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Prospects of MHD Generation in Bangladesh

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ABSTRACT
The production, conservation and management of energy is the challenging issues for any country, like in Bangladesh it is more. Energy resources are finite but our demand is too high. So a gap between supply and demand is seen. In this paper we propose some feasibility analysis of MHD generation in Bangladesh. Magneto-hydrodynamics (MHD) electric generator works on the principle that any conductor that is moved through a magnetic field will generate electricity. MHD generation is based on electromotive force explained by Faraday's induction law. This paper emphasizes on the feasibility of developing MHD generator in which the working fluid is natural gas, coal fired gas, and flowing salt water can be used to generate electricity. This proposed plant is also used in combined power plants not only used for generating large amount of power but also for increasing efficiency of the plant.

Keywords **-** Bay of Bengal Ocean, coal fired MHD, Lorentz Force Law, magneto hydrodynamics, natural gas, seawater.

I. INTRODUCTION

The deficit of electric power generation capacity in Bangladesh is due to the shortage of natural fuel. Day by day the demand of power increases but the production fail to meet the demand has resulted to an energy crisis in Bangladesh. To mitigate the demand we need to find out alternative energy source for a stable energy supply and sustainable development to the country. In the developed countries like U.S.A, Japan is widely using the MHD generator. On the other hand in the developing countries like Brazil, India MHD generator is still under construction. Bangladesh is not familiar with MHD generating yet, but it's has great prospectus in Bangladesh.

II. MAGNETO-HYDRODYNAMIC (MHD) GENERATOR

Magneto-hydrodynamics (MHD) generator is a device using magneto-hydrodynamic principles to generate electric power directly from gases. In the generator, a hot gas is passed through an intense magnetic field; a pair of collector plates picks up electrons from the ionized gas [1].

The MHD generation process is based on Faraday's electro-magnetic induction law. So Magneto-hydrodynamic generator generates thermal energy or kinetic energy of a moving conducting fluid into directly electrical energy. Examples of such kind of fluids are ionized gas, plasma, liquid metals, and seawater. It's a plasma technology. The gas is continuously seeded with potassium nitrate, making the gas electrically conductive at lower temperatures. The alkali metal ionizes easily at lower temperatures. MHD generators are different from conventional electric generators in that they can operate at high temperatures without moving parts. In figure 1 MHD generation arrangement and process is shown.

Since 1970, several countries have undertaken MHD research programs with a particular emphasis on the use of coal as a fuel. MHD power plants offer the potential for large-scale electrical power generation with reduced impact on the environment. MHD generators are also attractive for the production of large electrical power pulses. [2].

In accordance with the working fluid and the anticipated heat source, MHD generators are distinguished as: open cycle MHD generators operated on combustion products of various fossil fuels; closed cycle MHD generators working on noble gases, and liquid metal MHD generators and working fluid is recycled to the sources. The main types of MHD systems are Coal-fired MHD systems, natural gas as a fossil fuel source. Conventional nuclear reactors can employ hydrogen, or a noble gas such as argon or helium, as the working fluid, but they operate at temperatures that are too low to produce the thermal ionization used in MHD generators. Thus, some form of no equilibrium ionization using seeding material is necessary [2].

III. WORKING PRINCIPLE OF MAGNETO HYDRODYNAMICS GENERATION:

In accordance with Faraday's induction law, when an electric conductor is moved so as to cut lines of magnetic induction, the charged particles in the conductor experience a force in a direction mutually perpendicular to the B field and to the velocity of the conductor. The negative charges tend to move in one direction and the positive charges in

the opposite direction. This induced electric field or motional EMF provides the basis for converting mechanical energy into electrical energy.

In an MHD generator the hot gas or fluid is accelerated by a nozzle and injected into a channel. A powerful magnetic field is set up across the channel. So by the Faraday's law of induction, an electric field is established that acts in a direction perpendicular to both the gas flow and the magnetic field. The walls of the channel parallel to the magnetic field serve as electrodes and enable the generator to provide an electric current to an external circuit, which is shown in figure 1.

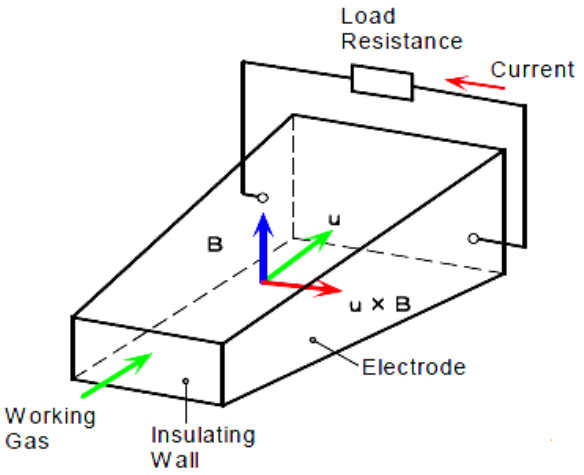

Figure 1: Basic principle of MHD generation [3]

For magneto hydrodynamic power generation, the solid conductor of a conventional generator is replaced by a fluid conductor. The fluid can be a liquid metal or heated and seeded noble gas. In an open cycle MHD generator, a fossil fuel, burnt in oxygen or preheated compressed air, is seeded with an element of low ionization (such as potassium or calcium). The interaction between the moving conducting fluid and the strong applied magnetic fluid across it generates an E.M.F on the Faraday principle.

The power output of an MHD generator for each cubic meter of its channel volume is proportional to the product of the gas conductivity, the square of the gas velocity, and the square of the strength of the magnetic field through which the gas passes. For MHD generators to operate competitively with good performance and reasonable physical dimensions, the electrical conductivity of the plasma must be in a temperature range above about 1800K [4]. The turbine blades of a gas-turbine power system are unable to operate at such temperatures. An adequate value of electrical conductivity—10 to 50 Siemens per meter—can be achieved if an additive, typically about 1 percent by mass, is injected into the hot gas. This additive is a readily ionizable alkali material, such as cesium, potassium carbonate, or sodium, and is referred to as the "seed." [2].

The power output per unit fluid volume (W) is given by

$$W = K\sigma u^2 B^2$$

Where,

σ = Conductivity
u = Velocity of fluid
B = Magnetic flux density
K is a constant.

Underlying the MHD body force is the fact that free charges moving in a magnetic field experience a "Lorentz" force perpendicular to both their velocity and the magnetic field induction. The simplest form of this law is given by the vector equation

$$F = Q.(u \times B)$$

Where,

F = Force acting on the particle, the vector F is perpendicular to both v and B according to the right hand rule.
Q = Charge on the particle
u = Velocity of particle
B =Magnetic field.

In a closed-cycle system of MHD, the fluid is continuously re-circulated through a compressor. According to the benefits of combined cycle, the number and output power of such cycles have increased recently. Higher efficiencies of combined cycle compared to Brayton or Rankine cycles have made them quite attractive for power generation. Based on these advantages and less emissions, combined cycle power plants have widely been used all around the world. Our proposed MHD generator is one whose fluid conductor is gas or seawater. This is because of the huge deposit of natural gas and abundance of salt water in Bay of Bengal. MHD is suitable to meet high short-term demands and this of course is a non - renewable source and has a major drawback of which air pollution is the lead.

IV. POSSIBILITY OF MHD GENERATION IN BANGLADESH

4.1 USING NATURAL GAS

Under high pressure condition, an electrically conducting gas is produced by burning a natural gas fuel and passed through a nozzle at a high speed of 1000 to 2000 meter per second. The hot gas enters into the channel through a strong magnetic field is applied with the help of superconducting magnets. As the gas passes through the channel, an electromotive force is experienced by it. According to the Faraday's law of electromagnetic induction current/voltage (EMF) is induced in a coil/wire whenever there is a change in the magnetic flux linked with the coil.

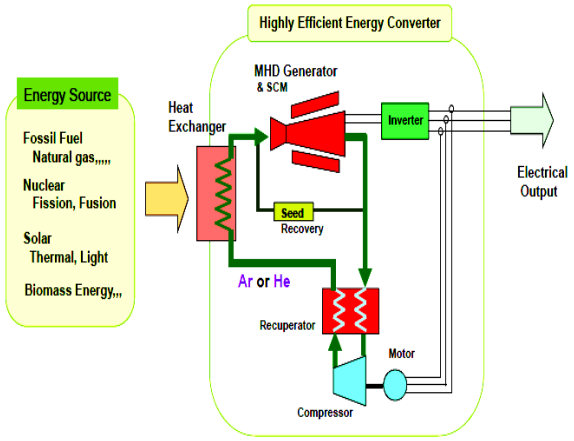

Figure 2: open cycle fossil fuel MHD generation [3]

In Bangladesh natural gas is one of the principle natural sources of energy. The total gas initially in place (GIIP) in these 23 fields is about 29 Tcf, of which about 16.59 Tcf is considered recoverable as of January 2012[5]. The average chemical compositions are 97.33% methane, 1.72% ethane, 0.35% propane and 0.19% higher hydrocarbons. So it has great possibility of MHD generation in Bangladesh.

4.2 USING SEAWATER

Seawater MHD generation is a unique system that transforms the kinetic energy of seawater flow into electric energy and also generates hydrogen gas as a by-product. An electric current is passed through seawater in the presence of an intense magnetic field. In MHD generation, applied magnetics field is an important factor for the generator output and efficiency. At this situation helical-type seawater MHD generator can be used [6].

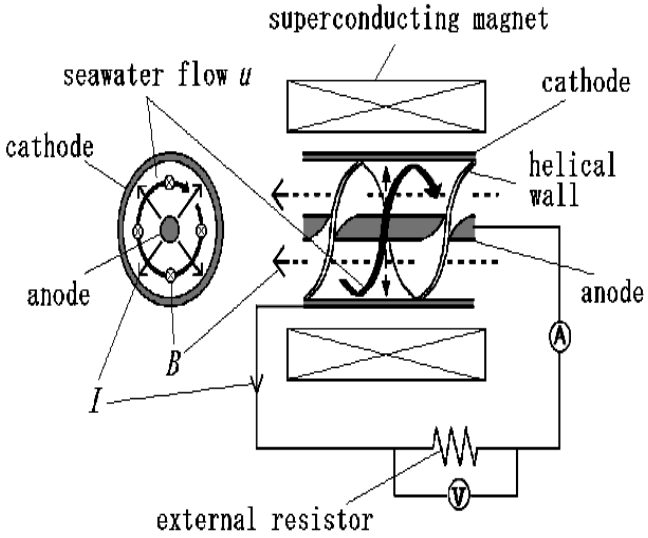

Figure 3: Helical-type seawater MHD generation [6].
Functionally, the seawater like a moving, conductive part. MHD generation needs the motion of a conducting fluid such as seawater.

Table 1: Characteristic Magnetic diffusivities D_M, decay times τ_M and Magnetic Reynolds Numbers R_M for some common MHD owes with characteristic length scales L and velocities V [7].

Substance	L, m	V, m s^{-1}	D_M, m^2 s^{-1}	τ_M, s	R_M
Mercury	0.1	0.1	1	0.01	0.01
Liquid Sodium	0.1	0.1	0.1	0.1	0.1
Laboratory Plasma	1	100	10	0.1	10
Earth's Core	10^7	0.1	1	10^{14}	10^6
Interstellar Gas	10^{17}	10^3	10^3	10^{31}	10^{17}

The existence of the Bay of Bengal in Bangladesh makes it an impressive method of power generation in the country. For the MHD generating from seawater, the necessary physical requirement of high conductivity and flow speed of fluid will be estimated. We think need some analysis about chemical composition of seawater and survey in Bangladesh.

4.3 COAL FIRED MHD SYATEM

In the burner coal is fired utilizing pure oxygen and recycled Co_2 as an oxidizer. Almost pure Co_2 at high temperature is obtained. In order to increase electrical conductivity, this gas is seeded by means of potassium carbonate. Afterwards it expands in the MHD channel. Part of the heat of the gas which leaves the channel, is utilized to warm up the oxidizer in a high heat exchanger then the gas is injected into the boiler and transfers the residual thermal energy to a conventional steam cycle [5]. It's also called combined plant. The coal deposit in Bangladesh is referable. It has great potential to use in diverse sector in Bangladesh. The MHD-steam combined cycle power plant could increase the efficiency up to 50-60%, which will result in a fuel saving of about 35%. If the new coal based plant is built and Co_2 emission can be minimize then it is possible to establish coal-fired MHD plant in the near future in Bangladesh.

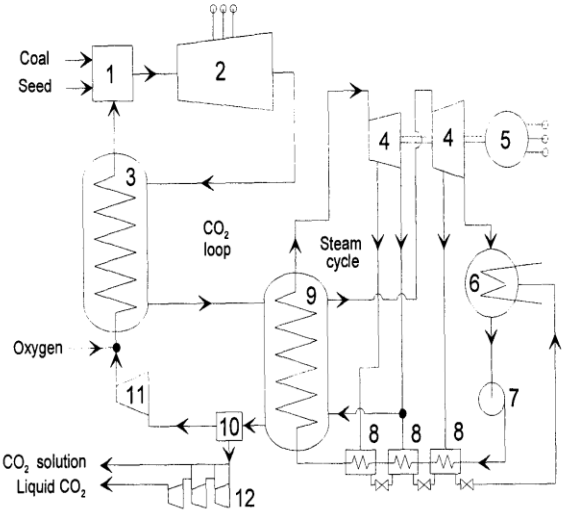

Figure 4 Schematic Diagram of the Plant [8].

V. CONCLUSION

We analyze about the feasibility of MHD system of generating electricity in Bangladesh using seawater, natural gas and coal fired MHD combined system. Since the availability of natural gas in Bangladesh, it would be possible to combine steam and MHD system and same as for the coal fired plant. We have considered the feasibility of generating electricity in Bangladesh using seawater from a source such as the Bay of Bengal and the coastal area river. Our proposed MHD system is free from moving parts like blades and it wouldn't be hazard for the ecosystems of sea. The fact is that the water used in this system is returned to sea eventually. The absence of greenhouse emissions it will be environment friendly if engineering design of MHD system is done properly. Such we integrate this proposed system with tidal energy extraction plant. However the MHD generation of electricity in Bangladesh has much potentiality. We think, need more investigations about our proposed medium of fluid and gas's chemical composition for MHD generation in Bangladesh.

VI. ACKNOWLWDGEMENT

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References:

[1] Stan Gibilisco ,*The Illustrated Dictionary of Electronics* (Eighth Edition)
[2] Encyclopedia Britannica: http://www.britannica.com/EBchecked/topic/357424/magnetohydrodynamic-power-generator#toc45897
[3] *Research Activities on MHD Power Generation at Tokyo Institute of Technology, Yoshihiro OKUNO*, (Department of Energy Sciences, Tokyo Institute of Technology.)
[4] Roberto Pintus, *Development of Inductive Magnetohydrodynamic Generator*, Page No. 15.
[5] *Ministry of Power, Energy and Mineral resources*: http://www.powercell.gov.bd/
[6] Yasuaki Okuji, Teruhiko Akazawa, Xiaojun Liu, and Tsukasa Kiyoshi;" Fundamental Studies of Helical-Type Seawater MHD Generation System, Minoru Takeda", *IEEE Transactions on applied superconductivity, vol. 15, no. 2, June*
[7] Roger D. Blandford and Kip S. Thorne, *Applications of Classical Physics*, (California Institute of Technology, Version 0418.1.K.pdf, 02 March 2005) Table: 18.1
[8] Carlo A. Borghi, Department of Electrical Engineering, University of Bologna, Viale, Risorgimento 2, 1-40136 Bologna, Italy and Motoo Ishikawa, The Department of Electrical engineering, Kyoto University, Yoshida-Honmachi, Sakyo-ku, Kyoto 606-01, Japan; "*New Concept of MHD Power Generation"*.