# A MAGNETOHYDRODYNAMICS BY FARADAY'S PRINCIPLES OF ELECTROMAGNETIC INDUCTION.

**1 Mrs S. BHUVANESWARI** **2 K. GNANESHWARI**

**1** Head of the Department & Asst. Prof.., Dept. Of Mathematics, Kamban College of Arts and Science for Women

**2** Post Graduate Student. Dept. Of Mathematics, Kamban College of Arts and Science for Women

***ABSTRACT*:**

*In this article, we explored magnetohydrodynamic (MHD) power generation, an electromechanical energy conversion technology. It generates electricity directly from a stream of ionized liquid flowing through a magnetic field. When an ionized liquid moves under a magnetic field, it produces electrical energy according to Faraday's electromagnetic principle.*

**KEYWORD: Magneto hydrodynamics, Power Generation, Ionized fluid, Magnetic field, Faraday's electromagnetic principle**.

## 1. INTRODUCTION

In our daily life, an electric machine called a generator is used to generate electricity. A Electric power plants [1] that takes some kind of energy and converts it into by electrical energy. Electromechanical energy conversion technology [2]. Magneto hydrodynamic (MHD) power.

Power generation technology [3-8] is an unprecedented power generation method [9].It generates electricity directly from the stream of ionized fluid flowing through the magnet field. An ionized fluid moving under a magnetic field acts as a moving electrical conductor [10].

Therefore, electrical energy can be produced according to Faraday's electromagnetic A magneto hydrodynamic generator or magneto hydrodynamic transducer acts as a fluid. A dynamo caused by the flow (motion) of a conducting fluid (conductor) under a magnetic field. The voltage generated across the fluid is perpendicular to the magnetic field and fluid flow. According to Fleming's right-hand rule. 1832, concept of MHD power generation.

This technique was first discussed by Michael Faraday [11] during a lecture. Since then, MHD power generation technology has been studied and researched by the Royal Society. The number of MHD generation study groups has many applications [12-15], These days, green energy harvesting processes seem important and much needed.

Renewable energy sources for sustainable development in this article, MHD electricity generation. The technology was presented, followed by a discussion of its components and instrumentation.

A technical review of research results in the field of MHD electricity generation has been published. From Recent developments in this technology and its major developments are highlighted. The future Trends in the MHD power generation process are also discussed along with their challenges Technology.

### 1.2 MAGNETOHYDRO-DYNAMICS :-

Fluid dynamics is an important science that is used to solve many natural phenomena such as the flight of birds, the swimming of fish and the development of weather conditions. Studying the laws governing the conversion of energy from one form to another, the direction of heat flow and the availability of energy to do work is the subject of thermodynamics. The study of charged particles in motion, the forces produced by electric and magnetic fields, and the relationships between them, represents the subject electrodynamics.

The collective effects of these three important fields of science, fluid mechanics, thermodynamics and electrodynamics, have created the subject of magnetron fluid dynamics (MFD)[16]. Magnetic field. There are two subtopics: Magneto hydrodynamics (MHD) and magnetogasdynamics (MGD). MHD works with conducting liquids, while MGD works with ionized, compressible gases.

Magneto hydrodynamics (often called MHD) deals with the dynamics of fluids with non-negligible electrical conductivity interacting with magnetic fields. As a result, the movement of a conductive fluid in the presence of a magnetic field induces an electric current in the fluid. A conducting fluid that moves in the presence of a (transverse) magnetic field that produces a force called the Lorentz force. This force tends to change the initial motion of the conducting fluid. In addition, induced currents create their own magnetic field and add to the primary magnetic field.

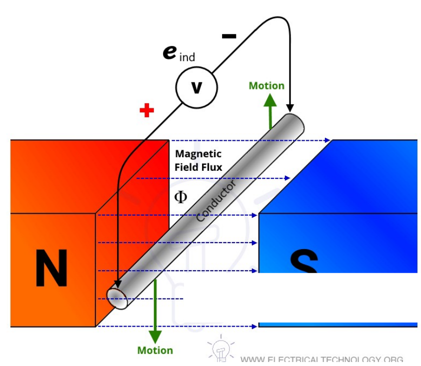
Therefore, there is a lock between the motion of the conductor and the electromagnetic field. MHD has many applications, including fusion research, MHD accelerators, generators, and laminar to turbulent flow deceleration. The first theory of laminar flow of conducting fluids in a uniform magnetic field was presented by Hartmann [17], but the discovery of Alfven waves completed the formation of MHD as a separate science by Alfven [18]. Alfven won the Nobel Prize in 1942.

## 2. THE CONTEXT OF THE STUDY

This section introduces a new generation of profile students who are experiencing law. In addition, it briefly discusses the role of mathematics in Faraday's Law in the context of engineering courses. Then focus on integrating the two to achieve the desired synergy.

### 2.1 FARADAY'S LAW:-

The Maxwell-Faraday equations (cited as one of Maxwell's equations) state that a space-varying (and potentially time-varying, depending on how the magnetic field changes with time) electric field is always electric, and this fact It explains that it contains a time. The changing magnetic field of Faraday's law is defined as the electromagnetic work done per unit charge on a conducting loop when the magnetic flux on the surface enclosed by the loop changes with time.



Faraday’s law of electromagnetic induction, also known as Faraday’s law, is a fundamental law of electromagnetism that helps predict how magnetic fields interact with electrical circuits to produce electromagnetic force (EMF). This phenomenon is known as electromagnetic induction.

Michael Faraday proposed the law of electromagnetic induction in 1831. Faraday’s law or law of electromagnetic induction is an observation or result of an experiment made by Faraday. He performed three main experiments to discover the phenomenon of electromagnetic induction.

Faraday's law of electromagnetic induction consists of two laws. The first law describes the induction of electromotive force in conductors and the second law quantifies the electromotive force created in conductors. Let's learn more about these rules in the next few sections.

- **FIRST LAW:-**

Every time the magnetic flux connected to the closed circuit changes, an EMF (Electromotive force) is induced in the circuit which remains in the circuit as long as the magnetic flux is changing.

- **SECOND LAW :-**

The magnitude of the induced EMF (Electromotive force) in a closed circuit is equal to the time rate of change of the magnetic flux connected to the circuit.

**2.2 ELECTROMOTIVE FORCE:-**

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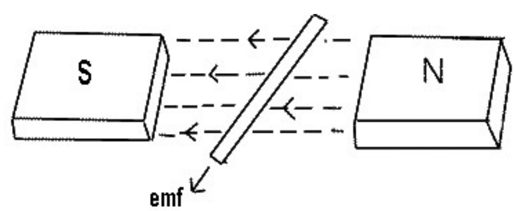
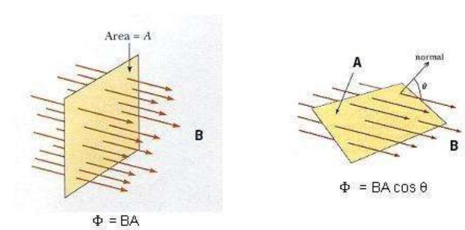


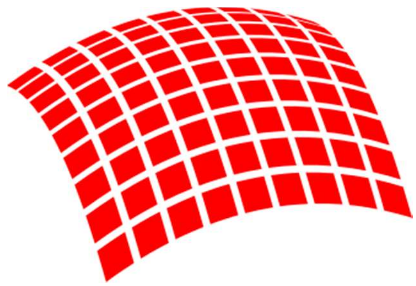

**2.3 MAGNETIC FLUX:-**

Magnetic flux is defined as the number of magnetic field lines that pass through a given closed surface. It gives a measurement of the total magnetic field passing through a given surface. Here, the desired area can be of any size and any orientation with respect to the direction of the magnetic field.



## 2.4 MATHEMATICAL DERIVATIVE OF FARADAY'S LAW:-

✓ MATHEMATICAL STATEMENT:



The definition of surface fraction relies on dividing the surface Σ into small surface elements. Each element is associated with a vector dA with the magnitude of the area of the element and the direction perpendicular to the element and pointing "outwards" ( relative to the direction of the surface).

For a loop of wire in a magnetic field, the magnetic flux ΦB is defined for each surface Σ bounded by the given loop. We write the surface as Σ (t) because the wire loop may be moving. Magnetic flux is a surface component.

$$\Phi_B = \iint_{\Sigma(t)} \mathbf{B}(t) \cdot \mathrm{d}\mathbf{A}\,,$$

Where, dA is the surface element of the moving surface Σ (t), B is the magnetic field, and B dA is the vector inner product representing the magnetic flux element through dA. More intuitively, the magnetic flux through a loop of wire is proportional to the number of magnetic field lines that pass through the loop.

When the magnetic flux changes (either due to a change in B or due to motion or deformation of the loop of wire, or both), Faraday's law of induction states that the loop of wire develops an electromotive force. [19]: ch17 [20][21] (Definitions vary in some sources, but this equation is chosen to be consistent with the equations of special relativity.) Make an open circuit, connect a voltmeter to the leads.

According to Faraday's law, electromotive force is also obtained by the rate of change of magnetic flux.

Where, Ɛ is the electromotive force (emf) and ΦB is the magnetic flux.

$$\mathcal{E} = -\frac{\mathrm{d}\Phi_B}{\mathrm{d}t},$$

- The direction of electromotive force is given by Lenz's law.
- The mathematical law of current induction was developed by Franz Ernst Neumann in 1845 [22].
- Faraday's law contains information about the magnitude and direction relationships of its variables. However, the relationship between the directions is not clear. They are hidden in formulas.

You can find the direction of the electromotive force (emf) directly from Faraday's law without reference to Lenz's law. The left-hand rule helps us do this:[23][24]

- Align the curved fingers of your left hand with the ring (yellow line).
- Extend your thumb. The extended thumb points in the n (brown) direction, which is normal to the ring area.
- Find the sign of ΔΦB, the flux change. Determine the initial and final flux (difference ΔΦB) with respect to the normal n, as indicated by the extended thumb.
- If the flux change ΔΦB is positive, the bent finger indicates the direction of the electromotive force (yellow arrow).
- If ΔΦB is negative, the direction of the electric driving force is opposite to the direction of the bent finger (opposite to the yellow arrow).

For a tight coil of wire consisting of N identical turns with the same ΦB, Faraday's law of induction states [25][26]:

$$\mathcal{E} = -N\frac{\mathrm{d}\Phi_B}{\mathrm{d}t}$$

Where, N is the number of wire turns and ΦB is the magnetic flux in a loop.

✓ DIFFERENTIAL & INTEGRAL FORM:

The differential form of Maxwell’s equations can be used to express law enforcement at individual points in space.

$$\int_{\mathbf{loop}} E.ds = -\, d/dt \int_{\mathbf{s}} B.dA$$

We can use Stoke’s theorem on the right-hand side of the equation to equate the integrands,

$$\int_{\mathbf{s}} \nabla.\ E\ dA = -\, d/dt \int_{\mathbf{s}} B.dA$$

Since the theorem holds for any closed surface, the two integrands can be realized as equal and represented as

$$\nabla.\ E = dB/dt$$

## 3. APPLICATIONS OF FARADAYS LAW

Below are the areas where Faraday's law applies.

- Electrical devices such as transformers operate according to Faraday's law.
- An induction cooker works on the basis of mutual induction, which is based on the principle of Faraday's law.
- Electric guitar and electric violin are musical instruments that apply Faraday's law.
- Maxwell's equations are based on the inverse of Faraday's law that changes in the magnetic field lead to changes in the electric field.

# 4. FUTURE RESEARCH

In the next few years, Electromagnets will be used in the medical field. Magnetic resonance imaging, or MRI scanning for short, is a device that uses electromagnets and applies mathematical techniques to scan a patient. "This device can scan every detail of the human body with the help of electromagnetism."

# 5. CONCLUSION

After doing this, Faraday finally concluded that when there is relative motion between a conductor and a magnetic field, the flux linkage with the coil changes and this change in flux creates a voltage in the connected coil.

Faraday's law basically states that "when a magnetic flux or magnetic field changes with time, an electromotive force is produced." In addition, Michael Faraday formulated two laws based on the above experiments.

## *Reference:*

*[1]*. ***Drbal, L., Westra, K., & Boston, P****. (Eds.) 2012 Power plant engineering. Springer Science & Business Media.*

*[2]*. ***Begamudre, R. D****. 2007 Electromechanical Energy Conversion With Dynamics Of Machines. New Age International.*

*[3]*. ***Messerle, H. K., & Messerle, H. K.*** *1995 Magnetohydrodynamic electrical power generation. Chichester, UK: Wiley.*

*[4]*. ***Sheindlin, A. E., Jackson, W. D., Brzozowski, W. S., & Rietjens, L. T.*** *1979 In Natural Resources Forum 3(2) pp 133-145. Oxford, UK: Blackwell Publishing Ltd.*

*[5]*. ***Dhareppagol, V. D., & Saurav, A.*** *2013. Int. J. Adv. Electl. Electrn. Engg. 2 pp 2278-8948.*

*[6]*. ***Petrick, M., Shumi a͡t s͡kiĭ, B. I., & Shumi͡at͡skiĭ, B. I.*** *1978 Open-cycle magnetohydrodynamic electrical power generation. Argonne National Laboratory.*

*[7]*. ***Rosa, R. J.*** *1961 The Physics of Fluids 4(2) pp 182-194.*

*[8]*. ***Sarkar, D.*** *2016 Thermal Power Plant: Pre-Operational Activities. Elsevier.*

*[9]*. ***Bansal, N. K.*** *2014 Non-conventional energy resources. Vikas Publishing House.*

*[10].****Branover, H.*** *1978 Magnetohydrodynamic flow in ducts. hp.*

*[11].****William D. Jackson and G. Ralph Strohl*** *2016 Encyclopædia Britannica, Encyclopædia Britannica, inc., Date Published: March 21, URL: https://www.britannica.com/technology/magnetohydrodynamic-power-generator, Access Date: Sept. 08, 2020*

*[12].****Steg, L., & Sutton, G. W.*** *1960 Astronautics 5.*

*[13].****Kantrowitz, A. R., Brogan, T. R., Rosa, R. J., & Louis, J. F.*** *1962. IRE Transactions on Military Electronics 1 pp 78-83.*

*[14]****.Stewart, W.*** *1966 U.S. Patent No. 3,275,860. Washington, DC: U.S. Patent and Trademark Office.*

*[15].****Bityurin, V. A., Bocharov, A. N., & Lineberry, J. T.*** *1999 In 13th International Conference on MHD Power Generation and High Temperature Technologies 3 pp 12-15 Beijing: IEE CAS.*

*[16].****Bhuvaneswari, S., Thirunavukarasu, P., Avinash, T.*** *2020. Magneto-fluid-dynamics with hall effect and rotation in the presence of magnetic field.*

*[17].****Hartmann, J.*** *(1937) Theory of the Laminar Flow of an Electrically Conductive Liquid in a Homogeneous Magnetic Field. Fys. Med.., 15, 1-27.*

*[18]*. ***Alfven, Hannes*** *(1942). "Existence of electromagnetic–hydrodynamic waves". Nature. 150 (3805): 405–406.Bibcode:1942Natur.150..405A.doi:10.1038/150405do. S2CID 4072220.*

*[19].**Feynman, Richard P**. "The Feynman Lectures on Physics Vol. II". Feynman lectures.Caltech.edu. Retrieved 2020-11-07.*

*[20]. **Griffiths, David J.** (1999). Introduction to Electrodynamics (3rd ed.). Upper Saddle River, NJ: Prentice Hall. pp. 301–303. ISBN 0-13-805326-X.*

*[21].Tipler; Mosca (2004). Physics for Scientists and Engineers. p. 795. ISBN 9780716708100.*

*[22].**Neumann, Franz Ernst** (1846). "Allgemeine Gesetze der inducirten elektrischen Ströme" (PDF). Annalen der Physik. 143 (1): 31Bibcode:1846AnP...143...31N. doi:10.1002/andp.18461430103. Archived from the original (PDF) on 12 March 2020.*

*[23].**Yehuda Salu** (2014). "A Left Hand Rule for Faraday's Law". The Physics Teacher. 52 (1): Bibcode:2014PhTea..52...48S. doi:10.1119/1.4849156. Video Explanation*

*[24]. **Salu, Yehuda.** "Bypassing Lenz's Rule - A Left Hand Rule for Faraday's Law". www.PhysicsForArchitects.com. Archived from the original on 7 May 2020. Retrieved 30 July 2017.*

*[25]. **Whelan, P. M.; Hodgeson, M. J.** (1978). Essential Principles of Physics (2nd ed.). John Murray. ISBN 0-7195-3382-1.*

*[26]. **Nave, Carl R.** "Faraday's Law". HyperPhysics. Georgia State University. Retrieved 2011-08-29.*