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[54] **METHOD FOR MANUFACTURING SENDUST CORE POWDER**

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[30] **Foreign Application Priority Data**

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[51] **Int. Cl.**[6] **B05D 1/02**; B22F 9/08; B22F 9/02; B22F 9/06

[52] **U.S. Cl.** **427/421**; 148/104; 148/105; 75/332; 75/337; 75/342; 75/768

[58] **Field of Search** 148/104, 105; 75/332, 337, 342, 768; 427/421

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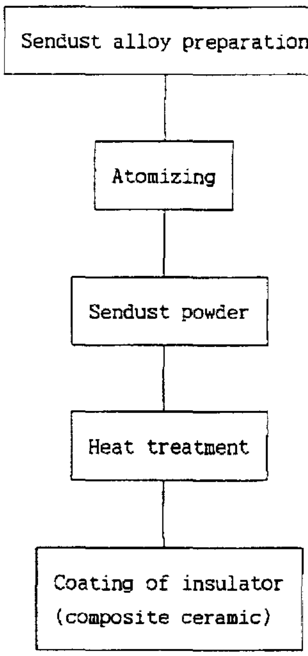
[57] **ABSTRACT**

A method for manufacturing a powder for sendust core is disclosed which is used in power supplies, converters and invertors, and in which the sendust powder is manufactured by applying the atomizing process, and the powder is coated with a special ceramic mixture insulator, so that the core loss would be small after forming a product. The method for manufacturing the powder for a sendust core includes the steps of: preparing a sendust alloy melt composed of (in wt %) 4–13% of Si, 4–7% of Al, and balance of Fe under an inert atmosphere; spouting water with a pressure of 1500–3500 psi to a flow of said sendust alloy melt through four or more nozzles having a diameter of 10–20 mm, so as to form a relatively regular polyhedral powder; adding 0.1–1.0 wt % of kaoline to the powder, and heat-treating it at a temperature of 700°–850° C. for 30 minutes or more under a reducing atmosphere; and carrying out a wet coating on the heat-treated powder by using 0.5–5% (relative to the weight of the powder) of a composite ceramic composed of milk of magnesia, kaoline and sodium silicate.

4 Claims, 2 Drawing Sheets



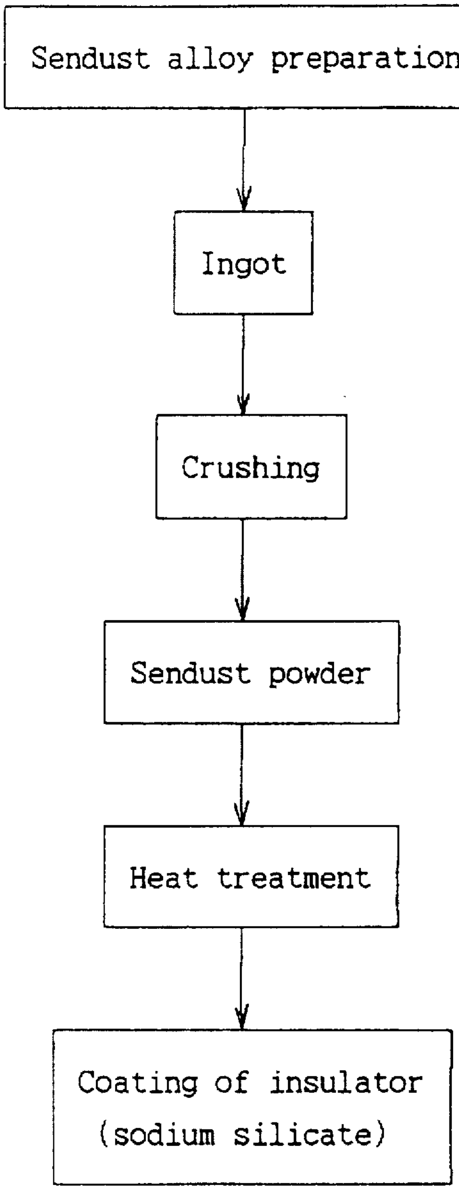

Sendust alloy preparation
Ingot
Crushing
Sendust powder
Heat treatment
Coating of insulator
(sodium silicate)

Fig. 1

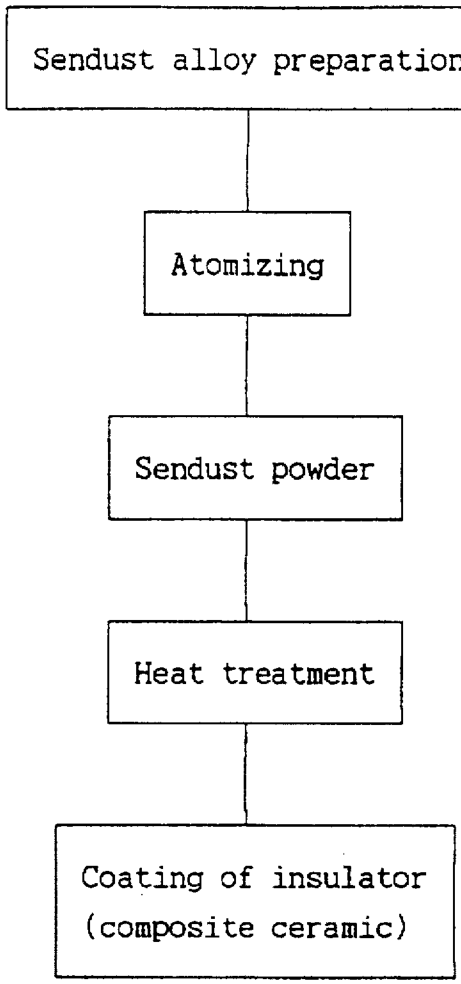

Sendust alloy preparation
Atomizing
Sendust powder
Heat treatment
Coating of insulator
(composite ceramic)

Fig. 2

METHOD FOR MANUFACTURING SENDUST CORE POWDER

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention generally relates to a method for manufacturing a powder for sendust core which is used in power supplies, converters and invertors, and more particularly, to a method for manufacturing a sendust core powder in which the loss generated is small.

2. Description of the Prior Art

Generally, a sendust core is a toroidal core which is manufactured by using an alloy powder having a composition of 85Fe-9Si-6Al. It is a kind of a compression-formed steel core such as an iron powder core, permalloy powder core (MPP) and ferrite core, which is used as inductors or transformers. That is, it is an electronic component which is used in power supply unit and the like.

Generally, the sendust alloy is composed of 4–13% of Si, 4–7% of Al, and balance of Fe.

Among the above mentioned cores, the sendust core has the highest magnetic flux density, is suitable for high current, and is most widely used. The characteristics of the core are influenced most greatly by the state of the powder.

The sendust core powder is manufactured in the following manner. As shown in FIG. 1, a sendust alloy is formed into an ingot. The ingot is then crushed with a jaw crusher, a hammer mill, or an attrition mill. A heat treatment is carried out. The powder is then coated with sodium silicate for insulation.

The sendust core powder thus manufactured is then subjected to a lubricant addition, forming, baking, evaluation of characteristics, followed by application of an outer coating (organic polymer coating), to complete the sendust core product.

In the above described sendust core powder manufacturing method, the ingot is crushed into particles of a proper size, and therefore, it is uneconomical in view of the cost and the number of process steps. Particularly, the powder has irregular sharp corners, and therefore, the coating efficiency is low. Further, during a high pressure forming, the coating layers are damaged, with the result that the core loss is increased.

To simplify the manufacturing process and to improve the ingot crushing method, a gas atomizing method is disclosed in Japanese Patent Application Laid-open No. Sho-62-250607. In this method, a melted alloy is subjected to a gas atomizing process to prepare a crude spherical powder. Crushing is then carried out through one or two steps into particle sizes of 40–110 μm. Subsequently, the surface of the powder is coated with an inorganic insulating material (sodium silicate) to complete the core manufacture.

Compared with the ingot crushing method, this method has the advantages that the process is shortened, and segregation of the ingredients can be prevented.

However, in this method, the spherical form is highly perfect, and therefore, the compression forming becomes difficult. Even if the forming is realized, the strength of the formed body is very low, with the result that the product manufacturing is very difficult. Therefore, a crushing step is necessarily required.

Thus, in this method also, the crushing is carried out, and therefore, sharp corners are produced. The insulating coating layers are destroyed during the compression forming, and therefore, a large loss is resulted.

Japanese Patent Application Publication No. Hei-3-48241 is another example of a method for manufacturing Fe—Si—Al alloy powder. In this method, the alloy melt is freely dropped through a nozzle of 5 mm into water to form coarse flake particles. Crushing is then carried out through one or two steps, thereby obtaining the desired particle size.

However, in this method also, the coarse flake particles are crushed to obtain the final powder. Therefore, the insulating coated layers are destroyed during the compression forming, resulting in large losses.

The present invention relates to the atomizing method which will be described below.

Generally, the atomizing method is carried out in the following manner. Gas or water is spouted to the flow of a melt, thereby manufacturing a powder. This atomizing method is widely used in fabrication of materials. However, in the functional material fields of MPP core or Sendust core manufacture, the technique that the final powder is manufactured by the atomizing method has not been proposed, and the reason is as follows.

First, in the case of the sendust alloy, it is composed of highly oxidable elements. Therefore, in the case where the melt is maintained in the air, the adjustment of the ingredients is not easy.

Second, as shown in Japanese Patent Application Laid-open No. Sho-62-250607, when atomizing is carried out, the powder has an almost spherical shape, and the desired particle size is difficult to obtain. Further, even after fabrication (which is the post process), the strengths cannot be maintained. Therefore, after atomizing, crushing has to be carried out into the desired particle size. Therefore, it is unavoidable that sharp corners are produced.

Further, in the case where water is used in the atomizing, the powder is formed in the shape of flat particles or irregular particles.

Therefore, in the manufacture of structural materials, the irregular particles have large surface areas, and therefore, a large driving force of sintering power is obtained, with the result that the final density is increased.

However, the powder has be coated with an insulating material in the sendust core manufacture, and therefore, the destruction of the insulating layer during the fabrication has to be considered. Therefore, a powder of regular size is required, while irregular particle sizes presents difficulties.

Therefore, the atomizing technique using water has not been applied to the manufacture of functional materials.

Third, in the case of the gas atomizing method, if the desired particle size is to be obtained, the pressure of the spouting gas has to be high. Therefore, entrapped pores are formed within the particles owing to the high pressure spouting gas. As a result, the characteristics of the powder are degraded.

That is, in the functional material of the present invention, the step of coating an insulating material has to be necessarily carried out, and the insulation coated powder has to be formed with a certain compression pressure. Even after the forming, the insulating layers should not be damaged.

Particularly, in the sendust core or MPP core, the forming pressure is about 18–24 ton/cm^2. Therefore, if the particle shape is irregular or if entrapped pores exist within the particles, a fatal result is invited.

Therefore, the atomizing technique has not been applied to the manufacture of the functional materials.

Meanwhile, in the case where a press formed iron core is manufactured by using a metal powder, the metal particles are insulated from one another for reducing the eddy current loss. Conventionally, sodium silicate or a polymer is used for insulating the particles, or the metal particles are slightly oxidized so as to insulate them.

However, in the case where the metal particles are insulated, the insulation resistance is low. Therefore, at 100 gausses, the core loss reaches 25–30 mW/cm^2.

SUMMARY OF THE INVENTION

In order to overcome the above described disadvantages of the conventional techniques, the present inventors carried out study and experiments, and has come to propose the present invention based on the study and experiments.

Therefore, it is the object of the present invention to provide a method for manufacturing a powder for a sendust core, in which the sendust powder is manufactured by applying the atomizing process, and the powder is coated with a special ceramic mixture insulator, so that the core loss is small after forming product.

In achieving the above object, the method for manufacturing a powder for a sendust core according to the present invention includes the steps of:

preparing a sendust alloy melt composed of (in wt %) 4–13% of Si, 4–7% of Al, and balance of Fe under an inert atmosphere;

spouting water with a pressure of 1500–3500 psi to a flow of said sendust alloy melt through four or more nozzles having a diameter of 10–20 mm, so as to form a relatively regular polyhedral powder;

adding 0.1–1.0 wt % of kaoline to said powder, and heat-treating it at a temperature of 700°–850° C. for 30 minutes or more under a reducing atmosphere; and

carrying out a wet coating on the heat-treated powder by using 0.5–5% (relative to the weight of the powder) of a composite ceramic composed of milk of magnesia, kaoline and sodium silicate.

BRIEF DESCRIPTION OF THE DRAWINGS

The above object and other advantages of the present invention will become more apparent by describing in detail the preferred embodiment of the present invention with reference to the attached drawings in which:

FIG. 1 is a flow chart showing the conventional process for manufacturing the powder for sendust core; and

FIG. 2 is a flow chart showing the process for manufacturing the powder for sendust core according to the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

If the powder for sendust core according to the present invention is to be manufactured, as shown in FIG. 2, a sendust melt has to be prepared. The sendust melt is composed of 4–13% of Si, 4–7% of Al, and balance of Fe, and is prepared under an inert gas atmosphere such as nitrogen (N_2) or argon (Ar).

When preparing the sendust alloy melt according to the present invention, ferro-silicon (Fe—Si), and ferro-aluminum (Fe—Al), Si and Al are used to adjust the composition of the melt rather than only the metallic Al and Si. The reason is that the alloy ingredients can be adjusted in a short period of time.

The reason why the melt is prepared under an inert atmosphere is as follows.

During the preparation of the melt, the Al and Si which are highly oxidable are oxidized and consumed into slag. Therefore, the ingredient adjustment for the alloy is not easy, and therefore, this has to be prevented. Further, another reason is for minimizing the lowering of the fluidity of the melt, which is caused by the melt oxidation.

Water supplied at a pressure of 1500–3500 psi is then spouted to a flow of said sendust alloy melt through four or more nozzles having a diameter of 10–20 mm, so as to form relatively regular polyhedral powder.

If the diameter of the nozzle is less than 10 mm, the atomizing time is extended. Consequently, clogging of the nozzles may occur, or excessively fine particles are formed, with the result that the formed powder has too low a permeability. On the other hand, if the diameter of the nozzles is more than 20 mm, coarse and almost spherical powder is obtained, with the result that the product forming becomes difficult, and that the loss becomes large. Therefore, the diameter of the nozzle should be preferably 10–20 mm.

The number of the nozzles is four or more, and the reason for it is as follows. If the number of the nozzles is less than four, the shape of the powder may become flake, and therefore, products having a large core loss are apt to be formed.

The nozzles should be preferably disposed equidistantly in the horizontal view. The reason is that if not equidistantly disposed, the powder may have an irregular elliptical shape.

Meanwhile, in a vertical view, the height difference between the highest nozzle and the lowest nozzle should be preferably 5–20 mm.

If the height difference is less than 5 mm, ordinary flake powder may be produced. On the other hand, if the height difference is more than 20 mm, lumps may adhere on the particles, thereby making the powder irregular.

In the case where the number of the nozzles is even, two nozzles having the largest mutually facing distance should have preferably the same height.

If the number of the nozzles is odd, the nozzles having the longest mutually facing distance form pairs, in such a manner that one nozzle forms only one pair. The nozzles forming this pair should have vertically same height.

One nozzle which does not form a pair should be preferably disposed between the nozzles of the pair in a vertical view. The reason is as follows. That is, if a nozzle which does not form a pair is disposed at the highest position or at the lowest position, the shape of the particles will become irregular.

Meanwhile, if the spouting pressure is less than 1500 psi, coarse and spherical powder is obtained, resulting in a great loss, as well as being weak in the formed strength. On the other hand, if the spouting pressure is more than 3500 psi, then the oxidation of the powder becomes severe. Further, the shape of the powder becomes irregular, and excessive fine particles are formed, so that forming into a core would be difficult. Further, the permeability is low, and therefore, optimum properties cannot be obtained.

Then, 0.1–1% of kaoline is put into the powder in weight % relative to the powder. Then it is heat-treated at a temperature of 700°–850° C. for 30 minutes or more under a hydrogen containing reducing atmosphere.

The hydrogen containing atmosphere is composed of hydrogen and nitrogen.

The reason for carrying out the heat treatment is for removing the oxides and impurities formed during the

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