Study Of H100 Raw Materials To Obtainment Of Isotropic And Anisotropic Magnets Of Strontium Ferrite

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Abstract– The aim of this work was a study to obtain isotropic and anisotropic magnets of strontium ferrites, through the Powder Metallurgy processes (P/M), using as raw material an alloy commercially known as H100. Ferrite Magnets are ceramic materials obtained from iron oxide and barium or strontium oxide and presents intermediate magnetic properties of coercivity and retentivity when compared to other magnets. The anisotropic ferrite magnets are compacted in dies coupled to coils, which results a low reluctance magnetic circuit. The electrical current that circulates in the coil generates a magnetic field necessary for the orientation of the powder particles when compacted. From the commercial powder of alloy H100, was performed its chemical and physical characteristics, and following a series of compactions are performed with and without magnetic field, percentage variation of lubricant and humidified powder. The average particle size of H100 resulted in 20 μm. The retentivity resulted in 1.95 kG for compression without field. With the application of a magnetic field of 8 kOe in compression, no occured retentivity variation , but this increased to 2.13 kG with addition of more 1% of zinc stearate and 2.54 kG with wetting. Finally compressions were performed under field with other raw material of strontium ferrite with average particle size of 1 μm, resulting in retentivity of 3.85 kG.

Index Terms— Alloy H100, anisotropic magnets, isotropic magnets, particle size, retentivity, powder metallurgy, strontium ferrite.

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1 INTRODUCTION

1.1 Ferrite Magnets

The magnetic oxide materials, especially the ferrites with hexagonal structure, contribute effectively to technological advances nowadays, given the large number of applications of these materials. The first studies, however, date back to 1925 with the description of magnetoplumbita, whose structure was only described in 1938, with the following composition $PbFe_7.5Mn_3.5A_{10}.5Ti_{0.5}O_{19}$ [1].

The hexagonal ferrites of the M type, $MO.6Fe_2O_3$ (M = Sr, Ba or Pb) have a complex crystalline structure, leading to a pronounced crystaline magnet anisotropy, coercivity, and a equally complex internal magnetic structure. The combination of these properties together with high saturation magnetization and high transition temperature of ferromagnetic order (around 450 °C/842 °F) makes the hexaferritas attractive for various applications such as data storage materials, electronic components operating in micro-waves frequency, permanent magnets, among others [2].

The hard ferrites, also known as ferroxdure are obtained by mixing SrO or carbonates (strontium ferrite), or BaO (barium ferrite), with Fe_2O_3. The mixture is calcined at a temperature above 1095 °C (2003 °F) to form the complex oxide compounds. After, is performed wet grinding to fine particles around a few micrometers. Some additives such as SiO_2, Al_2O_3 and BiO_2 are beneficial to increase the coercivity, also enabling a reduction of the sintering temperature. The lubricants used are stearates acid base. Some manufacturers of ferrite powders provide the pure powder, and others provide ferrite powder with the additives, which vary in composition and percentage according to the manufacture [3], [4], [5].

The compaction pressure ranges from 150 to 200 MPa, and the sintering is performed in the range of 1100 to 1300 °C (2012 to 2372 °F). On the sintering, the linear contraction of the part varies linearly between 10 and 20% and this depends mainly of the compaction pressure. It should be noted that, within certain limits, as larger the compaction pressure, lower the contraction in sintering [3], [4], [5].

Variations in temperature, pressure and contraction are extensive due to the wide variety of types of ferrite

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powders provided by suppliers. The presence of impurities, grain size, average particle size of the powder, the composition and percentage of additives results in different pressure and temperature values for the ferrites. Is cited, for example, that the manufacture of a part with a good surface finish must have the addition of stearic acid, but this reduces the remanent magnetism surface, also changing the parameters of pressure and temperature [3], [4], [5].

The origin of high coercive force of all hard ferrites is due to its high magnetocrystalline anisotropy. The magnetization must be performed in the compaction direction, which results in magnets with larger remanent magnetism. The sintering should be performed in order to obtain magnetic parts with the highest possible density. Thus, larger values of retentivity are obtained with a small grain growth. The grain size is inversely proportional to the coercivity [3], [4], [5].

The last step in the production of ferrites is the magnetization, which gives the remanent magnetism of the magnets. At this stage, the magnets to be magnetized are placed in magnetic circuits consisting of iron cores and coils. The electric current flowing in the coils is high, reaching up to thousands of Amperes. This high current is supplied by electric voltage sources, being the more known the capacitive discharge. Fig. 1 shows the flowchart for manufacturing ferrite [6].

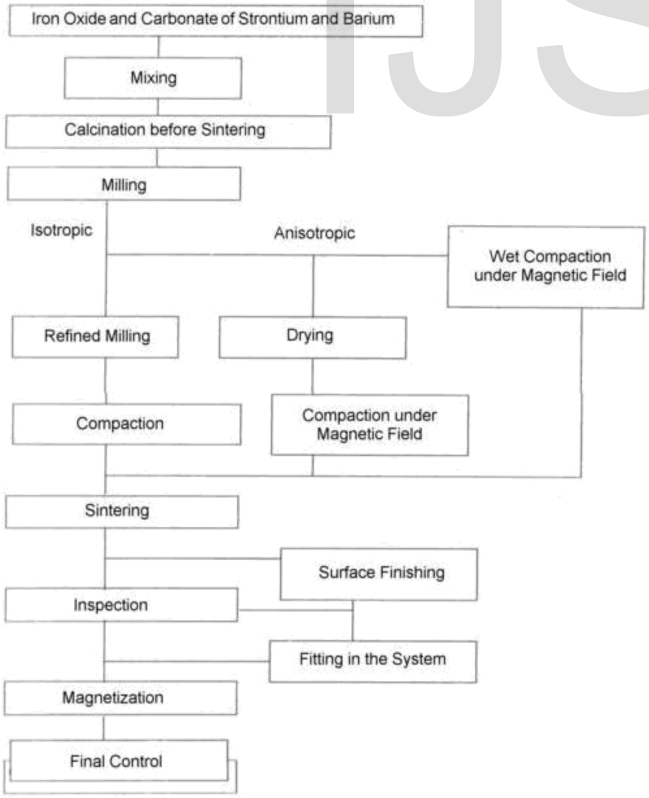


Fig. 1. Flowchart for manufacturing ferrite, NFT [6].

The anisotropic magnets of ferrite (compacteds with magnetic field) achieve higher values of magnetic properties than isotropic, mainly retentivity. Due to their low cost these are used in elements of magnetic circuits and instruments, motors and electric generators, alarms and microphones. Currently, ferrites are the most produced permanent magnets worldwide [7], [8].

For certain applications, there is now a requirement by the market of magnets ferrite with better magnetic properties of retentivity and coercivity. Thus, it seeks to reduce the size and weight of electric motors used in automobiles, for example, the windshield wiper motors and to increase the efficiency of electric motors used in electrical appliances such as air conditioners [7], [9].

When a need exists for magnets with high coercivity, it can be achieved from ferrite powders of fine grains and grain sizes compared to the critical domain size. Recently, intensive research efforts have been made to the preparation of powders ferrite with high coercivity using new techniques. A promising alternative is the Mechanical [10].

The Mechanical Alloying technique is to place the powders with steel balls in attritor mill of high-energy (high speed, a typical value being 800 RPM). This technique can be used as an effective means to produce ferrite powders with high coercivity. The major disadvantage from a technical point of view is the poor anisotropy of the particles, which is attributed to their microstructure consisting of ultra-fine grains randomly oriented [10].

Hard ferrites perform a dominant role in permanent magnets, marked by low cost per unit of energy available due to great availability of materials not processed and high chemical stability. Magnetic properties of hard ferrites comes from the anisotropic properties of iron oxides and barium or strontium oxides [9], [11].

1.2 Magnetic Properties

The magnetic properties of retentivity and coercivity are the basis for the analysis of magnetic materials such as permanent magnets of ferrite and these properties are obtained from the hysteresis curve or hysteresis loop. This curve relates the magnetic field **H** applied to a material with a resulting magnetic induction **B**. For the hard magnetic materials or permanent magnets, the relationship **BxH** has the characteristics shown in Fig. 2 [4], [12].

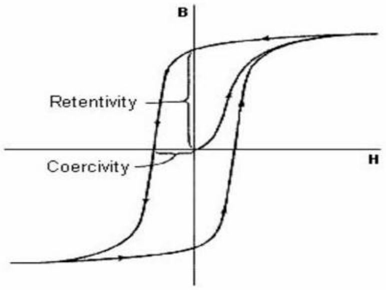


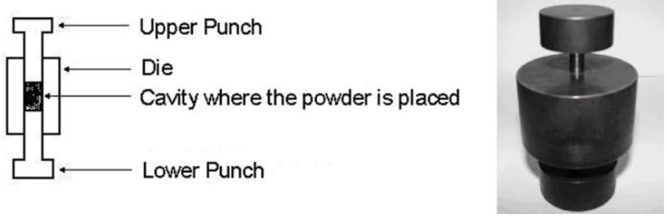
Fig. 2. Hysteresis curve of a hard magnetic material.

The point where the curve cuts the **B** axis, on the upper left quadrant, is called remnant magnetism or **Br** retentivity and represents the residual magnetic induction that remains in the material, without an applied magnetic field (**H** = 0). The cgs unit system (widely used to characterize magnetic materials), shows **B** in Gauss [**G**]. The point where the curve cuts the **H** axis in the same quadrant is called coercive force or **Hc** coercivity and represents the magnetic field needed to demagnetize the material (**B** = 0). In the cgs system, the unit of **H** is Oersted [**Oe**]. Another important factor to identify the magnetic materials is the energetic product **BHmax** and its unit in the cgs system is the Mega Gauss Oersted [**MG.Oe**] and it is associated with the energy density stored in a permanent magnet [4], [12].

However, a way faster and less expensive to evaluate a particular magnet is to use Gaussmeter. These measuring devices are generally constructed from linear Hall effect sensor, and measure the superficial remanent magnetism of the magnets, although they may also measure a magnetic induction of a circuit with coils. For this reason, its measurement size is the magnetic induction and the unit is Gauss (cgs unit system) and Tesla (MKS unit systems) [3], [4]. Thus, considering the same dimensions and magnets of different raw materials, a comparative analysis of the remanent magnetism of the alloy can be studied without the necessity of tracing the hysteresis curve.

1.3 Powder Metallurgy

The Powder Metallurgy (**P/M**) is a relatively recent metallurgical processing, where the parts are obtained from the powder constituents. The four basic processes of **P/M** are: Powder manufacture, powder mixture, compaction and sintering. Sometimes it is need a fifth step as rectification. In the **P/M**, the powders, after mixed, are compacted into dies in which acquire the shape of the die cavity. Finally the parts are placed in sintering furnaces where acquire consistency and mechanical resistance. It is noted that powders of different chemical nature are easy to obtain, since the powders are homogeneously mixed [13], [14]. Fig. 3-(a) shows the schematic drawing and Fig. 3-(b) shows the photography of a double effect die used for compaction of metallic and ceramic powder.



(a) (b)

Fig. 3. Double effect die for compaction of metallic and ceramic powders – (a) schematic drawing – (b) photograph DIAS.

The majority of magnets marketed today are obtained from the **P/M** processes. The only exception is the AlNiCo obtained by casting. The **P/M** is used, because with this process, it is possible to obtain the orientation of the magnetic particles constituting the material. For this reason, the magnets obtained by **P/M** have magnetic retentivity greater, when compared to the magnets obtained by conventional metallurgical processes such as casting [13], [14].

The manufacture of ferrite magnets occurs from the powder metallurgy, since these magnets are ceramics with a high melting point. For this reason, these magnets can not be manufactured by casting, because it would be necessary, furnaces with very high temperatures.

1.4 Anisotropic Magnets

The compaction process of anisotropic magnets occurs under the action of a strong magnetic field generated from coils coupled to die. This is necessary for orientation of the powder particles before consolidation. Magnets compacted without field (conventional compression) are called isotropic magnets. The magnitude of this magnetic field applied can reach until millions of A/m and, therefore, are required voltage sources capable of supply high electrical current [3], [4], [15].

Fig. 4 shows that, generally, a magnetic material particle is not a single crystal or grain, but aggregates of grains which, in turn, are divided in the magnetic domains. The magnetocrystalline anisotropy causes the magnetic moment of each atom aligns itself collectively and spontaneously, in a preferred direction. This is called easy direction of magnetization of that phase and corresponds to a family of directions. In a single crystal or grain, several magnetic domains can coexist, but within each domain, the magnetization of all the atoms will be parallel. The domains are oriented such that the energy is minimal, ie, the adjacent domains are opposite polarity, which reduces the reluctance and, consequently, the energy in the magnetic field, resulting in a null general magnetization. Decreasing the size of fragments, each particle may become of the size of a grain or single crystal, which occurs when it reaches the particle size of some microns [3], [4], [15].

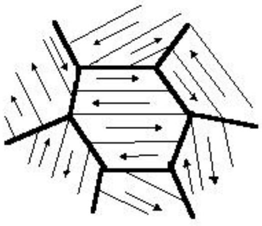


Fig. 4. Fragment of magnetic material divided in grains and subdivided indomains [14].

Under the action of magnetic field, during the compaction, the particles tend to rotate to align itself to their directions of easy magnetization along the direction of the external magnetic field applied, also ocurring the alignment of domains in the same direction, doing that the parts present magnetic properties. In the sintering as is exceeded the Curie temperature, the adjacent domains are oriented in opposite directions, and the part loss its magnetization, but the domains remain aligned parallel in their directions of easy magnetization. When the parts are subject to new magnetization, these magnetize itself again, the domains that were already aligned in the same direction now align itself in the same way, not requiring the rotation of the domains, resulting in a magnetic part or magnet with retentivity higher that the isotropic magnet [3], [4], [15].

When the fragments size approaches the powder grain size, the magnets obtained tend to have anisotropic characteristics, ie, larger retentivity. However, even with an average diameter of larger particles, such as a few tens of micrometers, the magnets have magnetic properties intermediate between the isotropic and anisotropic magnets. The reason for this is that a polycrystalline particle with several grains, although the direction of orientation of the domains is parallel in the same grain, this direction will be random of grain for grain, and even with the rotation of these particles, not all domains will be oriented in the direction of the magnetic field applied in the compaction, ie, in the direction of more easy magnetization [3], [4], [15].

READED

2 MATERIALS AND METHODS

2.1 Objectives of this Work

The aim of this work was a study on the various steps to obtain strontium ferrite magnets, isotropic and anisotropic, through the processes of Powder Metallurgy, using as raw material a alloy commercially known as H100. Initially, the powder acquired was analyzed as chemical composition, average size and shape of the particles. The compaction under magnetic field of the magnets was performed in the die coupled in coils, capable of generating a magnetic field within the die cavity of 10 kOe (800 kA / m). After the samples were compacted in a cylindrical shape, with and without the application of magnetic field, variation of lubricant and humidified powder. From the samples obtained, were plotted hysteresis curves and measured the supercifial remanent magnetism in the center of the magnets. Finally, was used another type of strontium ferrite powder, especial for obtaining anisotropic magnets, were plotted new hysteresis curves and the data were comparatively analyzed.

2.1 Die to Obtain of the Magnets

Fig. 5-(a) shows an experimental die of double-effect, in the which can be observed the upper and lower punches and the die itself (cavity). The punches were made with 1045 steel (magnetic steel), and the die (cavity) was made with austenitic stainless steel (not magnetic steel). The diameter of the punches and the cavity is thus 15 mm. This die can be used for compactin of ferrite magnets, isotropic and anisotropic. For compaction under field (anisotropic magnets) coils are coupled to die and can be placed in a surrounding form on die (cavity), or on the punches, as shown in Fig. 5-(b). Each coil has 500 turns and the same was made with 19 AWG wire. Fig. 5-(c) shows the experimental die mounted in a press in which can be observed that the coils of upper and lower punches are connected by wires to a source of continuous voltage, adjustable and with high power (right in the Fig.).

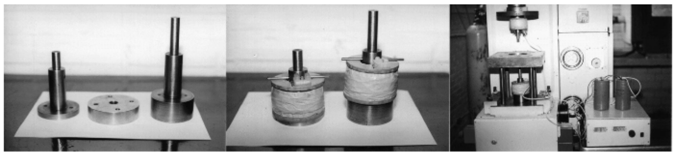

(a) (b) (c)

Fig. 5. Die for pressing under magnetic field - (b) punches associated to coils - (c) die mounted in the press.

2.3 Raw material

The powder to obtainment of the strontium ferrite magnets was provided by a manufacturer ready for compaction. The exact chemical composition of the powder was not identified by the manufacturer who only gave the following data of powder:

1. Denomination : H100 - Strontium Ferrite;
2. Density: 1.25 g / cm^3;
3. Lubricant: the base of zinc stearate (range 0.8% to 1%);
4. Additives: not informed;
5. Pressing pressure: 180 MPa;
6. Sintering levels (as indicated in the curve in Fig. 6).

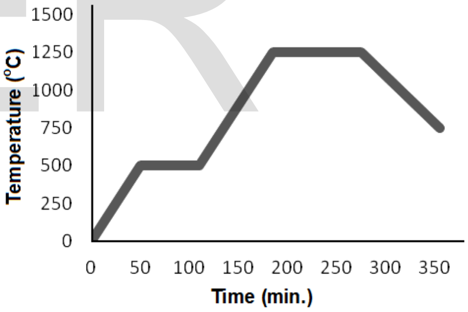


Fig. 6. Sintering levels for strontium ferrite H100.

After a superficial analysis of the powder ferrite H100 (in this case visual observation and handling), it was found that this particle size is similar to grains of sand, ie, with an average particle diameter in the order of a few tens of micrometers. This conclusion was made from practical results of other experiments conducted by the authors of this work. Other suppliers also provide ferrite powder of strontium and barium with particle size significantly smaller than the ferrite H100 (a few units of microns). The strontium ferrite powder H100 was analyzed for chemical composition, size and shape of the particles.

With respect to characterizing the composition, was used the technique of X-ray diffraction as the lattice structures of a material can be experimentally determined by X-ray analysis, which also show the crystalline structure [16], [17].

The characterization of the average particle size of strontium ferrite powder H100 was performed by the method of Laser Diffraction, since the particles with diameters less than 30 μm can not be granulometrically distinguished by sieves [18], [19]. The strontium ferrite powder H100 was also analyzed with the aid of an optical microscope by embed the powder in acrylic resins.

2.4 Obtainment of the Magnets

The pressing of the samples was performed in a universal machine of mechanical testing with a capacity of 1000 kgf (100 kN) with a rate of 50 mm / minute under 180 MPa of pressure. Were obtained cylindrical parts with a diameter of 15 mm and height of 5 mm. The die used is shown in Fig. 5, and was observed a reduction of 66% in volume of powder after the pressing. Table 1 shows the average of three specimens for each sample description. The specimens relating to a sample 1 were pressing without magnetic field, ie, without the coils.

The ferrite powder H100 was pressing under magnetic field (anisotropic magnets - specimens of the samples 2, 3, 4 and 5) of 10 kOe (800 kA / m). Important to note that, due to the fact that the field is generated within the die, the field measuring when the powder is pressed in the cavity, can be realized only indirectly. Therefore the die of Fig. 5 was mounted in the press without the cavity, only with the punches and the coils, with a separation between the punches of 10 mm (mean of height of the cavity considering the height of the powder 15 mm and height of the pressed part 5 mm). A Hall sensor was inserted between the punches and varied the voltage of the source, and therefore the electric current in the coils, until the Hall sensor register 10 kOe. The insertion of the cavity does not change the magnetic field in the cavity since it is constructed of non-magnetic stainless steel. Thus, considering the same current in the coils in the pressing of specimens, with the same height of the cavity (or the same separation between the punctures), there exists a magnetic field of 10 kOe. This field is sufficient to saturate the induction of the ferrite H100 pressed with and without magnetic field.

The specimens of sample 2, were pressed with magnetic field of 10 kOe without any alteration in the raw material. The following was added to the ferrite powder H100 1% of zinc stearate lubricant (specimens of sample 3). The H100 ferrite powder was moistened with water until become with aspect like "clay", featuring a wet pressing (specimens of sample 4). Attempt was made to wet the powder with paraffínic oil, however it was observed that the raw material leaked between the walls of the cavity and the punches, preventing the pressing. The wet pressing reduces the friction between the powder particles, thus enabling these to turn to their directions of easy magnetization, featuring an anisotropic magnet. Finally, was used a strontium ferrite powder with middle diameter of powder particle of 1 μm, according to the manufacturer and particle size analysis.

The samples were sintered in a furnace like muffle with resistance type silicon carbide and maximum temperature of 1500 °C (2732 °F). This furnace is controlled by thyristors, and temperature control performed by thermocouple PtRh Pt-10%. The sintering time was 3 hours at temperature of 1250 °C (2282 °F), with a period of 60 minutes at temperature of 500 °C (932 °F) to remove the lubricant. The heating rate was 10 °C per minute. Fig. 6 shows the levels of temperature and time used.

2.5 Magnetization and Hysteresis Loop

The made parts (compacted and sintered) from manufacturer's data of the H100 powder, were subjected to a magnetizing field of 10 kOe, using the same die shown in Fig. 5. The superficial remanent magnetism measurement was performed on the center of one of the surfaces, from a gaussmeter (device constructed from Hall sensors capable of detecting field and magnetic induction), having the caution with the observed values and the unit system used, ie cgs or MKS) [3], [4].

The Gaussmeter used was TLMP-HALL-XXk-T0 model, brand Globalmag with transversal sensor of 5 x 1.5 mm. Measurements were made at the center of a positive pole of the flat surfaces of the cylindrical magnets made. As the magnets after sintering resulted in very similar dimensions, it was created a mating structure of magnets and the Hall sensor of the Gaussmeter such that the remanent magnetism was always measured at the same location. A number of empirical considerations and experimental measurements, resulted an inaccuracy of 5% for the measurements considering inaccuracy in the measurement of Gaussmeter and difficulties in accurate positioning of the sensor over the center of the magnets.

The coercivity and retentivity were obtained from the hysteresis loop. The device used was a *Vibrating Sample Magnetometer*, a device suitable for plotting hysteresis curves of hard magnetic materials (permanent magnets). The curves were obtained in *Magnetism Laboratory* of *Physical Institute* of UFRGS (*Federal University of Rio Grande do Sul*, Brazil). Were plotted two hysteresis loop for each specimen (samples), the first curve was obtained from the application of a magnetic field or magnetization in the same direction of the pressing and parallel to the direction of the magnetic field applied in the pressing; the second curve was obtained from the application of a magnetic field in the perpendicular direction to the pressing direction and the magnetic field applied in the pressing The hysteresis loop is plotted from fragments of material taken from the samples, can be cylindrical, in which the length is much greater than the diameter to minimize the leakage flux [3], [4]. The maximum magnetic field applied to generate the hysteresis curves was 8 kOe (637 kA / m), and the inaccuracy of the resulting measures is 2% according to data from UFRGS.

3 RESULTS AND DISCUSSION

3.1 Analysis of Chemical Composition

From the analysis of the spectrum obtained, it was proved that the powder was of strontium ferrite, with chemical composition: **$SrO.6Fe_2O_3$**. It was Investigated the coincidence of other spectra as barium ferrite, additives such as SiO_2, BiO_2, Al_2O_3, and lubricants such as zinc stearate, but it was not possible to identify them by this method because these substances are present in very small proportions, generally near 1%. The ratio of intensity in function of incidence angle 2θ of powder analyzed to range from 0 to 180° is shown in Figure 7, but also was obtained spectra on range from 20 to 80° [16], [7].

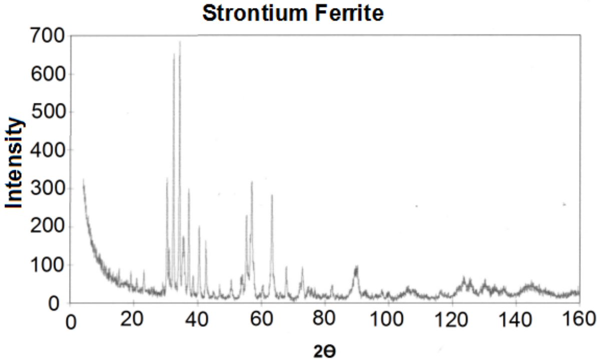


Fig. 7. Ratio of intensity in function of incidence angle 2θ of strontium ferrite powder H100 on range from 0 to 180°.

3.2 Particle size analysis

The analysis was performed out in aqueous medium, after conditioning of sample in ultrasonic, and mechanical agitation . It was observed that, the particles agglomerate easily, especially in water. It is inferred from this result, that such particles have hydrophobic character. From the histogram (Figure 8) representing the size distribution of particles per fraction, it was found that the average particle diameter was approximately 20 μm [18], [19].

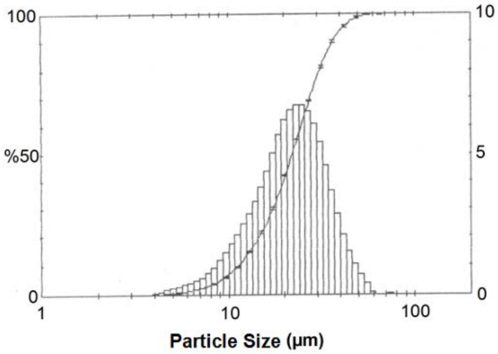


Fig. 8. Histogram representing the distribution of particle size fraction of the strontium ferrite powder H100.

3.3 Analysis of agglomeration of the particles

By microscopic examination, it was observed that the particles were agglomerated (Figure 9) due to the effect of the additives used, similar to the effect of the addition of stearic acid in other ferrites analyzed.

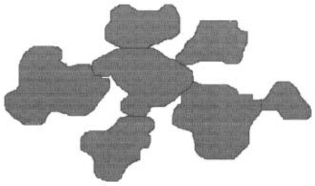


Fig. 9. Shape of particles of strontium ferrite powder H100 observed in an optical microscope.

3.4 Obtainment of the Magnets.

The pressing of all magnets (isotropic and anisotropic) were performed with a cavity height of 15 mm. In the pressing occurred a reduction of 66% in height of the specimens. On sintering, the parts had a linear shrinkage of about 12.5%, and resulted in a density of 4.7 g/cm^3., which are according with bibliografic data [3]. Figure 10 shows the photograph of the specimens (sample 1).

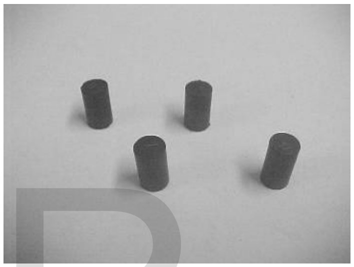


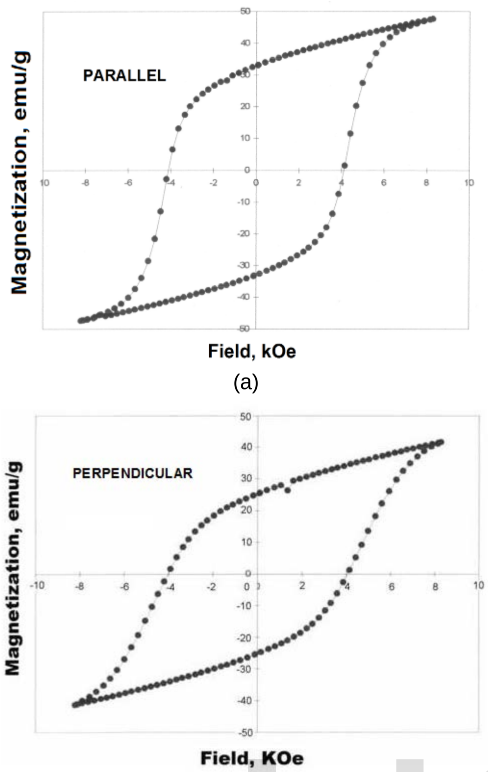
Fig. 10. Specimens prepared according to the manufacturer of strontium ferrite powder H100 (sample 1).

3.5 Hysteresis Loop of Isotropic Magnets

Figure 11-(a) shows a hysteresis loop for the specimens of sample 1, obtained with parallel magnetization to the pressing direction. Fig. 11-(b), in turn, shows a hysteresis loop of the same sample, but with perpendicular magnetization. Considering the magnetization parallel, which provide best results, it was found a coercivity of about 4.1 kOe (326 kA/m). The retentivity was approximately 1.95 kG (0,195 T) and was calculated using (1) [3].

$$B_r = 4\pi \frac{emu}{g}\rho \qquad (1)$$

where **ρ** is the density of the specimens.



(a)

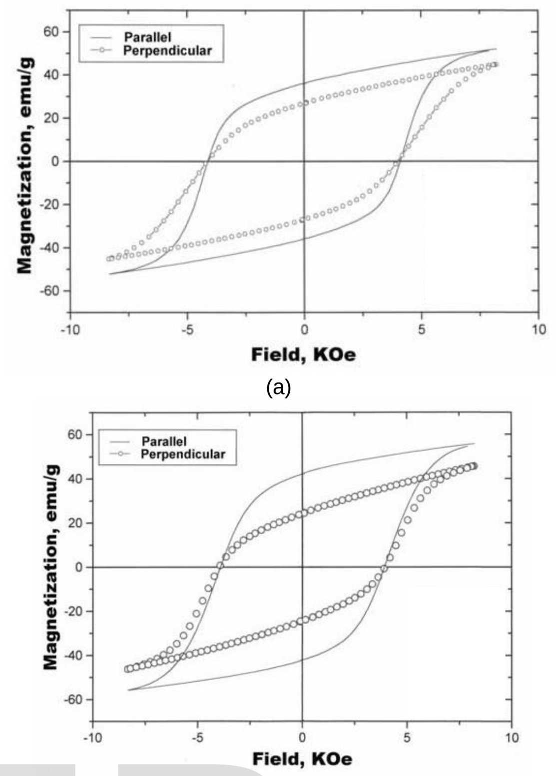
(b)

Fig. 11. Hysteresis loop of strontium ferrite magnets for H100 powder with the characteristics of pressure and sintering provided by the supplier (sample 1) wih magnetization – (a) Parallel – (b) Perpendicular.

3.6 Hysteresis loop of anisotropic magnets

The hysteresis loop of the specimens of Sample 2 (compacted under field) are identical to those of isotropic magnets (specimens of sample 1), ie, there were no changes in the data of sample 2 (1,95 kG and 4,1 kOe).

Figure 12-(a) shows one of the hysteresis loop of the specimens of sample 3, which can be observed that there was no change in the coercivity (4,1 kOe). In contrast, there was a 10% increase in the retentivity in relation to the isotropic magnet (2,130 kG), value calculated by equation 1. Importantly which was added 1% of zinc stearate in raw material H100 of the sample specimens 3. The Figure 12-(b) shows one of the hysteresis loop of samples 4, where can be also observed that there was no change in the coercivity (4,1 kOe), although it was observed 30% increase in the retentivity, compared to the isotropic magnet (2,540 kG). Also to note that to obtain specimens of the sample 4, the raw material H100 was humidified.



(a)

(b)

Fig. 12. Hysteresis loop of anisotropic ferrite magnets H100 with - (a) lubricant increase in the powder (sample 3) – (b) wetting powder (sample 4).

The specimens of Sample 5 were pressed using another powder of strontium ferrite with average particle diameter much smaller than the ferrite H100 (about 1 µm). With the same parameters of pressure and field in the pressing, and sintering levels previous, were obtained parts with approximate values of coercivity of 3 kOe (238 kA/m) and retentivity of 3.85 kG (0,385 T), according to data obtained from the hysteresis loop of Fig. 13. The density was approximately 4.5 g/cm^3, resulting in anisotropic magnet of strontium ferrite having the characteristics very similar to the commercial magnets these materials [3], [4], [5].

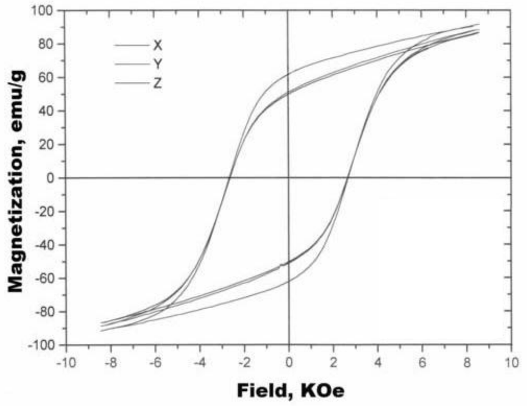


Fig. 13. Hysteresis loop of the anisotropic magnets with powder particle size in the range 1-5 microns (Sample 5).

The composition of the raw material (powder) used to prepare strontium ferrite magnets, isotropic and anisotropic, are different. The average particle diameter of powder to isotropic magnets is higher, when compared with the anisotropic, and have a certain difficulty of orientation of the powder particles of larger size [3], [4], [5].
The difference in the size of powder particles to ferrite magnets isotropic and anisotropic is due to two reasons. The size of particles of ferrite powder and the type of additives used by agglomeration of particles, especially the waxes and stearic acid. The addition of stearic acid improves the surface finish of the pieces obtained. The ferrite magnets obtained from powders without additives, produces parts with lower density and poor surface finish [3], [4], [5].
Table 1 shows the values of surface magnetic remanence Br* , measured by gassmeter (Hall effect sensor) in the center of one end of cylindrical specimens, and retentivity Br** (Parallel and Perpendicular), obtained from the hysteresis loop. The values shown in Table 1 represent the average of three specimens for each sample type. The coercivity for the H100 raw material (samples 1 to 4) resulted in identical coercivity of 4.1 kOe, and sample 5 resulted in coercivity of 3 kOe.

TABLE 1
SURFACE REMANENT MAGNETISM AND RETENTIVITY OF THE SAMPLES

Sample Nº	Br* Parallel [Gauss]	Br** Parallel [Gauss]	Br** Perpendicular [Gauss]
1	500	1.950	1.480
2	500	1.950	1.480
3	550	2.130	1.650
4	650	2.540	1.480
5	800	3.850	3.100

Observing the hysteresis loop with relation to parallel and perpendicular magnetization, to the direction of pressing, it was observed higher values of retentivity with parallel magnetization to the direction of pressing [3].

4 CONCLUSIONS

Increasing the lubricant in the powder used for isotropic magnets (large particles), allows a better distribution of the lubricant on the surface of the fragments (particles) of powder, which in turn reduces the friction force, allowing the particles to rotate more easily in the direction of the applied magnetic field, aligning itself partly in its direction of easy magnetization, also acting as an element of dissociation of the powder particles by waxes and other binders. Likewise, the wetting of the powder (to humid pressing) also acts as an element of dissociation of the powder particles.
For the ferrite powder H100 not was observed any variation in coercivity of the samples, same with increase of lubricant, wetting pressing or increase of the magnetic field in the pressing maintaining invariably in approximately 4.1 kOe.
For anisotropic ferrite magnets, to obtain magnetic properties according to literary data, as for example the retentivity, is only possible with particle size from a few units of microns. The additives improve the surface finish of parts but also impede the alignment of the powder particles in the compression under field.

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