Performance of Magneto Hydro Dynamic (MHD) as a Power Generation Support Tool

Wiwik Purwati W*[(1)], Slamet Priyo Atmojo[(2)], Margana[(3)], Suwarti [(4)], Budhi Prasetiyo[(5)], Ikhwatinah Khoiroh[(6)]
[1,2,3,4,5] *Department of Mechanical Engineering, Semarang State Polytechnic, Semarang, Indonesia*
[6]*Departement of Mechanical Engineering, National Kaohsiung University of Science and Technology, Kaohsiung, Taiwan*
Email address: ***wiwikpurwatiwidyaningsih@gmail.com**

Abstract*— Magnetohydrodynamics is a method for generating electricity by utilizing the interaction between a magnetic field and an electrolyte fluid. MHD components: salt water electrolyte, Neodymium N52 magnet, and Cu-Zn electrode. The MHD used is a coarse salt water electrolyte. The purpose of the MHD model is as an innovative technological breakthrough that is used to support increasing the efficiency of the power generation system. The lowest efficiency is shown in the second data with variations in salt content of the 5 grams/liter experiment without MHD support, which is 0.08%. The highest efficiency is shown in the twentieth data with variations in salt content of the 95 gram/liter experiment supported by MHD, which is 0.59%. The maximum efficiency increase that can be achieved is 0.37% with variations in salt content of 60 grams/liter.

Keywords—Magneto Hydro Dynamic, Power generation.

I. INTRODUCTION

Magnetohydrodynamic (MHD) or MHD Power generation is the movement and electrical delivery of fluids in a magnetic field. The fluids used are salt water, plasma, molten metal. In 1831 Michael Faraday tested MHD Power generation trials and the results showed that liquids have conductor properties, then in 1942 it was continued by Karlovitz and Halacz. In 1959 AVCO in the USA tested a trial of MHD Power generation using argon plasma with successful results. The basis of MHD conversion is by volume process, thereby the size of the MHD is increased so that the ratio of converted power to power losses from the wall surface becomes better.

The process of converting potential energy into electrical energy through a mechanical conversion process suffers a lot of losses. Based on this, the technology of photovoltaic generation systems (photovoltaic solar cells), electrochemical energy conversion (fuel cells), magneto hydro dynamic generation (MHD), electro gas dynamic generation (EGD), and thermoelectric power generation was developed [8]. The electrical energy generation system, potential energy or thermal energy is first converted into mechanical energy, then mechanical energy is converted into electrical energy. MHD is a reliable power generation technology in the future because MHD can be combined with other power plants (PLTU and PLTG).

MHD's performance as a power generation is electrolyte fluid (salt water) which is pumped across the micro-hydro generator turbine and passes through the MHD duct. This electrolyte fluid will collide with the magnetic field lines formed by the magnets that are placed opposite each other, and the electromotive force will be captured by the electrodes that are mounted opposite each other on the other side. MHD is a substitute for the electromagnetic process in an electric generator. Data retrieval is carried out by comparing the results of electricity without MHD support and with MHD support to prove whether the use of MHD can increase efficiency or not.

The induced electric field is a vector with the velocity and magnetic field can be calculated using the following equation [12]:

$$E_{ind} = v \times B \quad \text{..... (1)}$$

Description:

E_{ind} = Induced emf $(\frac{Volt}{meter})$

v = Velocity $(\frac{m}{s})$

B = Magnetic field (Tesla)

The voltage can yield a load current on resistance ®. Current conductor in a magnetic field will result a force on the conductor, the magnitude of the force [12]:

$$F = I \times B \ (\frac{Newton}{meter}) \quad \text{..... (2)}$$

Description:

F = Lorentz force $(\frac{Newton}{meter})$

I = Electric Current (Ampere)

B = Magnetic field (Tesla)

MHD models are:

Faraday Generator: The concept of the MHD generator was introduced by Michael Faraday, experiments were carried out with the Waterloo Bridge, England, to measure the current caused by the flow of the Thames to the earth's magnetic field. The Faraday model is the basic model that is commonly used.

Plasma: Hall generator is an extension of the Faraday generator with segmented electrode configurations. Faraday generator resistance is used a lot, in this generator resistance is directly connected to the first electrode and the last electrode of the line. This can be realized because the hall effect, which causes an electric field with a velocity parallel to the plasma, if not utilized, will be wasted [8].

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Disk Generator : It is an integrated MHD model and has the highest efficiency level. The generator disk has a tunnel / duct wrapped around the edges as shown in Figure 1, and the working fluid passes through the middle of the disk. Another advantage of this design is that the application of the magnetic field is more efficient, has a parallel field configuration, and the working fluid is processed in the magnetic disk closer so that the magnetic strength increases.

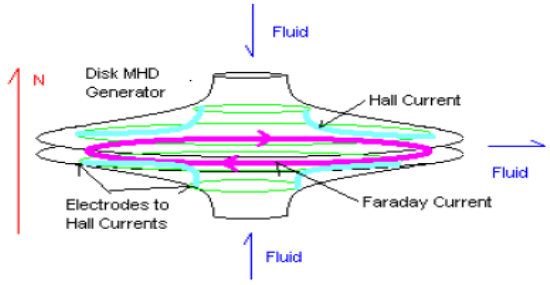

Fig. 1. Disk Generator.
Source: [8]

The working fluid cycle in the MHD is:

Open Cycle: The main fuel is burned in the combustion chamber with high pressure and temperature of 2300-2700 °C. Compressed air with fuel burning > 1000 °C. The hot gas from the combustion is injected with potassium carbonate/caesium ions to increase the electrical conductivity of the gas. The hot exhaust gas is reused with the Heat Recovery Steam Generator to obtain steam to turn the steam turbine [7]

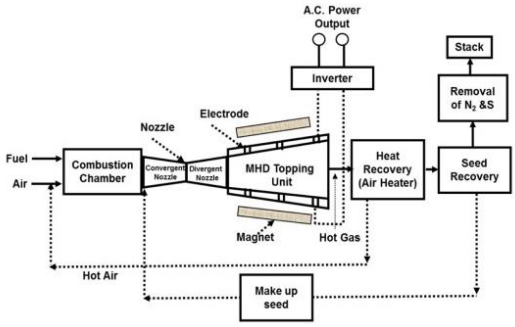

Fig. 2 Open Cycle

Source: [15]

Closed Cycle: The inert gas is heated in a heat exchanger 1 to about 2000 °C and seeded with cesium to be ionized and passed through the MHD duct to result DC electricity. The hot gas from the MHD duct is reused to yield steam by a heat exchanger. Combustion products are sent to the chimney after reducing the thermal energy by heat exchanger 1 [7]. A closed cycle system can result in 200 MW of power and an efficiency of 60% [8].

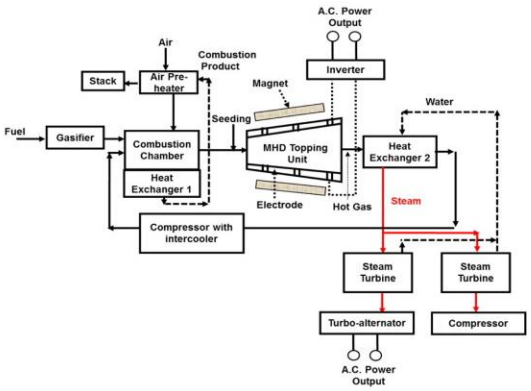

Fig. 3. Closed Cycle System
Source: [15]

The main requirement for the MHD working fluid is to be able to conduct electrical ions in order to yield electromotive force in a magnetic field. Several types of MHD working fluids include:

Plasma: It is an electrically neutral medium of unbound positive and negative particles, they are not "free" meaning they are not affected by forces. The moving charged particles yield an electric current in a magnetic field, each movement of the plasma particles affects and is influenced by the field created by other charges [5].

Liquid Metal: A mixture of chemical compounds with a low melting point. The most famous are mercury (Hg) melting point > 234.3 K. Cesium (Cs) melting point 301.5 K, Rubidium (Rb) 302 K, Francium (Fr) 300 K, and Gallium (Ga) 303 K. Advantages Another feature of the liquid alloy system is its high density [4]. .

Salt Water Electrolyte: Salt consists of a strong acid and a strong base that is neutral in nature and has a neutral pH of 7. Salinity is part of the physical and chemical properties of water (salt), in addition to temperature, pH, substrate and others. Salinity is affected by tides, rainfall, evaporation, precipitation and topography in waters [6].

Solution: A homogeneous mixture of substances, the composition evenly distributed throughout the volume. The solute is the component in a small amount, the solvent is the component in the large amount. Salt is an ionic compound consisting of positive ions (cations/basic compounds) and negative ions (anions/acidic compounds), thus forming neutral compounds (without charge).

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Ions in an electrolyte solution can be yield in two ways, that is:

1. The solute is an ionic compound: $NaCl_{(s)}$ + water $\longrightarrow$ $Na^{+}_{(aq)} + Cl^{-}_{(aq)}$

2. The solutes are not ionic compounds when dissolved in water:

$HCl_{(g)}$ + water $\longrightarrow$ $H^{+}_{(aq)} + Cl^{-}_{(aq)}$

Electrolytes are generally in the form of acids, bases or salts. Certain gases can function as electrolytes under certain conditions, for example at high temperatures or low pressures. Electrolytes are compounds with polar ionic and covalent bonds. Strong electrolytes are identical to strong acids, bases and salts [14].

Based on the type of magnets they are divided into three, it is permanent magnets, non-permanent magnets and artificial magnets:

1. Fixed Magnet: Does not require power to yield magnetic power
   Neodymium Magnets (Neo): The most powerful permanent magnets. The MHD Neo has a magnetic strength of 1.44 Tesla, a total area of 1.8 x 10-3m2 and a flux of 2.592 x 10-3 Weber.
   Samarium-Cobalt Magnets: Made of an alloy of samarium and cobalt.
2. No-permanentMagnets (remanent): Depends on the electric field to yield a magnetic field. An example of a non-permanent magnet is an electromagnet.
3. Artificial Magnets: Made by humans with the main materials iron and steel. Examples include U magnets, horseshoe magnets, circular magnets and bar magnets.

II. RESEARCH METHODS

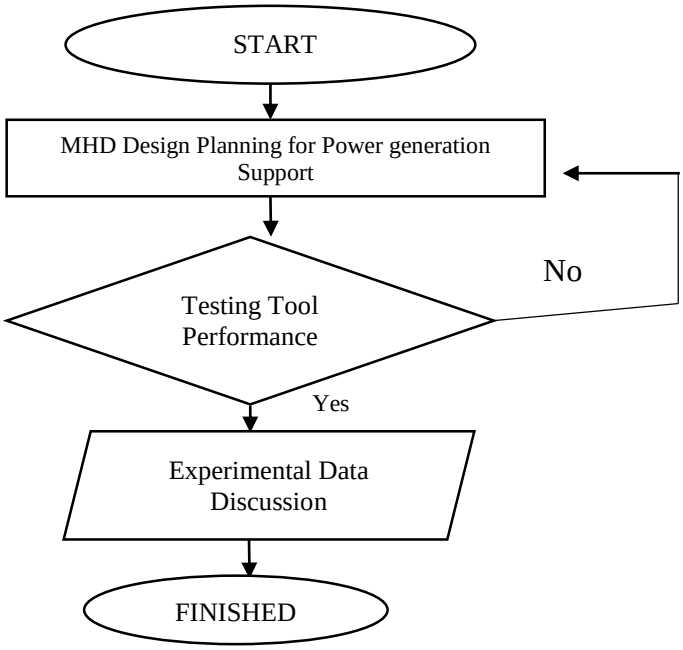

Fig. 4. Research Flowchart

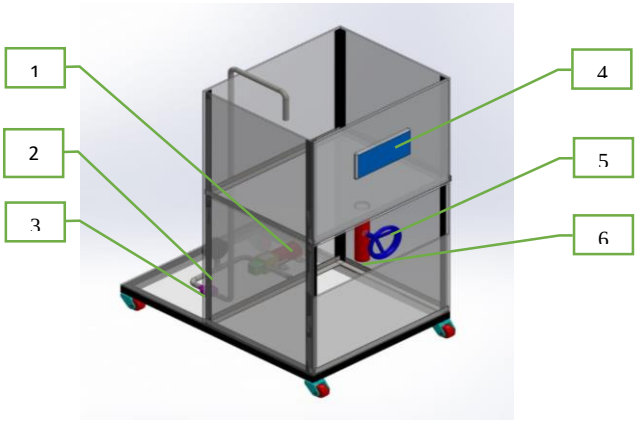

Fig. 5. MHD Simulation Design

Description:
(1) Power Pump 36 Watt Pressure 80 Psi Discharge 3,1 $\frac{\text{Liter}}{\text{s}}$
(2) *Pressure Gauge*
(3) Micro Hydro Turbine Generator
(4) Electrical Panel
(5) Valve
(6) MHD *Duct*

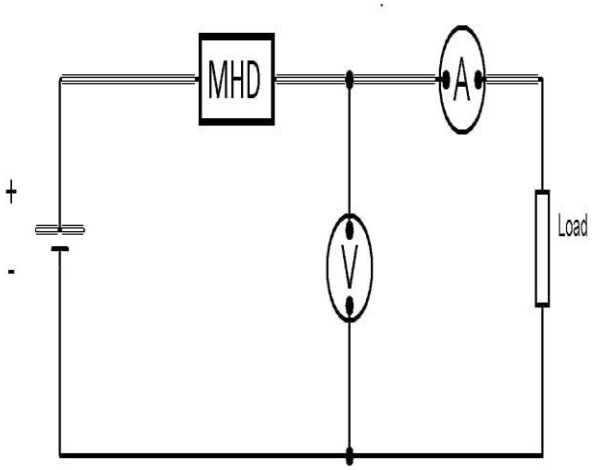

Fig. 6. MHD Electrical Circuit

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III. RESULTS AND DISCUSSION

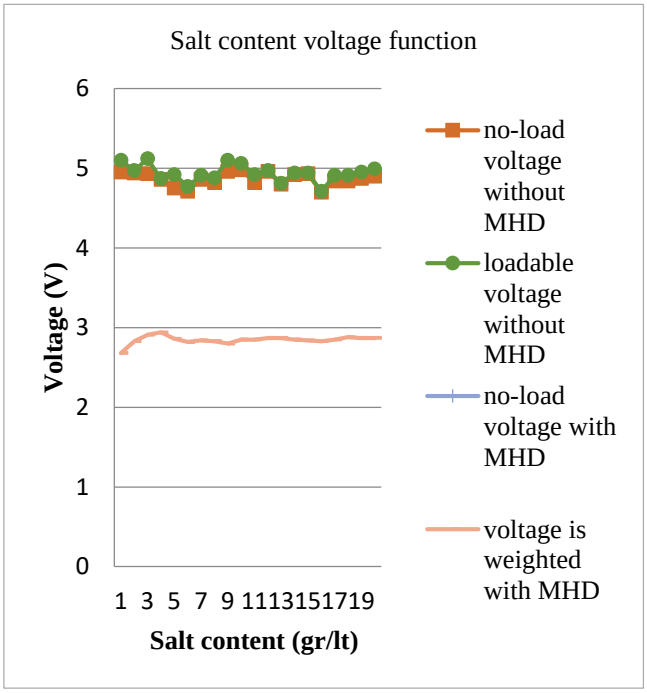

Fig. 7. Voltage function of salt content

Without a low-voltage MHD, this is due to the absence of a magnetic field. The presence of the MHD voltage becomes more constant. After being given a load, the voltage in the circuit without MHD is unstable, while with MHD the voltage becomes more constant.

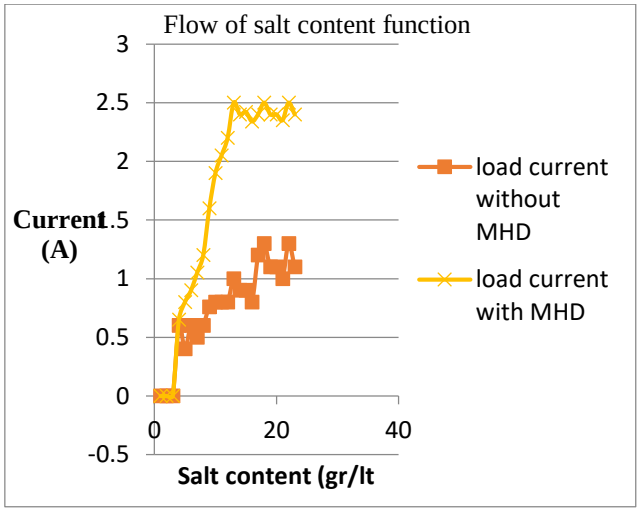

Fig. 8. Function of flow salt content

The graph above shows that the load current without MHD did not increase significantly even though the salt content was increased, with the load current MHD increasing with the addition of salt content. The more salt content, the more electrons will hit the magnetic field. In accordance with the Lorenz force F = B x I, the more salt content the collision between electrons and magnetic field lines has reached its maximum point due to the small magnetic area so that the magnetic field that is pounded is limited.

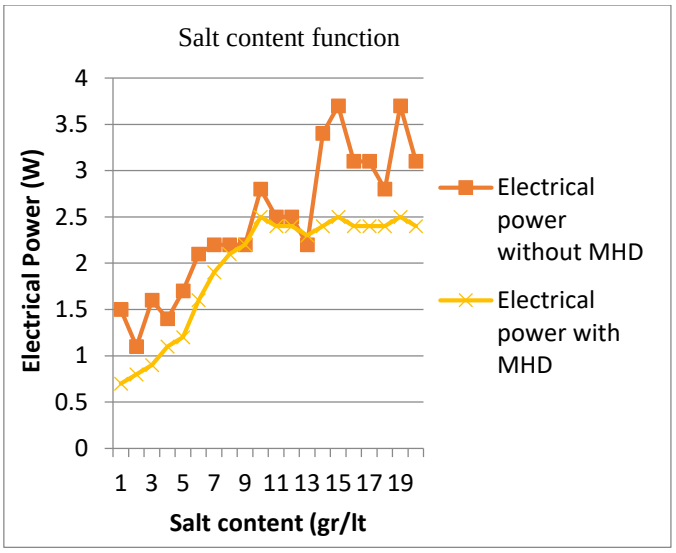

Fig. 9. Functional power of salt content

The higher the salt content, the higher the current, supported by MHD the electric power increases as the electric current increases. When the current increases the power increases because I is proportional to P. In the electric power graph after being supported by MHD with 45 gram/liter salt content and after, the current yield is constant due to the limited magnetic field so that the electric power shows a trend that tends to be flat.

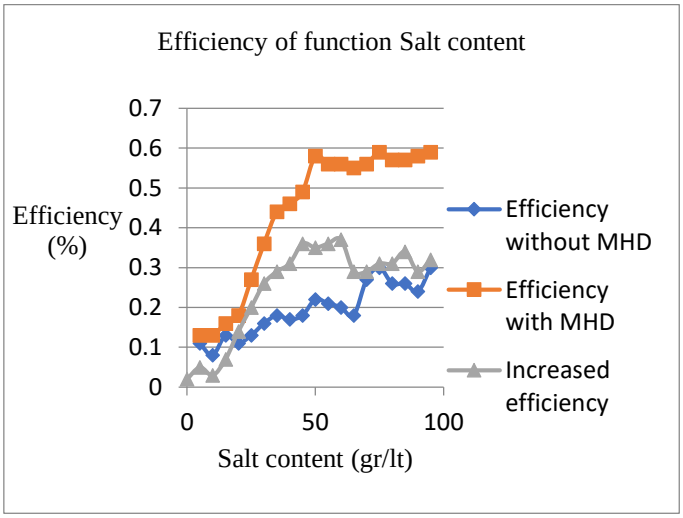

Fig. 10. Efficiency of salt content function

The relationship between efficiency and salt content shows that without MHD tends to be straight/constant, salt content does not significantly affect electrical efficiency. The lowest efficiency without MHD is 0.08% with a salt content of 5 g/lt and the highest is 0.30% with a salt content of 90 g/lt. Meanwhile, with MHD, it can be seen that the linear graph increases, due to the increase in the electrical power yield. The lowest efficiency is 0.13% with a salt content of 5 gr/lt and the highest is 0.59% with a salt content of 95 gr/lt. The biggest increase that can be achieved is 0.37% which is shown in the nineteenth experiment with a variation of 60% salt content.

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IV. CONCLUSSION

1. MHD utilizes the waste fluid yield by the micro hydro generator turbine where the exhaust flow hits the magnetic field lines of force so that it increases the electrical power resulted and increases efficiency.
2. MHD can increase the amount of voltage yield, it is 2.54 Volts to 5.12 Volts for the zero load experiment and in the load experiment, the voltage increases from 2.78 Volts to 2.94 Volts.
3. MHD can increase the amount of electric current yield from 1.3 milliamps to 2.5 milliamps with a salt content of 90 grams/liter.
4. MHD can increase the amount of electrical power yield from 3.67 milli Watts to 7.2 milli Watts with a salt content of 90 grams/liter.
5. MHD increases the efficiency of the power generation system with a salt content of 60 grams/liter, from 0.18% to 0.55%, resulting in an efficiency increase of 0.37%.

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