ISSN: 2186-8476, ISSN: 2186-8468 Print
Vol. 1 No. 4, December 2012

MAGNETO HYDRODYNAMICS POWER GENERATION USING SALT WATER

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ABSTRACT

Magneto hydrodynamics (MHD) is the study of the dynamics of electrically conducting fluids such as salt water. The principle of operation of MHD power generator is based on Faraday's induction law. This work concerns the feasibility of developing MHD generator in which the working fluid is flowing salt water, such that a resource like the Atlantic Ocean in Nigeria can be used to generate electricity. Furthermore, the practical possibility of MHD in Nmahi River in Uburu, Ebonyi State can also be explored. Estimates of the amount of salt in the Atlantic put it at $6.4 \times 10^{-4} \frac{mol}{m^3}$. *with this and a channel of a kilometer width accommodating a flow speed of 50ms^{-1}, a voltage of about 32V/mol is estimated feasible. The possibility of stacking the output of many such systems in series and the absence of many disadvantages associated with non-renewable methods of electric power generation should make MHD using flowing salt water a very attractive alternative for energy generation in Nigeria.*

Keywords: Magneto hydrodynamics, Nmahi River, Atlantic Ocean, Lorentz Force Law, Salt water

INTRODUCTION

The continual decline in supply of conventional energy in Nigeria due to the depletion of fossil fuel reserves as the demand for power continues to increase has resulted to an energy crisis with epileptic power supply, rising cost of production and food prices and threat to poverty reduction as its effects. There is therefore the need for an alternative energy source for a stable energy supply and sustainable development to be achieved.

Magneto hydrodynamics (MHD) is the study of the dynamics of electrically conducting fluids such as plasma, liquid metal and salt water. In advanced countries, MHD generators are widely used but in developing countries like India, it is still under construction. MHD can be classified according to the working fluid and the anticipated heat source. Open – cycle MHD generators operate with the products of combustion of fossil fuels. In a Closed MHD system, the working fluid is recycled to the sources and thus re used (Ferdous et al, 2011).

PRINCIPLE OF MAGNETO HYDRODYNAMIC POWER GENERATION

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. At present, nearly all electrical power generators utilize solid conductors which are caused to rotate between the poles of a magnet. In the case of hydroelectric generators, the energy required to maintain the rotation is supplied by the gravitational motion of river water. Turbo generators, on the other hand, generally operate using a high-speed flow of steam or other gas. The heat source required to produce the high speed gas flow may be supplied by the combustion of a fossil fuel or by a nuclear reactor.

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 caesium). This element is thermally ionized at the combustion temperature (usually over 2500K) producing sufficient free electrons eg ($K \rightarrow K^+ + e$) to produce adequate electrical conductivity. 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 per unit fluid volume (W) is given by

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

Where

σ stands for the conductivity

v stands for its velocity

B stands for the magnetic flux density

K is a constant.

The Lorentz force law describes the effects of a charged particle moving in a constant magnetic field. The simplest form of this law is given by the vector equation

$$F = Q \cdot (v \times B)$$

Where

F stands for the force acting on the particle

Q stands for the charge on the particle

V stands for the velocity

B stands for the magnetic field.

The vector F is perpendicular to both v and B according to the right hand rule.

In a closed-cycle system of MHD, the fluid is continuously re circulated through a compressor; the fluid consists of a heated and seeded noble gas or liquid metal.

Our proposed MHD generator is one whose fluid conductor is salt water. This is because of the huge abundance of salt water –Atlantic Ocean in Nigeria. MHD is suitable to meet high short-term demands. Nigeria is highly dependent on fossil fuels for power generation. This of course is a non - renewable source and has a major drawback of which air pollution is the lead. Harnessing power by employing an MHD generator with salt water as its fluid conductor is hugely advantageous in that the source is renewable, it requires no external energy input to facilitate its operation, it has no moving parts and as such does not contribute to mortality of aquatic organisms and finally, it does not pose problems of pollution.

Feasibility of MHD Generation in Nigeria Using Salt Water

MHD generation only requires the motion of a conducting fluid such as sea water. Thus the presence of the Atlantic in Nigeria makes it a viable method of power generation in the country, in as much as the necessary physical conditions of high conductivity and flow speed can be met. But while the latter can be solved by a suitable engineering design, we must be a bit conservative about the former.

The reasons for this conservatism may be apparent from a few observations. First, initial estimates may suggest the practicality of the method, yet it must be noted that only the simplistic Lorentz force law coupled with the definition of work, which leads to an estimate of motional EMF in a medium such as flowing salt water, which contains charged ions, has been used in obtaining this estimate. In-depth analysis requires a consideration of both the Navier-Stokes equation and the Maxwell's law of electromagnetism in addition to the Lorentz force law. Second, research in other places on sea water has shown that MHD has exclusively been in respect of developing high-speed boats that exploit the Lorentz force law by sending intense electric currents into the surrounding sea water, while MHD electric power generation has been exclusively restricted to the use of plasma. So if it turns out that the reason for this is that sea water just isn't conducting enough on the basis of other considerations that go deeper than the Lorentz force Law, we cannot do much, since any attempt to adjust the conductivity of the sea water would alter its salinity, which is not advisable for the reasons of conservation of the natural habitat.

Putting all this into perspective, therefore, it should be said that more research is needed to decide on the feasibility of the method, which we shall undertake in the sequel to the present paper. However, encouraging in this regard is that U-tube demonstrations have shown small-scale successes in France and England using the method, although demonstrations are in controlled environments and the voltages shown in the demonstrations are terribly fluctuating.

CONCLUSION

We have considered the feasibility of generating electricity in Nigeria using salt water MHD from a source such as the Atlantic Ocean and the Nmahi River in Uburu, Ebonyi State. We have seen that the advantages of MHD power generation using the system proposed in this paper include the absence of moving parts such as blades which may constitute hazard to swimming sea life, the absence of green house emissions, the fact that water used is returned to sea eventually, thereby not altering the ecosystem and the obvious implication of reducing dependence on conventional fossil fuels, which not only cuts back on carbon and other emissions, but also ensures the longevity of our fossil fuel reserve. The downside of it is that only the Lorentz force law coupled with the definition of work, which leads to an estimate of motional EMF in a medium such as flowing salt water, which contains charged ions, has been invoked. Certain other problems, however, naturally present themselves for consideration. They include the problem of magnetic reconnection and a fluid thermal gradient which creates eddies in the charged moving fluid, dissipating the energy of the system. Clearly, all these must be considered in relation to the conductivity of the working fluid – here salt water from the Atlantic Ocean. We therefore propose to take up these problems in the sequel to this paper, titled "Magneto hydrodynamics power Generation using salt water II"

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