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J. FARRELL ET AL

3,538,600

METHOD OF DEBURRING MAGNETIC CORES

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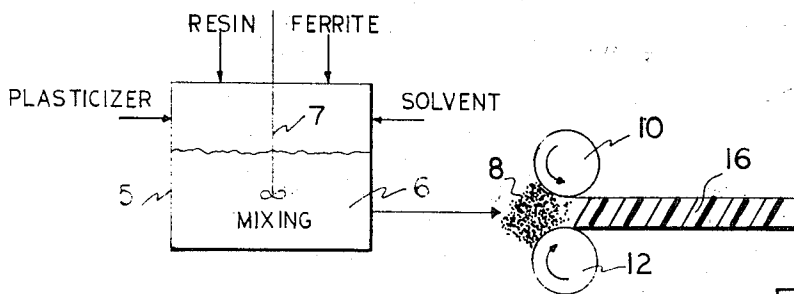


FIG. 1

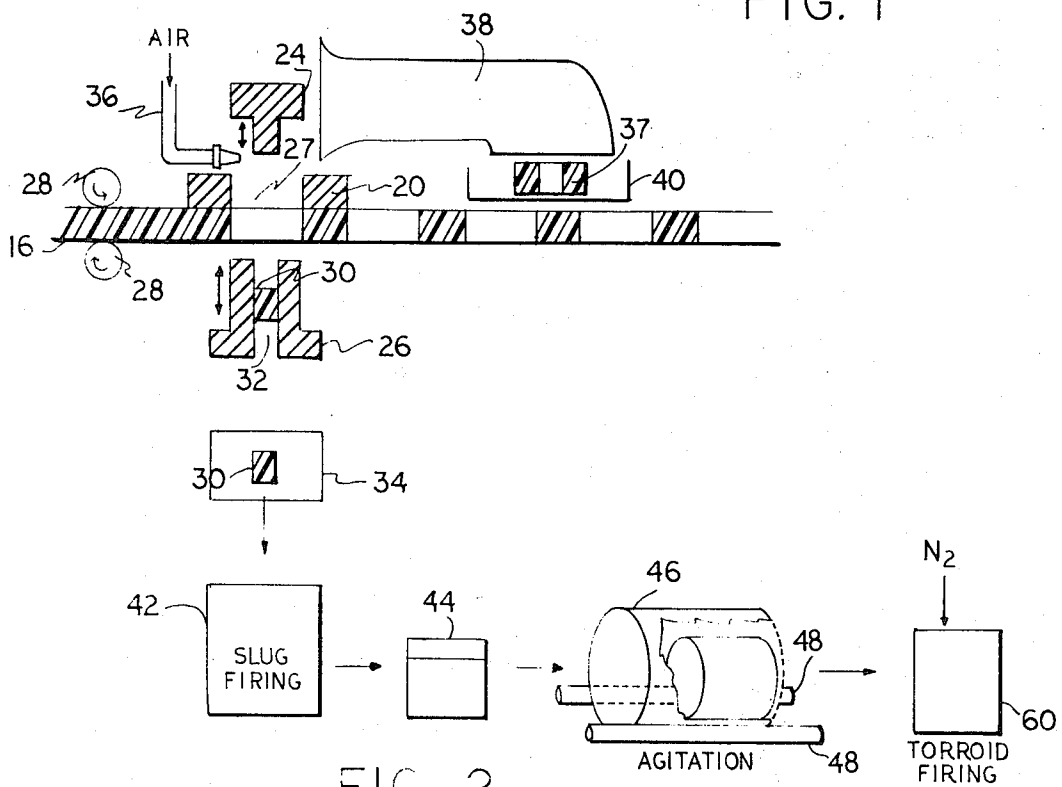


FIG. 2

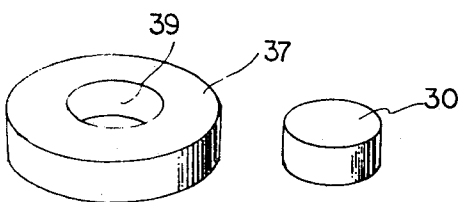


FIG. 3

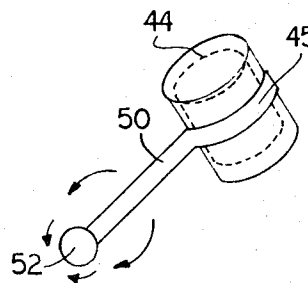


FIG. 4

INVENTOR.
SEAMUS GIBBONS
JOHN FARRELL
BY
Lindenberg & Freilich
ATTORNEYS.

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METHOD OF DEBURRING MAGNETIC CORES

John Farrell and Seamus Gibbons, Dublin, Ireland, assignors to Core Memories, Ltd., Dublin, Ireland, a corporation of Ireland

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8 Claims

ABSTRACT OF THE DISCLOSURE

A system for forming magnetic cores is disclosed. The cores are formed by simultaneously stamping green state toroids and center slugs from a sheet containing 70 to 95% by weight of a square loop ferrite and 5 to 30% by weight of a heat pyrolyzable binder. The green state toroids are combined in a closed container with a hard, dense material having a diameter less than the inner diameter of the toroid. The container is agitated for a time between about 5 minutes and 2 hours which is sufficient to remove scratches and burrs from the surface of the toroids. Preferably, the green state slugs are fired to sinter and shrink the slugs and the fired slugs are utilized as the polishing material. The polished toroids are then finally fired to remove the binder to sinter the ferrite particles and to establish the desired square loop characteristics.

BACKGROUND OF THE INVENTION

Field of the invention

The present invention relates to a method for producing magnetic cores and more particularly to a method of deburring punched green state ferrite toroids.

Description of the prior art

Magnetic ferrite cores suitable for use as magnetic core logic or data storage devices have usually been manufactured by pressing a powder into a mold and finally firing the molded core. Uniformity in core size and density has not been entirely acceptable and the abrasive ferrite grains tend to wear out the core-forming mold quite rapidly. Recently, a system for manufacturing magnetic ferrite cores having more uniform and predictable properties has been developed. For example, a process of stamping ferrite cores from a sheet is disclosed in Ser. No. 682,366, filed Nov. 13, 1967.

As a result of the stamping operation, the cores may have sharp edges and burrs along the inner and outer peripheries of the toroids. After firing of the green state cores, these burrs and edges present a hindrance to wiring the cores into memory banks and also may contribute to a variance in properties between individual cores.

OBJECTS AND SUMMARY OF THE INVENTION

It is therefore an object of the invention to provide a process for preparing smooth and uniform ferrite cores.

Yet another object of the invention is the provision of a process for producing smooth, stamped ferrite cores having uniform and predictable properties.

These and other objects and many attendant advantages of the invention will become apparent as the description proceeds.

In accordance with the invention a ribbon or sheet of green state ferrite dispersed in a mechanically shearable binder is prepared. Toroids are punched from the sheet to form the toroids and a core disk or slug. The green state toroids are combined with a hard, dense granular material in a container. The container is agitated and during agitation the grains of material roll over the surface of the toroid and through the core space thereof and de-

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burr and smooth the surfaces. The toroids are removed from the container and are fired to a final state under conditions which remove the binder, sinter the ferrite grains and develop the desired square loop hysteresis magnetic properties. Preferably, according to the invention the slugs are fired and are utilized as the hard, dense material to deburr the toroids.

The invention will now become better understood by reference to the following detailed description when considered in connection with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic view of an apparatus for forming a shearable sheet of green state ferrite;

FIG. 2 is a simplified sectional view of an apparatus for stamping and forming magnetic cores according to the invention;

FIG. 3 is an enlarged perspective view of a ferrite core and slug according to the invention; and

FIG. 4 is a schematic illustration of an alternate agitation means according to the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The sheet or ribbon material for use in the process of the invention may be made by one of several techniques which produce a homogeneous dispersion of ferrite-forming grains dispersed in a temporary, heat pyrolyzable and mechanically shearable binder. The sheet must be uniformly dimensioned and reproducible and preferably has smooth outer surfaces to promote uniformity in the stampings.

A process for forming such a sheet is illustrated in FIG. 1. Measured portions of sheet-forming materials such as resin, plasticizer, solvent and ferrite are added to a mixing tank 5. These materials are agitated by rotation of mixed blade 7 until a homogeneous dispersion 6 is obtained. A portion 8 of the dispersion is placed between casting rolls 10 and 12 and after milling at a first setting the spacing is reduced and the sheet passed through the reduced gap until a smooth sheet 16 of the desired diameter is produced.

The smooth sheet could be produced by other techniques such as doctor blade casting. In this technique the dispersion is flowed onto a smooth plate of glass having side runners of the thickness of the desired sheet. Excess material is removed by running a knife-edged scraper or doctor blade across the side runners. The sheet is cured and is then ready for stamping. The casting processes could be run continuously by feeding the sheet onto a conveyor having side runners or by feeding the sheet into a series of consecutively reduced gap rollers.

The binder need only be present in a minor amount sufficient to hold the grains together during handling and stamping. The green state sheet usually contains 70 to 95% ferrite powder and the remainder being binder. Thermoplastic hydrocarbon type of materials are preferred because of their workability, shearability and the ease by which they can be thermally decomposed. The binder may be of a waxy consistency such as a polyethylene or a polyethylene glycol wax or materials of higher viscosity, such as vinyl resins, alkene resins, such as polyethylene or polypropylene or diene resins such as natural rubbers or synthetic butadiene or isoprene polymers or copolymers.

A particularly effective and controllable green state sheet has been obtained with the use of plasticized polyvinyl chloride or polyvinyl acetate. The following specific example is offered by way of illustration only and is not intended in any way to limit the invention.

3 EXAMPLE

A mixture of 86% by weight of ferrite powder and 14% by weight of plasticized, polyvinyl chloride or polyvinyl acetate were mixed for a few minutes with sufficient methylethylketone or toluene to form a pasty dispersion. The rollers were set for milling, rotating in opposite directions but at slightly different speed. This pasty dispersion was fed to the nip between the rolls and milling of the mixture proceeded with volatilization of the solvent. The spacing between the rollers was gradually reduced, and the sheet was repeatedly passed through the rolls until a glossy sheet was formed. The rolls may be heated to a temperature of 90° F. to about 100° F. if desired.

At these temperatures the whole milling process can be performed in less than 5 minutes and the higher temperature insures a smooth glossy surface on both sides of the sheet. This sheet has been found to have extremely good stamping machine workability. With the proportions recited above, shrinkage after sintering would be about 20% of the original green density which is comparable with that obtained in the pressing molding process. The stiffness of the sheet can be modified by increasing or reducing the amount of plasticizer.

The process of the invention can be used with any square loop hysteresis ferrite. Such ferrites generally contain at least one of manganese, magnesium zinc or lithium ferrites and usually contain at least two types of these ferrites. In addition, square loop ferrites may also contain other ingredients such as copper, nickel, chromium or aluminum usually added to the green ferrite as an oxide. A typical soft square loop ferrite formulation contains in mol percent 14.3 MgO, 3.7 ZnO, 40.8 MnO and 41.2 Fe₂O₃. The ferrites are processed through standard processing techniques to prepare the particles in a form ready for final sintering. Typically, a raw ferrite composition of the oxides is formed into a slurry by adding a small amount of water or alcohol and the slurry is ball-milled, dried and screened to about 20 to 30 mesh size. The screened particles are calcined at about 1000° C. and the calcined powder is re-slurried, ball-milled, dried and screened to form particles having an average particle size of about 3 to 5 microns. The ferrite is combined with the binder to form a sheet as discussed above.

The sheet is further processed as described in FIG. 2 to 4. Referring now to FIGS. 2 and 3, the sheet 16 is moved between a die plate 20 and an upper die 24 and a lower die 26. The sheet is advanced incrementally into stamping position by drive rolls 28 or other suitable drive means. The die plate 26 has a cylindrical aperture 27 having a diameter equal to the diameter desired for the green state ferrite core before firing. The upper die 24 is a rod-like member having a diameter equal to the core portion of the ferrite toroid. The lower die 26 is an annular cylindrical member having an outer diameter slightly smaller than that of the die plate 20 and an inner diameter slightly larger than that of the upper die 24.

Stamping is performed by moving the lower die 26 upwardly through the die plate to punch a disc out of the sheet 16. Simultaneously, the upper die 24 moves downwardly to punch a slug 30 out of the sheet 16. The slug 30 falls through the central core passage 32 of the lower die 26 and is collected in receptacle 34. The upper and lower dies 24 and 26 are retracted and the green state toroid 37 is blown by means of air hose 36 into conduit 38 and is collected in tray 40. The sheet is then advanced by the drive rolls 28 to provide a fresh increment for stamping.

The green state slugs 30 are placed in a furnace 42 and are fired at a high temperature, for example, 2000° F. for 6 hours. Due to the high temperature firing conditions, the center slugs lose the binder, the ferrite powder granules coalesce to a dense, multigrained solid with approxi-

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mately 20% less volume than the green state slug. This fired slug is now a solid, hard piece of ferrite which easily passes through the center of the toroid out of which it was originally stamped.

The fired slugs 30 and green state toroids 37 in about equal numbers are placed in a closed container 44, leaving at least about 1/3 free space for relative movement between the toroids and the slugs. The container 44 is placed on a tumbling mill. For example, the container 44 may be placed within a longitudinal cylinder 46 which is resting on the roller bars 48 of a jar mill. The roller bars are revolved at moderate speed which results in relative movement of the dense, hard slugs 30 over the outside surfaces and through the center core 39 of the toroid 37. After a short period of time, approximately 1 to 2 hours, the agitation and tumbling are terminated and the burrs and scratches are found to have been removed by this treatment. The particular time of agitation depends on the degree of mechanical agitation being imparted to the particles, the hardness of the green state core and of the polishing material. Usually the smoothing and deburring can be accomplished within a period of 5 minutes to 3 hours.

There are many types of agitation that will provide the necessary relative movement between the toroids and the hard, dense particles. For example, vibration may be used or a combination of rotation and reciprocation is permissible. As shown in FIG. 4, the closed container 44 containing the slugs and toroids is placed within an inclined sleeve 45 attached to an arm 50. The arm 50 is rotated by reciprocating drive means 52. During the reciprocal motion of the arm, the container will both rotate and reciprocate permitting good contact and movement between the toroids and slugs.

Other hard, dense particles may be utilized in place of the hard slugs as the polishing media. The polishing particles should have a density that is at least 20% greater than the density of the green state toroid and should also have a substantially greater hardness. For example, Carborundum powder may be placed in the container and utilized to polish the surface by being repeatedly rolled over and through the toroid. However, the use of fired green state slugs is preferred since the slugs have the same composition as the toroid and this eliminates the opportunity for molecular contamination of the toroids.

The polished green state toroids are removed from the container and are separated from the polishing material. The green state toroids are placed in a furnace 60 and are fired at a sintering temperature, for example, 1235° C. for 6 hours, the last two hours of the firing being conducted in nitrogen. The toroids are then slowly cooled to below Curie temperature and found to have uniform and acceptable magnetic properties.

The fired slugs may be ball-milled and recycled to be utilized to form a new run of green state ferrite sheet. The punched sheet may be dissolved in an organic solvent for the resin and either or both the resin solution and the suspended ferrite particles can be recycled for incorporation into the formulation for forming a fresh run of green state ferrite sheet.

It is to be understood that the foregoing relates only to preferred embodiments of the invention and that numerous substitutions, alterations and modifications are all permissible without departing from the spirit and scope of the invention as defined in the following claims.

What is claimed is:

1. A method of forming a ferrite magnetic core comprising the steps of:

- stamping a plurality of green state toroidal cores and center slugs from a sheet of resin bonded ferrite;
- firing the slugs to form a hard, dense, particulate material;
- disposing in a container a plurality of the stamped green state cores and said hard, dense particulate

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material, the particles of which have a diameter less than the inner diameter of the core;
agitating the container to polish the cores;
separating the cores; and
finally firing the cores.

2. A method according to claim 1 in which the green state cores contain 70 to 95% by weight of ferrite, the remainder being a heat pyrolyzable binder.

3. A method according to claim 2 in which the ferrite is selected from at least one of manganese, magnesium, zinc and lithium ferrites.

4. A method according to claim 2 in which the binder is a vinyl polymer.

5. A method according to claim 4 in which the binder is selected from polyvinyl acetate and polyvinyl chloride.

6. A method according to claim 1 in which about equal numbers of green state toroid cores and fired slugs are placed in a closed container and the container is agitated for about 5 minutes to 3 hours.

7. A method according to claim 6 in which the container is simultaneously rotated and reciprocated.

8. A method of manufacturing magnetic ferrite cores for memory or logic devices comprising the steps of: stamping green state cores and center slugs from a thin sheet comprising 70 to 95% by weight of ferrite

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and 5 to 30% by weight of a hydrocarbon resin; firing the green state slugs;
placing the fired slugs and green state cores in a closed container;
agitating the container for 5 minutes to 3 hours until the cores are smoothed and deburred; and
finally firing the cores.

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JOHN F. CAMPBELL, Primary Examiner

C. E. HALL, Assistant Examiner

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29—608; 51—316, 323; 264—63, 67, 104, 153, 155