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Ferromagnetic Material for Strong Magnetic Shielding

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Abstract

Purpose of this research is to find out the effective way to shield the magnets by using two most common available materials that is iron and steel. The material that is available in market they shield less magnetic field and also are costly. If you want to shield the higher magnetic field you have to expense a lot. To shield the magnetic field you have to make the sheet and wrapped it around the magnet, but thickness of shielded plates varies with the type of magnet and the power of magnet. Finally here we have a better material that can shield your magnet and can save your 100s of equipment that you are using. This is good for your observation which material is having the best results. The cost of these metal sheets is 20-30 times less than the best material available in market for shielding and also they can shield high strength magnetic field.

Keywords: Ferromagnetic material; Magnetic field; NdFeB; Magnetic domains

Introduction

We have a magnet very strong one. Neodymium magnet I am using of near 4000gauss magnetic field. It's not that easy to shield the magnet with the material like mu metal. Only few gauss can be shield by the mu metal. To shield the maximum portion of it we have to expense many dollars even. So you don't have to expense a lot of money and easily you can shield any area as per your requirement by common material like steel and iron [1,2]. Figure 1 describes about the magnetic field around a bar magnet.

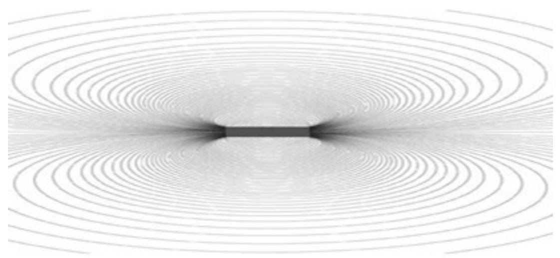

Figure 1: Describes about the magnetic field around a bar magnet.

Material and method

The materials that are being used in this are listed below.

- A nonmagnetic stainless steel plate of thickness of 1 mm to 5 mm.
- A magnetic stainless steel plate of thickness of 1 mm to 5 mm.
- An iron sheet of thickness of 1 mm to 5 mm.
- Neodymium magnet of 50*20*10 mm. the magnets having gauss power of 4000 gauss on surface.

Magnetic property of Iron and Steel

Iron gets magnetized faster but loses its magnetism as soon as the inducing magnet is removed. Hence soft iron is said to have high susceptibility but low retentivety. This property of soft iron is very useful in making temporary electromagnets where we need strong but temporary magnets. If the magnets used in these devices were to retain their magnetism for a longer period, the devices would not function properly.

Steel is slow to be magnetized but retains the acquired magnetism for a long time. Steel is said to have low susceptibility but high retentivety. Steel is used for making magnets. Ferromagnetism is the phenomenon of spontaneous magnetization – the magnetization exists in the ferromagnetic material in the absence of applied magnetic field. The best-known examples of ferromagnetic are the transition metals Fe, Co, and Ni, but other elements and alloys involving transition or rare-earth elements also show ferromagnetism. Thus the rare-earth metals Gd, Dy, and the insulating transition metal oxide CrO_2 all become ferromagnetic under suitable circumstances. Ferromagnetism involves the alignment of an appreciable fraction of the molecular magnetic moments in some favorable direction in the crystal. The fact that the phenomenon is restricted to transition and rare-earth elements indicates that it is related to the unfilled 3d and 4f shells in these substances. Ferromagnetism appears only below a certain temperature, which is known as the ferromagnetic transition temperature or simply as the Curie temperature. This temperature depends on the substance, but its order of magnitude is about 1000°K for Fe, Co, Gd, Dy. It might be however much less. For example it is 70K for EuO and even less for EuS. Thus the ferromagnetic range often includes the whole of the usual temperature region.

Available solution (Mu Metal)

Mu metal is a nickel–iron soft magnetic alloy with very high permeability suitable for shielding sensitive electronic equipment against static or low frequency magnetic fields. It has several compositions. One such composition is approximately 77% nickel, 16% iron, 5% copper and 2% chromium or molybdenum. More recently,

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Mu metal is considered to be ASTM A753 Alloy 4 and is composed of approximately 80% nickel, 5% molybdenum, small amounts of various other elements such as silicon, and the remaining 12 to 15% iron [3,4]. The name came from the Greek letter mu (μ) which represents permeability in physics and engineering formulae. Mu metal typically has relative permeability values of 80,000-100,000 compared to several times of ordinary steel. The high permeability of Mu metal provides a low reluctance path for magnetic flux, leading to its use in magnetic shields against static or slowly varying magnetic fields. Magnetic shielding made with high permeability alloys like Mu metal works not by blocking magnetic fields but by providing a path for the magnetic field lines around the shielded area [5-11].

Mu materials Magnetic Properties

Density: 8.7 [g/cm^3]

Young's Modulus: 225 [GPA]

Poisson Ratio: 0.29

Yield Strength: 280 [MPa]

Ultimate Tensile Strength: 700 [MPa]

Thermal Conductivity: 19 [W/ (m*K)]

Linear Expansion: 1.2 [10^{-5}m/m/C]

Specific Heat: 460 [J/ (kg*K)]

Melting Point: 1440 [C]

Resistivity: 55 [μ? cm]

Cost of Mu metal

One normal sheet of Mu Metal can be purchased online or from the store at cost b/w 1-10$. It is very costly compare to ferromagnetic material.

Method

I cut the sheet in pieces as per my requirement of size of 100*50 mm of thickness form 1 mm to 5mm. the material are of both iron and stainless steel (magnetic and nonmagnetic)

So the total sheets are 15 (5 of iron, 5 of magnetic stainless steel, 5 of nonmagnetic stainless steel)

Directly putting the plates on magnets can shield it by maximum amount. The attractive force or repulsive force also varies with the thickness of the material that we are using.

Results

Magnets are being attracted to the sheets and to some it isn't. Only ferromagnetic materials are attracted to the magnet. The magnetic field of any magnet can't be finished. The magnetic fields can be redirected towards the plate. And then I wrapped the whole magnet by the same sheet by changing the thickness again and again. As the sheet is changed the shielding effect also varies with the thickness.

The better result completely depends upon the way of shielding. When I am having all material in form of sheet it's having little effect. For better result it should be shielded from all other except the required one.

A nonmagnetic stainless steel can't be used for the shielding. It's not capable of redirecting the magnetic forces around the sheet no matter how much thick sheet you have. So its effect is same as the normal magnet.

Table/Graph

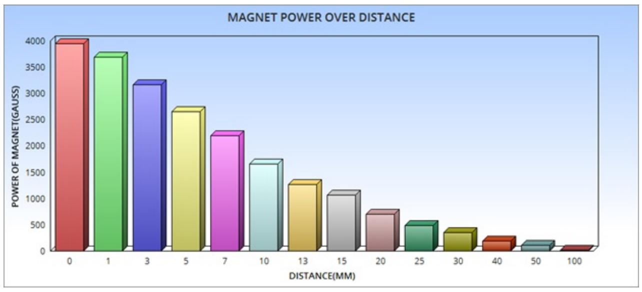

Figure 2: Magnetic power over distance.

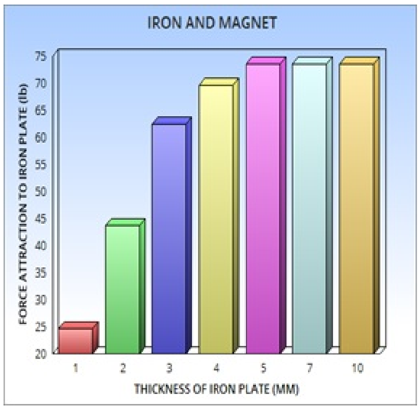

Figure 3: The attraction force towards the iron plate and how it varies with thickness.

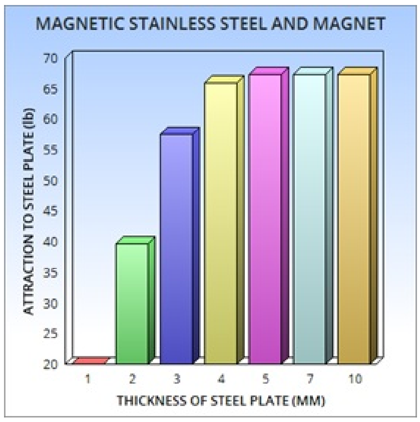

Figure 4: The attraction force towards the stainless steel plate and how it varies with thickness.

Figure 2 shows magnetic power over distance. Figure 3 shows the attraction force towards the iron plate and how it varies with thickness. Figure 4 shows the attraction force towards the stainless steel plate and how it varies with thickness.

When the thickness varies (increases) the pull force also increases but with increase in pull force the magnetic field gets redirected towards the plate and it is providing shielding to maximum of the magnetic field. The effect of magnetic field outside the plate decreases as the thickness of plate is increases.

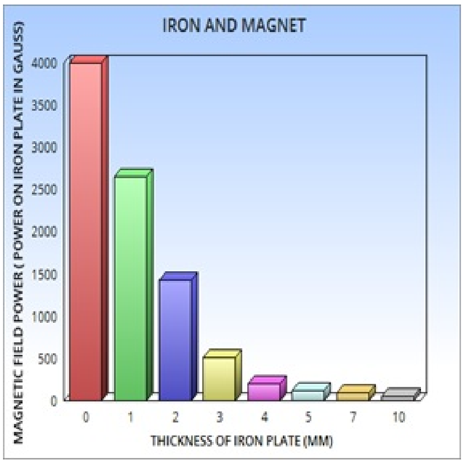

Figure 5: The magnetic power reduction in magnetic field with the variation in thickness of iron plate.

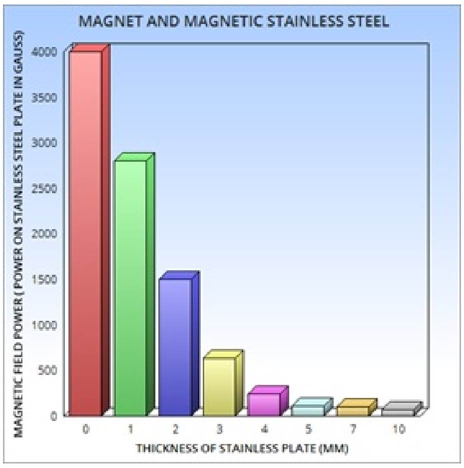

Figure 6: The magnetic power reduction in magnetic field with the variation in thickness of stainless steel plate.

Figure 5 show the magnetic power reduction in magnetic field with the variation in thickness of iron plate. Figure 6 show the magnetic power reduction in magnetic field with the variation in thickness of stainless steel plate.

When the thickness of plate is maximum the magnetic field is minimum and the magnetic field strength finished. Magnetic field strength at 1 mm is approx. 4000 gauss and at 10 mm thickness of plate it is only 50 gauss maximum.

Discussion

It has been a question in mind why all this is happening. The material which is being attracted to the magnet it is redirecting its magnetic field. Because of magnetic field can't be blocked that's why they are being redirecting around the shielding material. If you are dealing with very high magnetic field then this is very effective. For low field also it is preferable because of It's widely availability. Even when the available space is less and low magnetic fields/strength are available then it would be effective to use Mu metal. But when the strength and space both are more, then Mu metal can't be used. In this case ferromagnetic materials can be used [12-18].

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