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Strong Magnetic Shielding by Common Available Material

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Abstract

Purpose of this research paper is to find way to shield a very strong magnet that is of neodymium n50 grades or any other grade. There are several places where we require to shield the magnets completely or some sides/part of it. There are materials available in market for shielding but they are costly. The main aspect of this paper is to find a material by which we can shield very strong magnetic field and the cost can be reduced by significant amount. The method is to use many different common available material to shield it which are available commonly. The material that are being used are ferromagnetic, paramagnetic and diamagnetic. To find the perfect material for shielding we have to add different sheets of different material. The shielding also consists of some amount of rubber sheet. The final result of the experiment are we successfully finds a combination of material that shield the magnets perfectly in both attraction and repulsion. Magnet that are being used for the test have the power of 3900 gauss, they are made of NdFeB. The material that are available for shielding like Mu metal and more are costly and also can't shield very high magnetic field. The material which we have found can shield very high magnetic field but are not preferable where space is less. And the price of the ferromagnetic material is significantly low.

Keywords: NdFeB; Mu metal; Ferromagnetic material; Magnetic shielding; Dipoles; Magnetic field redirecting

Introduction

Is it possible to reduce the power of magnet by our requirement or 10% or 20% to its original power? It's interesting because as per your need in any experiment, you easily can reduce the power of the magnets. The side you wanted and use them for your purpose. This paper is representing a way to shield the magnet even strongest one of neodymium with common materials.

Few of the devices are there where we are using shield material are available in our daily life. But few of the place and sometime at experimentation we have to block magnetic field by few sides. In that side we can apply few common material that are available in market for shielding but the ferromagnetic material can shield it perfectly [1].

Available solution (Mu Metal) for magnetic shielding

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, 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 [2-4]. 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: Cost of Mu metal varies from 1$ to 10$ for small sheet of few inches.

Material and method

List of the materials

- Neodymium magnets n50 grade, side of 50*20*10mm in size. Neodymium is one of the strongest by power and made of rare earth metal.
- The plates of the material are required for the shielding. The plates are Iron, Stainless Steel, Tin, Rubber, Aluminium Brass and some

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more common material. I also have used spacer that is made of plastic and also of wood. Thickness of spacer is 4mm.

- The electric tape and aluminum tape is required.
- Cut all sheet of material in the size of 100*50mm including the rubber and spacers.
- Thickness of all the materials are near one mm.
- Thickness of rubber is 3MM.

Material that we are using, their's property

When a material is placed within a magnetic field, the magnetic forces of the material's electrons will be affected. This effect is known as Faraday's Law of Magnetic Induction. However, materials can react quite differently to the presence of an external magnetic field. This reaction is dependent on a number of factors, such as the atomic and molecular structure of the material, and the net magnetic field associated with the atoms. The magnetic moments associated with atoms have three origins. These are the electron motion, the change in motion caused by an external magnetic field, and the spin of the electrons.

In most atoms, electrons occur in pairs. Electrons in a pair spin in opposite directions. So, when electrons are paired together, their opposite spins cause their magnetic fields to cancel each other. Therefore, no net magnetic field exists. Alternately, materials with some unpaired electrons will have a net magnetic field and will react more to an external field. Most materials can be classified as diamagnetic, paramagnetic or ferromagnetic.

Diamagnetic materials: Diamagnetic materials have a weak, negative susceptibility to magnetic fields. Diamagnetic materials are slightly repelled by a magnetic field and the material does not retain the magnetic properties when the external field is removed. In diamagnetic materials all the electron are paired so there is no permanent net magnetic moment per atom. Diamagnetic properties arise from the realignment of the electron paths under the influence of an external magnetic field. Most elements in the periodic table, including copper, silver, and gold, are diamagnetic.

Paramagnetic materials : Paramagnetic materials have a small, positive susceptibility to magnetic fields. These materials are slightly attracted by a magnetic field and the material does not retain the magnetic properties when the external field is removed. Paramagnetic properties are due to the presence of some unpaired electrons, and from the realignment of the electron paths caused by the external magnetic field. Paramagnetic materials include magnesium, molybdenum, lithium, and tantalum.

Ferromagnetic materials: Ferromagnetic materials have a large, positive susceptibility to an external magnetic field. They exhibit a strong attraction to magnetic fields and are able to retain their magnetic properties after the external field has been removed. Ferromagnetic materials have some unpaired electrons so their atoms have a net magnetic moment. They get their strong magnetic properties due to the presence of magnetic domains. In these domains, large numbers of atom's moments (1012 to 1015) are aligned parallel so that the magnetic force within the domain is strong. When a ferromagnetic material is in the unmagnitized state, the domains are nearly randomly organized and the net magnetic field for the part as a whole is zero. When a magnetizing force is applied, the domains become aligned to produce a strong magnetic field within the part. Iron, nickel, and cobalt are examples of ferromagnetic materials. Components with these materials are commonly inspected using the magnetic particle method [12-16].

Cost of these materials: In 5$ 2 kg-5 kg sheet of all these material can be purchased. The cost is being varied as per the countries and the material availablily, but these are most commonly available.

Method

Some important information

If your magnet is of less power i.e. not strong enough so by using a sheet of iron you easily can shield it. If you are shielding a normal magnet by iron then easily can be shielded. Stainless steel can also be used but it should be ferromagnetic which can attract the magnet. If the steel that you are using isn't attracted to the magnet it's worthless to use it. The magnetic field will be the same, they won't be shielded.

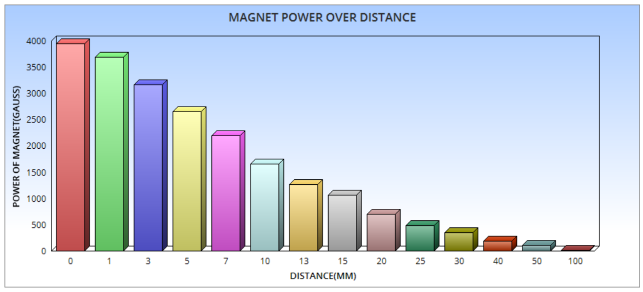

Figure 1: Magnetic field power in gauss up to 100 mm from its surface.

Figure 1 is representing the magnetic field power in gauss up to 100 mm from its surface. At 30mm it's having the strength around 340 gauss.

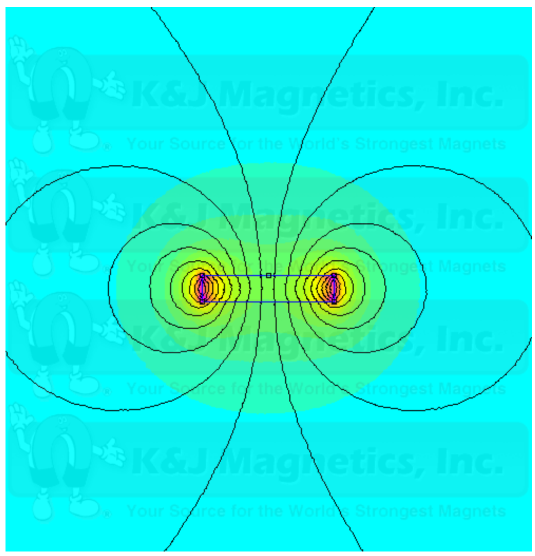

Figure 2: Strength of the NdFeB (Neodium Iron Boron) magnet.

Figure 2 represent the strength of the NdFeB (Neodium Iron Boron) magnet. Figure 1 shows how the strength decreases as distance increases. It shows the magnetic field lines into open space. The magnetic field line originates from north side and terminates to south side.

My experiment with neodymium

Figure 3 shows the relation b/w material sheet that are A, B, C, D and E and the amount(%) of Shielding they are providing to Neodium Magnet.

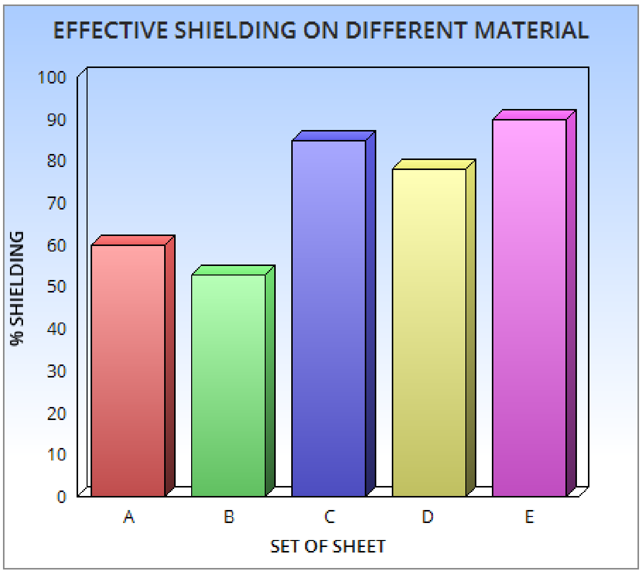

Figure 3: Relation b/w material sheet that are A, B, C, D and E and the amount (%) of Shielding they are providing to Neodium Magnet.

Arrangement A= IRON+ TIN+ RUBBER (1 MM+1 mm+3 MM=5 mm)

Arrangement B= IRON+ SS+ TIN+ SS (1+1+1+1=4 mm)

Arrangement C= TIN+TIN+ RUBBER+TIN+TIN+RUBBER (1+3+1+3+1=9 mm)

Arrangement D= IRON+ SS+ TIN+ TIN+ RUBBER (1+1+1+3+. 5=6.5 mm)

Arrangement E= IRON+ IRON+ TIN+ SS+ TIN wrapped in aluminum tape. (1+1+1+1+1=5 mm)

In another one experiment, then I have used the spacer made of plastic on magnet and then put the sheet of 7 mm thick. This is neglecting repulsion by maximum amount but little attraction b/w two big neodymium magnet still there. But it can't be attracted or repelled by any ordinary magnet. A very little attraction its showing cause of material being attracted to the magnet. The gauss field is reduced around 100 gauss now at a distance of 10 mm from plate sheet.

Mu metal I also have purchased from the marked and shielded different magnet.

For the magnet whose power was less Mu metal is giving better results compare to Ferromagnetic material, but as the magnetic field is being varies (increasing), the usability of the Mu metal is removed in this case the ferromagnetic material is giving better results.

Results

The magnetic shielding is perfectly can be done by different material. It also depends on types of magnets. So after adding the material sheet we achieved at a point where all repulsion forces are removed. The attraction power of the magnets can also be reduce by more than 50% by using same sheet of the material [17,18]. Now no material can be attracted by your magnets. And no magnet can reel your magnets, if you are having the same layer of shield on two sides of the magnets. The most preferable choice is E grade because the thickness of the material sheet is also less and has very better effect for shielding. The magnetic field that was at 10 cm that you can develop at 1 cm by adding these metal sheet. It's better to make a cage type structure for better shielding effect. The material can be transformed in any structure as per the need.

Because of the strength and thickness problem, it is preferable when the magnetic field is less i.e. less than. 5 tesla or 1 tesla at the surface of magnet it is better to use different arrangements of Mu Metal.

But when the magnetic field strength are increasing from 1 Tesla to 4 Tesla the Mu metal are not preferable, in this case only ferromagnetic and diamagnetic material shielding can be used for better configuration. Otherwise strong Mu metal will be required but their cost will be very much (Table 1).

Before Shielding	Before Shielding	After Shielding	After Shielding	After Shielding
Magnetic Field(G)	**Distance (mm)**	**Magnetic Field (G)**	**Distance (mm)**	**Arrangement Type Used**
2650	5	230	10	C
1659	10	215	10	D
1061	15	190	10	E
706	20	220	10	A
486	25	280	10	B

Table 1: Effect of magnet before/after the magnetic shielding.

By using the following shielding material the magnetic field is reduced to approx. 200 gauss from 1600 gauss. The magnetic field at 15, 20 and 25 mm distance is very less. At 25mm the magnetic field is only 30 gauss after adding the magnetic shielding plate. These

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materials can be used for shielding where there is no availability of funds or Mu Metal, which is most preferable for shielding.

Discussion

Why it's happening at initial we are using iron plate, and it's being attracted to the magnet strongly. There is one most basic thing that magnetic field can't be blocked but they can be redirected. The same thing is happening in the experiment when we are taking the sheet near the magnet it's being attracted and redirecting the magnetic field. When magnetic field is redirected then we are seeing that it's not repulsive anymore nor attractive by some amount. If we are taking any another piece of iron or anything else. It's not being attracted. All the magnetic dipoles are acting in the same direction when some magnetic material is being attracted by magnet.

This shield is perfect if you want to deal with very high magnetic field. If you dealing with low magnetic field then mu metal which is available in market you can use but its cost effective and can only use for low magnetic field.

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