 3/24**

[58] **Field of Search**.....29/192, 420, 420.5, DIG. 26, 29/DIG. 31, 182.1, 423, 527.2; 264/111; 75/200, 201; 106/74

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[57] **ABSTRACT**

A method of providing a machined powder metal article, which comprises the steps of: pressing metal powder into a green compact; sintering the green compact in a substantially non-oxidizing atmosphere; substantially impregnating and coating the sintered compact with an aqueous alkali metal silicate solution; and machining the sintered compact, thereby forming a machined article.

6 Claims, No Drawings

MACHINING SINTERED POWDER METAL

The use of powder metal articles has grown at a very rapid rate in recent years. Largely responsible for this, is the recognition that powder metal articles can combine the economic advantages of mass production for both simple and complex configurations. Today, powder metal articles are continuing to find new markets as replacements for articles machined from conventional wrought and cast materials.

A shortcoming of powder metal articles is that they are not as easily machined as are wrought or cast articles of the same chemical composition. Although it is not entirely certain, it is believed that the machining difficulties of powder metal articles are due to the presence of unreduced oxides on the surface surrounding their pores and to their rough discontinuous cutting surfaces which create a more severe cutting action than do the relatively continuous surfaces of wrought and cast articles.

The present invention improves the machinability of sintered powder metal articles by substantially impregnating and coating them with an aqueous alkali metal silicate solution; a solution which outwardly appeared to be detrimental to machinability, prior to the present invention. Alkali metal silicates are comprised of oxides, substances generally known to be detrimental to machinability. More specifically, they are comprised of oxides of silicon and alkali metal; e.g., SiO_2 and Na_2O.

A copending application, Ser. No. 762,968, filed on Sept. 26, 1968, now abandoned discloses a method of improving the corrosion resistance of powder metal articles with an alkali metal silicate. Unlike the present invention, it relates to a method of applying an alkali metal silicate to an already formed article and not to one which is to be machined. This is especially evident in light of the fact that alkali metal silicates outwardly appeared to be detrimental to machinability, prior to the present invention.

The present invention involves the steps of pressing metal powder into a green compact; sintering the green compact in a substantially non-oxidizing atmosphere such as hydrogen; substantially impregnating and coating the sintered compact with an aqueous alkali metal silicate solution; and machining the sintered compact, thereby forming a machined article. Pressing, sintering, coating and impregnating can be accomplished by any of the conventional prior art techniques. Machining relates to any of those operations wherein the shape of an article is altered by a tool which removes material therefrom. Illustrative machining operations include turning on a lathe and drilling holes.

The alkali metal silicate heats up and flows during machining and thereby acts as a lubricant. As a general rule it is sodium silicate but it can be other alkali metal silicates such as potassium silicate. In addition, the aqueous alkali metal silicate solution can contain wetting agents such as "Wetanol" (Glyco Products, Inc., New York, New York) and corrosion inhibitors such as sodium oxalate, sodium phosphate and sodium aluminate. The required concentration of alkali metal silicate within the solution varies with such interrelated variables as the conditions under which the compact is coated and impregnated and the proposed amount of machining. As a general rule, it is sufficient to provide an impregnant and coating having an average thickness of at least 15 microinches subsequent to curing.

In most instances it is desirable to cure the aqueous alkali metal silicate impregnant and coating prior to machining. Curing protects the impregnant and coating from being wiped off and renders it hard and water insoluble. It is generally performed at temperatures in excess of 300° F., preferably 600° to 900° F., for time periods of from 1 to 10 minutes or more, depending upon the bulk of the article being treated, the thermal properties of the heating equipment, the thickness of the coating and impregnant, and other interrelated variables.

The following examples are illustrative of the invention. They are directed to stainless steel embodiments despite the fact that the invention is believed to be adaptable to a wide variety of metals, including other alloy steels and carbon steels, as stainless steel probably constitutes the most important use for the invention.

EXAMPLE I

A.I.S.I. Type 316L stainless steel powder having the composition and particle size distribution shown below in Table I was blended with **0.5** percent by weight of stearic acid and pressed into compacts with nominal dimensions of 1-inch in diameter × ¾ inches thick and to a density of 6.28 to 6.34 g/cu. cm. Based on the published density value of 7.9 g/cu. cm. for fully dense Type 316L wrought alloys, the compacts had 19.5 to 20.2 percent porosity.

TABLE I

Alloy	Composition (wt. %)					
	C	Mn Si	Cr	Ni	Mo	Fe
Type 316L	0.03	0.140.73	17.30	13.05	2.35	Bal.

Particle Size Distribution (Mesh wt. %)

Type 316L	+100	−100 +200	−200 +325	−325
	trace	22.9	31.1	46.0

The compacts were sintered for one hour at 2,200° F. in dry hydrogen. After sintering, the density of the compacts was 6.55 to 6.60 g/cu. cm. and the porosity was 16.5 to 17.1 percent.

Two drill life tests were conducted to evaluate the machinability of the compacts. Holes were drilled in the compacts to a depth of three-fourths of an inch with a standard one-fourth inch diameter, Type M-1 high speed tool steel drill, 118° angle, heat treated to a Rockwell C hardness of 64.5 to 65. The drill speed was 75 surface feet per minute, the feed was 0.005 inches per revolution and the lubricant was a standard chlorinated oil.

Drilling was discontinued after the cutting edges of the drills were destroyed and drill lives were calculated, for the two tests, by computing the total depth drilled prior to drill failure (number of holes × ¾ inch depth/hole). The computations revealed drill lives of 32.25 and 33.75 inches.

Additional compacts were vacuum coated and impregnated in an aqueous alkali metal silicate solution, cured, and subjected to two drill life tests in the same

manner as discussed above. The aqueous alkali metal silicate solution was a sodium silicate solution and contained about 19 wt. percent solids in water with 0.1 percent by weight of "Wetanol," wetting agent. Coating and impregnating involved the steps of immersing the compacts in a tray of coating solution for 1 hour, in a chamber drawn under vacuum, and for an additional period of time until atmospheric pressure was reached, after the vacuum was released. Curing involved heating at 200° F. for 30 minutes, heating at 400° F. for 30 minutes and heating at 600° F. for 30 minutes.

The two drill life tests using alkali metal silicate coated and impregnated compacts were stopped after drilling 74.25 and 178.5 inches. Upon examination subsequent to drilling, the drill used for 74.25 inches of drilling revealed only slight wear on its point and the drill used for 178.5 inches of drilling showed 0.02 inches of wear on the point, but was still capable of further drilling.

In summary, drills used upon alkali metal silicate coated and impregnated compacts were still usable after drillings of 74.25 and 178.5 inches whereas drills used on uncoated and impregnated compacts were destroyed after drillings of 32.25 and 33.75 inches. Examination of the coated and impregnated compacts revealed a concentration of silicate directly below the point of the drill. This indicates that silicate flowed directly below the drill point, thereby, providing lubrication for the drill.

EXAMPLE II

Additional compacts of Type 316L stainless steel having the composition set forth above in Table I were double-action pressed in an automatic compacting machine to dimensions of 1-inch in diameter × about ⅝ inches thick and subsequently sintered for 1 hour at 2,200° F. in a dry hydrogen atmosphere. The compacts had a density of 6.31 g/cu. cm. before sintering and a density of 6.60 g/cu. cm. after sintering.

Two groups of these compacts (compact groups B and C) were coated and impregnated with an aqueous alkali metal silicate solution in accordance with the coating and impregnating procedure outlined in Example I. Compact group B was air dried after coating and impregnating while compact group C was cured at 600° F. Compact group A was left as sintered.

Drill life tests were performed on the compact groups in accordance with the procedure set forth in Example I. The results of the tests are set forth in Table II.

TABLE II

Compact Group	Drill Speed (surface feet) (per minute)	No. of 3/4 Inch holes per drill	Total inches drilled	Inches per drill
A	75	29; 72; 21; 31	114.8	28.7
A	85	15; 6; 7; 15	32.3	8.1
A	95	4; 4; 5; 5	13.5	3.4
B	125	35; 25; 43; 42; 31	132.0	26.4
C	115	84; 98; 77; 59; 85	302.2	60.4
C	125	40; 63; 22; 33; 24	136.5	27.3
C	135	7; 9; 5; 2; 7	22.5	4.5

A study of the results of Table II reveals that the as sintered compacts; i.e., Group A compacts, were not as machinable as were the coated and impregnated compacts; i.e., Group B and C compacts, and that the air dried coated and impregnated compacts; i.e., Group B compacts, and the cured coated and impregnated compacts; i.e., Group C compacts, exhibited similar machinability. For example, the air dried compacts had a drill life of 26.4 inches at a drill speed of 125 surface feet per minute while the cured compacts had an equatable drill life of 27.3 inches at the same drill speed; two drill lives which compare quite favorably with the 3.4 inches displayed by the as sintered compacts at drill speeds of only 95 surface feet per minute.

From the above paragraphs it will be apparent to those skilled in the art that the novel principles of the invention disclosed herein in connection with specific examples thereof will suggest various other modifications and applications of the same. It is accordingly desired that in construing the breadth of the appended claims they should not be limited to the specific examples described herein.

I claim:

1. A method of providing a machined powder metal article, which comprises the steps of: pressing metal powder into a green compact; sintering said green compact in a substantially non-oxidizing atmosphere; substantially impregnating and coating said sintered compact with an aqueous alkali metal silicate solution; and machining said sintered compact, thereby forming a machined article.

2. A method according to claim 1 wherein said machining of said sintered compact comprises the step of drilling said compact.

3. A method according to claim 1 including the step of curing said aqueous alkali metal silicate impregnant and coating prior to machining.

4. A method according to claim 1 wherein said metal powder is stainless steel.

5. A method according to claim 1 wherein said aqueous alkali metal silicate solution is an aqueous sodium silicate solution.

6. A method according to claim 1 wherein said metal powder is stainless steel, wherein said aqueous alkali metal silicate solution is an aqueous sodium silicate solution and wherein said machining of said sintered compact comprises the step of drilling said compact.

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