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METHOD OF PRODUCING POWDER METAL ARTICLES

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ABSTRACT OF THE DISCLOSURE

Described herein is a method of producing articles of predetermined carbon content from powdered iron and iron alloys which involves blending with the powdered iron, powdered cast iron which has been heat treated to at least partially spheroidized iron carbide in the cast iron.

In the production of sintered parts of iron and iron alloys, e.g. steel, it is conventional practice to blend iron powder with graphite powder to adjust the carbon content and thereafter compact the powder and sinter same to produce a coherent article. An inherent problem with the addition of graphite to iron powder is the non-uniform distribution of graphite which typically results. This is due to the considerable difference in densities of graphite and iron powder and the tendency for the graphite to agglomerate if moist. Variations in the chemical composition of graphite from different sources also make the final carbon content of the blend difficult to predict and control. In addition to segregation, other problems arise due to the increased amounts of graphite which must be added. It has been found for example that increased amounts of graphite added to iron powder decreases the flowability of the powder into the die cavity. Furthermore, large quantities of graphite reduce the green strength of the pressed powder. Since sintered powdered iron articles of higher carbon contents are being required in industry for strength and other properties possessed by such materials, it is desirable to be able to increase and adjust the carbon content more expeditiously.

The present invention provides a method of adjusting the carbon content of powdered ferrous material, i.e. iron and iron alloys, by blending therewith a controlled amount of powdered cast iron having a known carbon content and which has been heat treated to at least partially spheroidized iron carbide contained in the cast iron. The amount of powdered cast iron which is blended with the powdered ferrous material is adjusted in proportion so as to result in a blended mixture of desired carbon concentration. Following blending, the mixture may be compacted and sintered to produce a coherent article. Thus, the invention provides a way of adding a source of carbon to iron powder with a minimum of carbon segregation, with no loss of flow characteristic to the iron powder and a minimum loss of green strength to the pressed powder article. The term "cast iron" as is used herein has the ASTM definition, that is an alloy of iron and carbon which may contain silicon and in which the carbon is present in excess of the amount which can be retained in solid solution in austenite at the eutectic temperature. The Cast Metals Handbook refers to the term "cast iron" as covering a wide range of iron carbon alloys containing 2 to over 4% carbon and from nearly 0 to 6% silicon with minor amounts of manganese, sulphur, phosphorus and, occasionally, alloying elements.

In accordance with the preferred embodiment of the invention atomized cast iron powder is employed which, due to the sudden chilling during the atomizing process, is extremely hard and brittle. This powder is then heat treated at at least partially spheroidized iron carbide contained therein. The heat treatment comprises heating in a non-oxidizing atmosphere at a temperature in the austenitic range but below that which would cause sintering following by slow cooling. This treatment results in a powder which consists of spheroidal iron carbide in a matrix of ferrite. The carbon content of the powder is not significantly altered by the spheroidizing heat treatment. The carbon content of the heat treated powder is determined and by calculation the amount of this powder required for blending with iron powder, also of known carbon content, to produce desired carbon level.

The following example will serve to illustrate the practice of the invention and the superior properties resulting therefrom as compared to the usual graphite blended iron powder. In the example atomized cast iron powder of +100 mesh size was ball milled to produce a −100 mesh product. In the atomized condition the powder has the following chemical analysis in weight percent.

C	4.04
Mn	0.42
P	0.045
S	0.006
Si	0.009
Cr	0.068
Ni	0.071
Cu	0.13

The ball milled powder was heat treated by heating for one hour at 1700° F., furnace cooling at 100° F. per hour to 900° F. and cooling to room temperature under a flowing dry nitrogen atomsphere. At this state the powder had a compressibility of 6.28 g./cu. cm. at 45 t.s.i. and a Knoop microhardness of 356 to 445 and the carbon content of 3.58%.

The cast iron powder was then blended with −100 mesh commercial iron powder to produce mixtures containing 1.00, 0.75, 0.50 and 0.25% carbon. A small amount, i.e. 0.5%, of a commercial powder lubricant, Emersol 150, was also blended with the powder. These blends are identified as blends **411, 412, 413** and **414**, respectively.

A commercial grade of graphite identified as SW graphite was blended with the iron powder to produce blends containing 1.00, 0.75, 0.50 and 0.25% carbon and a similar amount of the same powder lubricant was also added. These blends are identified as blends **415, 416, 417** and **418**, respectively.

The flow characteristic and apparent density of the blends were determined and are reported in Table I.

TABLE I

Blend	Carbon additive	Percent aim carbon	Flow in secs./50 g.	Apparent density in g./cc
411	Cast iron	1.0	22.4	3.49
412	do	0.75	22.8	3.40
413	do	0.50	22.9	3.34
414	do	0.25	24.1	3.26
415	Graphite	1.0	30.6	3.21
416	do	0.75	26.7	3.28
417	do	0.50	25.2	3.25
418	do	0.25	24.9	3.27
450	None	0.0	26.9	3.15

It is apparent from the data in Table 1 that better flow properties are achieved with blends containing cast iron additions. The powdered iron and graphite mixtures resulted in relatively poor flow of properties.

To determine the physical and mechanical properties of green compacts of the above described powders, the ferrous blends were pressed into transverse rupture strength bars at 25, 35 and 45 t.s.i. The density and transverse rupture strength was then determined and the results are

reported in Table II. Each value listed is the average of five tests.

TABLE II

Blend	25 t.s.i. Green density, g./cc.	25 t.s.i. Green TRS, p.s.i.	35 t.s.i. Green density, g./cc.	35 t.s.i. Green TRS, p.s.i.	45 t.s.i. Green density, g./cc.	45 t.s.i. Green TRS, p.s.i.
411	6.41	622	6.71	858	6.90	1,137
412	6.46	580	6.75	875	6.96	1,232
413	6.51	634	6.81	1,050	7.02	1,901
414	6.61	1,093	6.87	1,639	7.06	1,961
415	6.60	619	6.87	1,125	7.04	1,105
416	6.63	696	6.89	1,057	7.07	1,201
417	6.61	627	6.91	1,022	7.08	1,161
418	6.63	634	6.90	943	7.08	1,123

The test bars were then pressed at 25 t.s.i. and sintered. Bars of equivalent blended carbon contents produced from cast iron and graphite blends were placed adjacent to each other during sintering to eliminate variations of sintering temperatures and time. Carbon contents of the sintered bars were determined and are shown in Table III.

TABLE III

Blend	Weight percent Aim carbon	Weight percent Actual carbon
411	1.00	1.00
412	0.75	0.76
413	0.50	0.54
414	0.25	0.33
415	1.00	0.89
416	0.75	0.69
417	0.50	0.51
418	0.25	0.31

As can be seen there was relatively slight variation in carbon content in the cast iron blends as compared to the graphite blends particularly at higher carbon concentrations.

It has been found that the flow properties of metal properties are greatly affected by the particle shape. Therefore, if completely spherical heat treated cast iron powder is added to iron powder, increased flowability of the blend would result with increasing amounts of cast iron powder. However, it is also recognized that pressed parts of spherical powders tend to have low green strength and the proper balance of the particle shape therefore is desirable to obtain the best flow and green strength combination for a given cast iron powder addition.

In a similar manner the apparent density of the powder is affected by the particle shape. Spherical powders do not "bridge" and for a given analysis would have higher apparent densities than irregular shaped powders. It has been found that higher apparent densities can be obtained with cast iron powder additions than with graphite additions, thus more weight per unit volume of powder is obtained, which is a desirable characteristic in designing a die for automatic die fill of production presses. As an example of the variations possible to achieve more compressible powder blends, ball milled cast iron powder was heat treated as follows: 144 hours at 1650° F., cooled 10° F./hr. to 1420° F., held 91 hours at 1420° C., cooled 10° F./hr. to 1100° F., cooled to room temperature under flowing dry nitrogen. After this treatment, the powder had a compressibility of 6.77 g./cu. cm. at 45 t.s.i., a Knoop microhardness of 150 to 164, and a carbon content of 3.54%. Using this heat treated powder, blends were made with commercial iron powder and lubricant described above to produce carbon levels to 1.00, 0.75, 0.50 and 0.25% carbon in transverse rupture strength bars were pressed at 45 t.s.i. and the density and transverse rupture strength, i.e. green strength was determined. The results obtained are shown in Table IV.

TABLE IV

Blend	Percent aim carbon	Green density, g./cc.	Green transverse rupture strength p.s.i.
431	1.00	6.98; 6.97; 6.97	1,337; 1,222; 1,146
432	0.75	7.00; 7.00; 7.00	1,212; 1,375; 1,219
433	0.50	7.05; 7.05; 7.05	1,352; 1,383; 1,541
434	0.25	7.07; 7.08; 7.09	1,666; 1,627; 1,641

It can be seen from the foregoing examples that in the case of graphite additions the green strength is entirely dependent upon the compacting pressure and is not affected by the amount of graphite added in the range of 0.25 to 1.0% carbon. In contrast the amount of cast iron does affect the green strength and lower transverse rupture strength values are obtained with increasing additions in the same range of 0.25 to 1.00% carbon. However, the green strength of the pressed blends containing cast iron is equal to or higher than those blends containing graphite.

It is apparent from the above therefore that the addition of eat treated cast iron powder to iron powder for the purpose of adding carbon or increasing the carbon content in producing sintered steel parts makes it possible to achieve better flow properties, higher apparent densities, better green strengths, closer control of carbon contents and equivalent compressibility in those blends containing equivalent amounts of carbon additives to iron in the form of graphite powder.

I claim:

1. A method of producing ferrous articles of desired carbon content, from metal powder, which comprises the steps of: heat treating atomized cast iron powder to at least partially spheroidize iron carbide contained therein, by heating said cast iron powder in a non-oxidizing atmosphere at a temperature in the austenitic range but below that at which sintering would occur; blending said heat treated cast iron powder with ferrous powder having a lower carbon content than that of said cast iron powder, the amount of blended cast iron powder being sufficient to result in a blended mixture of desired carbon content; compacting said blended mixture; and sintering said compacted blended mixture to produce a coherent article.

2. A method of producing ferrous articles of predetermined carbon content, from metal powder, which comprises the steps of: adjusting and increasing the overall carbon content of ferrous metal powder of known carbon content by blending therewith a controlled amount of atomized cast iron powder having a higher and known carbon content, said cast iron powder having been heat treated to at least partially spheroidize the iron carbide contained therein, the amount of said cast iron powder being sufficient to result in a blended mixture of predetermined carbon content; compacting said blended mixture; and sintering said compacted blended mixture to produce a coherent article.

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