ISSN: 2775-5118 VOL.4 NO.10 (2025) I.F. 9.1

PHYSICAL ESSENCE OF THE ELECTROMAGNETIC FIELD AND ITS SIGNIFICANCE IN TECHNOLOGY

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ABSTRACT: The basis of the technical progress of mankind is the processes associated with electricity and magnetic phenomena. Electric and magnetic fields are closely related to each other, and together they form an electromagnetic field. The electromagnetic field plays an important role not only in natural processes, but also in the fields of technology, communications, transport and medicine. This article will cover the physical essence of the electromagnetic field, the principle of operation and its importance in technology.

Key words: Electromagnets are used in motors, generators, electromechanical solenoids, relays, speakers, hard drives, MRI machines.

An electromagnet is a type of magnet in which a magnetic field is produced by an electric current. Electromagnets usually consist of a coil of wire wrapped around it. Current flowing through the wire creates a magnetic field that is concentrated between the turns of wire, which is the center of the coil.

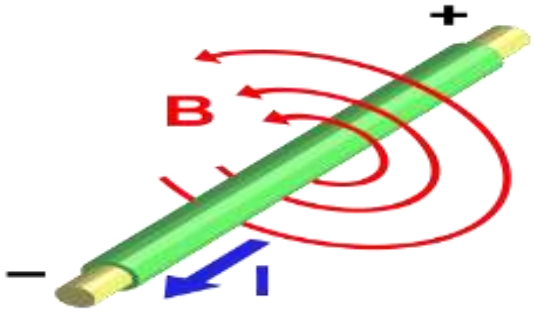

Figure 1.a

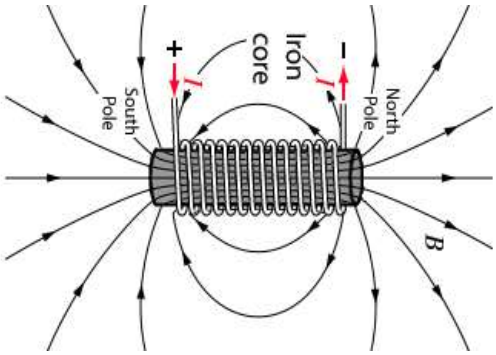

Figure 1.b

When the current is turned off, the magnetic field also disappears. The coils of wire are often wound around a magnetic core made of ferromagnetic or ferromagnetic materials such as iron; the magnetic core collects the magnetic flux and creates a stronger magnet.

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Electromagnets are widely used as components of other electrical devices, such as motors, generators, electromechanical solenoids, relays, speakers, hard drives, MRI machines, scientific instruments, and magnetic separation equipment. Electromagnets are also used in industry to pick up and move heavy ferrous objects, such as iron and steel scrap.

Danish scientist Hans Christian Eersted discovered in 1820 that an electric current produces a magnetic field. British scientist William Sturgeon invented the electromagnet in 1824. His first electromagnet was a horseshoe- shaped piece of iron wrapped around about 18 turns of copper wire (insulated wire did not exist at that time). The horseshoe was varnished for insulation.

When current was passed through the coil, the iron became magnetized and attracted other pieces of iron; when the current was stopped, it lost its magnetism. Sturgeon showed in his experiments that he could lift a weight of nine pounds (about 4 kilograms) with an electromagnet weighing only seven ounces (about 200 grams).

However, Sturgeon's magnets were weak because the uninsulated wire he used was only wound in one intermediate layer around the core, limiting the number of windings.

Applications of electromagnets

Industrial electromagnet lifting scrap iron, 1914

Portable electromagnets were originally designed to hold material in place; an example is the lifting magnet. A magnet that pulls something in motion by applying force.

Electromagnets are widely used in electrical and electromechanical devices, including:

Motors, generators,Transformers, Relays, Electrical bells and signals

Speakers and headphones, Magnetic memory and data storage devices: tape recorders, video recorders, hard drives, MRI machines, Particle accelerators, Magnetic locks

Magnetic separation equipment used to separate magnetic from non-magnetic materials, such as separating ferrous metal from scrap from other materials.

Another equation that gives the magnetic field for each small segment of current is the Biot-Savart law. The magnetic field and strength of ferromagnetic materials are difficult to calculate for two reasons. First, the field strength varies in a complex way from point to point,

ISSN: 2775-5118 VOL.4 NO.10 (2025) I.F. 9.1

especially outside the core and in air gaps. Second, the magnetic field and strength B are nonlinear functions of the current, and depend on the nonlinear relationship between B and H for the core material used. For precise calculations, computer programs are used that generate a magnetic field model using the finite element method.

The magnetic field of a typical electromagnet (green) forms a closed loop with an iron core C, inside which are two air gaps G. B— Magnetic field in the core BF— "scattered fields". In the gaps G, the magnetic field lines "bulge", so the field strength is less than in the core:$B_F<B$ *BL*— magnetic field lines that do not correspond to a complete magnetic circuit

L— the average length of the magnetic circuit used in the equation. This is the sum of the length of the iron core sections L and the air gaps G, the length L.

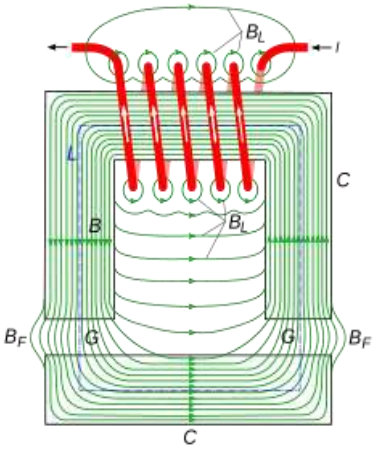

Figure 2

In strong electromagnets, the magnetic field exerts a force on each turn of the windings due to the Lorentz force. The Lorentz force is perpendicular to both the axis of the wire and the magnetic field.

This can be seen as the pressure between the magnetic field lines, pushing them apart. The winding of an electromagnet has two effects:

The field lines inside the coil axis exert a radial force on each turn of the windings, pulling them outwards from the coil in all directions. This causes mechanical tension in the wire.

The field lines between each turn of the coil provide an attractive force between adjacent turns, tending to pull them together.

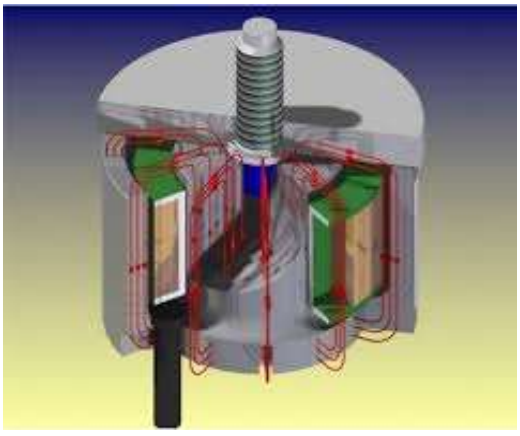

Figure 3

Summary

The electromagnetic field is used as a primary energy source and control tool in almost all areas of technology. Electric motors, generators, communication devices, medical devices, and transportation systems all rely on the laws of the

ISSN: 2775-5118 VOL.4 NO.10 (2025) I.F. 9.1

electromagnetic field. Therefore, it can be said that electromagnetic phenomena are the heart of human technical progress.

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