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FORMATION OF FERROUS METAL POWDERS AND FORMATION OF ARTICLES BY SINTERING

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This invention relates to the formation of sintered objects of ferrous metals and to the formation of ferrous metal powders.

It is well known to manufacture articles by compressing metallic powders and subsequently sintering. Articles of iron, for example, have been formed of iron powder compressed at suitable pressures and then sintered at a temperature sufficient to obtain adhesion of the particles. Mixtures of iron and copper powders have also been compressed into articles of desired form which then have been sintered at a temperature sufficient to melt the copper, thus binding the iron particles together. Another common form of sintering is involved in the manufacture of tungsten carbide tools. Mixtures of high melting point carbides with a lower melting point metal such as cobalt or nickel may be compressed and then sintered at a temperature sufficient to melt the metal to cement the hard carbide particles together.

In my improved process of forming sintered iron objects I mix in suitable proportions, iron particles or low carbon content iron particles with particles containing iron carbide. The mixture is compressed at a suitable pressure, from 30,000 to 100,000 pounds per square inch, for example, or higher if desired, to form the desired shape. For most purposes pressures of from 40,000 to 50,000 pounds per square inch are satisfactory. The compressed mixture is then heated to a temperature at least that of the melting point of the iron-iron carbide eutectic, which is approximately 2050° F. Temperatures of 2100° F. or about 50° above the melting point of the eutectic have proven satisfactory. When the particles containing the iron carbide are heated to this temperature they melt and fuse to the adjoining low carbon iron particles which remain solid. As the fusion of the low melting point particles occurs, carbon migrates from the high carbon areas into the low carbon iron particles and tends to produce an article of uniform carbon content. In order to obtain any desired carbon content in the finished article the proportion of the powdered high carbon content iron may be varied as necessary. The sintering is preferably carried out under non-oxidizing conditions as in an atmosphere containing carbon monoxide.

In order to obtain a large quantity of the liquid material with which to bind the solid iron particles together, I prefer that the high carbon content particles contain approximately 4.3% carbon, this being the composition of the iron-iron carbide eutectic. In this way the material will all melt at the melting point of the iron-iron carbide eutectic which, as previously noted, is approximately 2050° F. Lower carbon contents than 4.3% also may be used however since there is a phase in iron carbon alloys containing in excess of 1.7% carbon which melts at the melting point of the iron-iron carbide eutectic.

Various alloy irons and steels may be produced by introducing the desired alloying metal or metals into high carbon low melting point bonding materials. For example, if desired to produce an alloy containing 1% chromium and .25% molybdenum, a low melting point alloy may be formed containing 4% carbon, 5% chromium and 1.25% molybdenum. This alloy may be made into powdered form and used as 20% of a mixture containing 80% iron powder. The mixture then may be compressed and sintered to cause the carbon, chromium, and molybdenum to uniformly diffuse and form an alloy of the desired analysis. In the same way other alloys may be mixed with the low melting point alloy to produce in the finished article the desired alloy composition.

The iron or low carbon iron particles to be used in my sintering process may be made by processes heretofore known, if desired, or by the following described processes.

The processes which I propose for the formation of powdered iron involve the atomization of molten iron as it comes from the blast furnace or the atomization of molten cast iron or steel. The atomization may be carried out by the use of compressed air or the use of high pressure water or other suitable fluid. One convenient method is to allow the molten metal to flow by gravity through a small orifice in the bottom of a suitable container into a stream of cold water or the like.

After the molten iron from the blast furnace or molten cast iron has been atomized as described the resultant hard particles containing combined carbon may be ground or pulverized to the desired fineness. For this purpose any suitable pulverizer or crusher or the like may be used. Thereupon the material may be annealed in a decarburizing atmosphere to reduce the combined carbon content the desired amount. The silicon content of the initial iron will determine the nature of the annealing cycle for obtaining the desired result.

The iron powder resulting from the described process may be mixed with high carbon iron particles and compressed into the general shape of the article desired, which will then be heated to a temperature at least as high as, and preferably slightly above, the melting point of the iron, iron carbide eutectic as heretofore described.

It will be understood that the process described for the formation of powdered iron has other applications than of providing powdered iron suitable for use in my sintering process.

As a specific example of my process an iron carbon alloy was made containing approximately 5% carbon and the material was cast into water in order to break it up into small particles and to make it brittle. The particles were then ground in a mill so that the powder passed through a 200 mesh screen. Preferably the high carbon iron powder is subjected to an annealing operation to soften the particles. The annealing treatment for this purpose is one that will soften the particles without decarburizing the same. When the particles are thus annealed the material may be more readily formed to the desired shape in the briquetting operation and wear on the dies is greatly reduced. To the above alloy was added during the melting process about 1% manganese in order to render the iron carbide stable, the reason being that without some stabilizer the iron carbide would tend to revert to iron and free carbon, even at room temperature. Ten percent of this high carbon iron powder was mixed with 90% of low carbon iron powder. This was briquetted into a cylindrical form with a pressure of 40,000 pounds per square inch and heated to 2100° F. in an atmosphere containing approximately 35% carbon monoxide. A hard, strong, ductile high carbon steel cylinder was produced.

Various changes and modifications may be made in the embodiment of my invention described herein by those skilled in the art without departing from the principle and spirit of my invention and I do not wish to limit the patent granted thereon except as necessitated by the prior art.

I claim:

1. A process of forming an article which comprises mixing iron or low carbon iron particles with high carbon content iron particles containing more than 1.7% carbon, compressing said mixture into the desired form and heating the compressed mixture to a temperature less than the melting point of the low carbon iron particles and at least as high as the melting point of the iron-iron carbide eutectic.

2. A process as in claim 1, in which said high carbon content iron particles have approximately 4.3% carbon.

3. A process as in claim 1, in which the mixture of particles is compressed at a pressure of from about 30,000 pounds per square inch to about 100,000 pounds per square inch.

4. A process as in claim 1, in which the compressed mixture is heated to a temperature of about 2100° F.

5. A process of forming an article which comprises mixing low carbon iron particles with high carbon content iron particles containing 1.7% to 4.3% carbon, compressing said mixture at a pressure of from approximately 30,000 pounds per square inch to about 100,000 pounds per square inch into the desired shape and then heating the compressed mixture at a temperature of approximately 50° F. above the melting point of the iron-iron carbide eutectic.

6. A process as in claim 5, in which said high carbon content iron particles contain a small amount of manganese.

7. A process as in claim 5, in which the compressed mixture is heated in the presence of carbon monoxide.

8. A process of forming an article which comprises mixing low carbon iron particles with high carbon content iron particles containing about 4.3% carbon, compressing said mixture at a pressure of from approximately 30,000 pounds per square inch to about 100,000 pounds per square inch into the shape of the article desired and then heating the compressed mixture at a temperature of approximately 50° F. above the melting point of the iron-iron carbide eutectic.

9. A process as in claim 8, in which said high carbon content iron particles contain a small amount of manganese.

10. A process as in claim 8, in which the compressed mixture is heated in the presence of carbon monoxide.

11. A process of forming an article which comprises mixing about nine parts of low carbon iron particles with about one part of particles of an alloy containing approximately 5% carbon, 1% manganese and the remainder substantially iron, compressing said mixture into the general shape of the desired article at a pressure of approximately 40,000 pounds per square inch and then heating said compressed mixture to a temperature of approximately 2100° F. in an atmosphere containing about 35% of carbon monoxide.

12. An article made of a compressed mixture of iron or low carbon iron particles and high carbon content iron particles containing more than 1.7% carbon, said mixture having been heated to a temperature at least as high as the melting point of the eutectic mixture of iron and iron carbide and less than the melting point of the low carbon iron particles.

13. An article as in claim 12, in which said iron carbon alloy contains about 4.3% carbon and the mixture has been heated to about 2100° F.

14. A process of forming an article which comprises atomizing molten cast iron, molten steel, or molten iron as it comes from the blast furnace to form particles of rather small size, forming said particles into smaller particles of desired fineness and removing carbon from said particles to provide low carbon content iron particles, mixing said low carbon content iron particles with high carbon content iron particles containing more than 1.7% carbon, compressing said mixture into the desired form and heating the compressed mixture to a temperature less than the melting point of the low carbon content iron particles and at least as high as the melting point of the eutectic mixture of iron and iron carbide.

15. A process of forming an article which comprises atomizing molten iron containing more carbon than desired in the final product, such as molten cast iron, molten steel, or molten iron as it comes from the blast furnace, to form particles of rather small size, forming said particles into smaller particles of desired size, removing carbon from said particles to provide low carbon content iron powder particles, forming a briquette of the desired shape composed principally of said low carbon content iron powder particles, and sintering said briquette at a temperature appreciably lower than the melting point of the low carbon content iron particles.

16. A process of forming an article which comprises atomizing molten iron as it comes from the blast furnace to form hard particles of rather small size, grinding said particles to form powder particles of the desired degree of fineness, annealing said fine particles in a decarburizing at-

mosphere to soften the powder particles and reduce the combined carbon content the desired amount, briquetting said annealed powder particles into the shape of the desired article, and sintering said briquette at a temperature appreciably lower than the melting point of the powder particles in a non-oxidizing atmosphere.

17. A process of producing an article which comprises mixing powdered iron particles containing little or no carbon with powdered high carbon content iron particles containing about 1.7% to about 4.3% carbon, said particles being of such fineness as to pass through a 200 mesh screen, compressing said mixture of powdered particles at a pressure within the range of approximately 30,000 pounds per square inch to approximately 100,000 pounds per square inch and thereafter heating the compressed mixture at a temperature of approximately 50° F. above the melting point of the eutectic mixture of iron and iron carbide.

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