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# METHOD OF PRODUCING HIGHLY PERMEABLE DUST CORES

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This invention relates to a method for making highly permeable cores from powdered material and particularly to a method for making such cores from a powdered material consisting of hollow spherical particles.

According to the prior art, there is known a method for producing an iron powder in which the powder is made up of hollow spherical metal shells. This method is known by the name "Pig-Iron Crust Method," a detailed description of which may be found in: "the journal Stahl und Eisen 68 (1948), pages 346–353 and German Patent 864,563."

Briefly, this method comprises, spraying under compressed air, molten iron-carbon-alloy, in an atmosphere of controlled oxidation to obtain a desired proportional relationship between the carbon and oxygen. The spraying process converts the little iron drops into hollow spherical balls. The spherical ball powder is then annealed at about 950° to reduce the dross which has been formed; the dross consisting primarily of iron oxide.

It is an object of this invention to provide a powdered core of hollow spherical particles to greatly increase the permeability thereof.

It is a further object of this invention to provide a powdered core which has lower losses than similar cores heretofore known.

It is a feature of this invention to provide a core which may be pressed into the proper form with lesser pressures than processes heretofore known.

It is a further feature of this invention to provide a powdered core comprising relatively coarse particles without increasing the eddy current losses of the core.

In accordance with a first aspect of the inspection, there is provided a method for making a core of powdered material consisting of hollow spherical metal shells. The method comprises the step of alloying the metal, before it is made into hollow spheres, with another material to either, improve the permeability or reduce the eddy current losses, thereof.

The above mentioned and other features and objects of this invention and the manner of attaining them will become more apparent and the invention itself, and will be best understood by reference to the following description of an embodiment of the invention. Utilizing the steps of the known method described above for making a powder consisting of hollow spherical particles, there is added to the iron-carbon-alloy, while in the liquid or molten state, another material to increase the permeability of the resultant powder. As it is desired to reduce the eddy current losses of the resultant core, the added material shall increase the resistance of the alloy.

The formula for eddy current losses is:

$$w=1.25\mu\sigma.d^2$$

wherein

$w$ is the eddy current loss-coefficient
$\mu$=permeability
$\sigma$=electric conductance in m./ohm mm.$^2$, and
$d$=diameter of the particles in mm.



Thus it is seen that by varying the permeability or conductance of the material there will be caused a corresponding change in the eddy current losses.

As a first example, it has been found that the eddy current losses may be reduced by adding silicon and manganese to the liquid alloy in the percentages of 5–10%.

As another example, it was found that by adding 6% aluminum and 10% silicon to the alloy the permeability is increased.

Also, in accordance with the invention, advantages may be obtained by using a mixture of the final iron powder having different grain sizes. In such a case the spaces which occur between the particles may be substantially filled with a material having desirable characteristics; for example, a material having desirable magnetic properties. The grain size may be determined by properly proportioning the amount of carbon to iron. Of course the size desired will depend on the use to which the material is destined.

After the hollow spherical particles have the desired properties by alloying the material with aluminum and/or silicon or with manganese and silicon the powder is formed into the core. This process may be carried out by applying the working methods which have proved to be valuable in dust core engineering. Thus one may, for instance, add suitable insulating and binding agents to the iron powder which, owing to the porous surface of the individual particles, are sucked-up in a well-adhesive manner and at certain events it is also recommendable to mix the raw powder with other materials such as ferrites or other sorts of iron powder in order to influence the magnetic properties of the dust cores to be produced, in a desired manner. According to the invention the annealing of the raw powder is to be carried out only up to a temperature, at which a mutual agglomeration of the particles is still avoided, so that the usually required crushing process will be saved.

At the production of the mixtures mechanical shaking methods or ultra-sound waves may be applied.

Preferably the hollow spherical particles are first rolled flat and thereupon pressed to become a core. This step is a simplification over the known procedures because the requisite pressure is much lower than that heretofore required for pressing solid particles. The flattened particles are then mixed with a binding agent, or an insulating agent if such is desired, and poured into a mold or matrix. The mixture is then pressed into a desired form.

Under certain conditions, it may be desirable to anneal the flattened particles in a reducing atmosphere to relieve the stresses produced during the prior steps of formation. The heat treatment is suitably thus accomplished that again no agglomeration of the individual particles is attained. The heat treatment may be eventually utilized simultaneously to the reduction of the tinder layer that was created during the production of the hollow spherical particles, so that the glowing of the raw powder becomes obsolete at this process.

While I have described above the principles of my invention in connection with specific apparatus, it is to be clearly understood that this description is made only by way of example and not as a limitation to the scope of my invention as set forth in the objects thereof and in the accompanying claims.

What is claimed is:

1. A method of producing a ferromagnetic core, comprising providing hollow dust-size shells from an alloy comprising iron and silicon and a metal selected from the group consisting of manganese and aluminum pressing and molding said shells into a desired shape.

2. The method according to claim 1, wherein said silicon and manganese is added to the iron in the range of 5–10%.

3. The method according to claim 1, wherein said aluminum and silicon comprises approximately 6% aluminum and 10% silicon.

4. The method according to claim 1, wherein said shells are first pressed and subsequently molded into a desired shape.



**References Cited** in the file of this patent

UNITED STATES PATENTS

| | | |
|---|---|---|
| 1,582,353 | Smith | Apr. 27, 1926 |
| 2,186,659 | Vogt | Jan. 9, 1940 |

FOREIGN PATENTS

| | | |
|---|---|---|
| 864,563 | Germany | Jan. 26, 1953 |

OTHER REFERENCES

Stahl und Eisen, vol. 68, 1948, pages 346 to 353.