

1

2

3,497,347

PHOSPHORUS CONTAINING IRON POWDER
Norbert Dautzenberg, Lank-Niederrhein, Gerhard Naeser,
Duisburg-Huckingen, and Gerhard Findeisen, Rheydt,
Germany, assignors to Mannesmann Aktiengesellschaft,
Dusseldorf, Germany, a corporation of Germany
No Drawing. Filed Aug. 28, 1967, Ser. No. 663,524
Int. Cl. B22f 1/00; C22c 39/54
U.S. Cl. 75—5

2 Claims

ABSTRACT OF THE DISCLOSURE

An iron powder that contains phosphorus, and is used in forming sintered pressed articles that have a high degree of strength and are shrink free during sintering, is composed of a mixture of two iron powders one of which has a large content of phosphorus and the other has but a minute content of phosphorus.

The invention relates to phosphorus containing iron powder, for use in forming therefrom sintered pressed articles that have a high degree of strength and, during sintering, are free from shrinkage.

Sintering, for use in the mass production of accurately dimensioned articles composed of iron and steel, has successfully joined the group of noncutting shaping processes. Although the knowledge gained in general steel metallurgy is not of much use for the development of the new sinter steels, sinter steels have been produced that maintain industrially a tensile strength of up to 60 kiloponds per square millimeter. Copper, nickel and carbon, the latter as an additive in the form of graphite, have been used successfully as alloying elements in such sinter steels. Among the drawbacks of using copper and nickel in high grade sinter steels has been found to be the high cost of copper and nickel; furthermore, it has been found that the degree of elongation at rupture that may be achieved in such sinter steels lies far below the value of a comparable steel obtained from a molten steel mass. The degree of elongation at rupture of sinter steels may be increased, but only with the aid of expensive operational steps, such as double pressing and double sintering, or hot pressing, and the like.

It is known that sinter iron with a high content of phosphorus of from .3 to .8 percent by weight, though with a low carbon content preferably below .02 percent by weight, has good tensile strength and elongation at rupture characteristics. In the literature there have been proposed mixtures of soft iron powder with the following additives: powders of red phosphorus, iron phosphate, or ground ferrophosphorus with from about 14 to about 18 percent by weight of phosphorus (P).

Experiments have furthermore been made with pre-alloyed powders, that have been made by atomizing of melts, or by machining.

The best strength values and elongation values, however, have been achieved with a phosphorus content of about .5 percent by weight. For instance, elongation rupture rods have been tested and found to have the following values, after a one-hour sintering at 1200° C., at a phosphorus content of .52 percent by weight and a carbon content of .01 percent by weight, and remaining impurities of less than 1.0 percent by weight:

Tensile strength.—39.0 kiloponds per square millimeter
Elongation at rupture.—14.5 percent
Density.—6.91 grams per cubic centimeter
Change in size as compared to the matrix $\Delta l = -2.10$ percent (linear).

Comparable sinter steels alloyed with copper and nickel

would yield an elongation at rupture of about 5 percent, though would have a change in size of about —.10 percent.

As the advantages of sintering prominently include the fact that articles can be manufactured to theoretical size, the large change in size of the ferrophosphorus is a material drawback, particularly as the change in size of the powder mixtures mentioned in the foregoing ranges between 5 and 20 percent, and even for the aforementioned pre-alloyed powders still has a range of change in size of 2 to 3 percent. The large shrinkage may be due to an occurrence of a liquid phase during sintering and the Fe_3P/Fe -eutectic. The excellent strength values of this material would promise wide acceptance in the field of production to accurate size if it were possible to suppress the large changes in size mentioned hereinbefore; in that case the ferrophosphorus would be acceptable as an equal with the copper alloyed and the nickel alloyed sinter steels, but would have a much better elongation characteristic and, notably, would have the further great advantage of being less expensive. It would moreover have the advantage that such a phosphorus containing iron would obtain its desirable properties after a single pressing and sintering, and furthermore would be characterized by an easy machinability.

The instant invention accordingly has among its principal objects to provide a phosphorus containing iron powder that retains unchanged the strength and elongation characteristics of such powders of the prior art, and yet to reduce as much as possible the disadvantageous changes in size that had heretofore characterized articles made from the aforesaid powders.

Further objects and advantages of the invention will be set forth in part in the following specification and in part will be obvious therefrom without being specifically referred to, the same being realized and attained as pointed out in the claims hereof.

Generally, the instant invention achieves the aims by providing a phosphorus containing iron powder that comprises a mixture of two iron powders, one of which has a high content of phosphorus, and the other a content of phosphorus that is as low as possible. The entire content of phosphorus of the mixture preferably is between .2 and 1.4 percent by weight, with a preferred range of between .3 and .8 percent. The share of the phosphorus lean iron powder of the mixture is from 30 to 90 percent by weight, preferably between 60 and 80 percent by weight; and the phosphorus rich powder of the mixture contains less than 5 percent by weight of phosphorus, while the phosphorus lean iron powder contains only about .03 percent by weight of phosphorus.

The content of phosphorus of the phosphorus rich iron powder, however, must not be materially in excess of 3 percent by weight, as otherwise, as at the ferrophosphorus addition during sintering, there may occur a liquid phase that would cause a large change in size. It has been found that surprisingly the change in size of pressed articles from the steel powder mixtures of the invention is much smaller than of comparable pressed articles made from alloyed steel powders. Yet the sintered parts made from the mixed powders, and those made of the alloyed powders, have the same mechanical properties; the powder mixture therefore must be completely homogenized.

EXAMPLES

In the examples below, a powder mixture is used that has an overall content of .5 percent by weight of phosphorus, and that is composed of normal phosphorus lean iron powder that has a content of .03 percent by weight of phosphorus, and an iron powder that is alloyed with phosphorus. The strength of sintered articles made there-

from ranges from 38 to 40 kiloponds per square millimeter; for the different mixing proportions, however, there are found to exist different changes in size, as set forth in the table below:

Powder (percentages by weight):	Changes in size, (percent)
(1) Homogenous powder -----	-2.10
(2) Mixture: 50% soft iron, 50% soft iron with 1% P -----	-.95
(3) Mixture: 66.6% soft iron powder, 33.3% iron powder with 1.5% P -----	-.43
(4) Mixture: 90% soft iron powder, 10% iron powder with 5% P -----	-12.4

As a comparison between the powders (1), (2) and (3) reveals, the instant invention provides that by the use of powder mixtures there can be achieved very small changes in size during sintering. It is only with this small change in sizes that it becomes possible to utilize for technical advantage, for powder metallurgical purposes, the excellent properties of carbon lean, phosphorus containing powder steels. The unexpectedly large reduction in shrinkage probably may be explained due to the so-called "Kirkendahl" effect. The example (4) of the above table shows that, probably due to the occurrence of a liquid phase, the mixtures heretofore used of soft iron powder and ferrophosphorus powder yield too large changes in size.

We wish it to be understood that we do not desire to be limited to the exact details described, for obvious modifications will occur to a person skilled in the art.

Having thus described the invention, what we claim as new and desire to be secured by Letters Patent, is as follows:

1. A phosphorous iron powder mixture, for use in producing sintered pressed articles having a high degree of strength and being substantially shrink-free during sintering, of from 30 to 90 percent by weight of the mixture consisting of one iron powder type having a phosphorus content of about .03 percent, the remainder of the mixture consisting of a second iron powder type having a phosphorus content of less than 5 percent wherein the total phosphorus content of the mixture is between .2 and 1.4 percent by weight.

2. A phosphorous iron powder, as claimed in claim 1, said one type powder forming of from 60 to 80 percent by weight of the mixture.

References Cited

UNITED STATES PATENTS

2,213,523	9/1940	Jones et al. -----	75—123
2,661,282	12/1953	Daley -----	75—123

FOREIGN PATENTS

571,442	8/1945	Great Britain.
---------	--------	----------------

L. DEWAYNE RUTLEDGE, Primary Examiner

T. R. FRYE, Assistant Examiner

U.S. Cl. X.R.

75—123