Abstract. As increasing of agricultural and industrial activities each year has led to an increasing in demand for energy. Possibility in the future, the country was not able to offer a lot of energy and power demand. This means that we need to focus on renewable energy to supply the demand for energy. Energy harvesting is among a method that can contribute on the renewable energy. MHD power generator is a new way to harvest the energy especially Ocean wave energy. An experimental investigation was conducted to explore performance of MHD generator. The effect of intensity of NaCl Solution (Sea Water), flow rate of NaCl solution, magnetic strength and magnet position to the current produce was analyzed. The result shows that each factor is give a significant effect to the current produce, because of that each factor need to consider on develop of MHD generator to harvest the wave energy as an alternative way to support the demand for energy.

1. Introduction
Magneto hydro dynamic (MHD) is the study of the dynamics of electrically conducting fluid. The word MHD is derived from magneto meaning magnetic field, hydro meaning liquid and dynamic meaning movement (Vishal. D. Dhareppagol, 2013). The fundamental concept behind MHD is the magnetic field can induce currents in moving conductive fluid, which in turns creates force on the fluid and also changes the magnetic field itself. The generator used in this process is called Magneto Hydro Dynamic (MHD) Power Generator. MHD power generator don't have any mechanical part to produce current and the actual conductor are replaced by magneto-fluid (plasmas gas, liquid metals, and salt water).

In conventional turbine generator, the rotation of rotor inside the turbogenerator will cut the magnetic flux and the current will produce perpendicular to the magnetic field. The principal of MHD power generator also similar with conventional turbine generator which is the moving fluid (plasmas gas, liquid metals, and salt water) move pass through the magnetic fields, the voltage is induced in the conductor, which results in flow of current across the terminals that are parallel and opposite to each other (A.R Kantrowitz, 1962) as shown in figure 1.0. This principle knows as Faraday’s law of electromagnetic induction.
The potential of MHD generator as a method on Renewable energy is very high, because there are many advantages of this system if compare to others type of generator. It is seen that the MHD generator operates in a manner similar to that of a conventional generator in that the "armature" of the MHD is a hot, high-speed electrically-conducting gas, while the force or torque-required to move a metallic conductor through a field is replaced by a pressure gradient in the gaseous armature (A.R. Kantrowitz, Jan 1962). Thus the functions of turbine and generator are combined in a single machine. Because of that the system is very and less numbers of component are use, this will result in low frequency of system maintenance, low construction and maintenance cost. Next the MHD generator also can consider as nearly zero pollution especially thermal pollution in water and also no noise pollution. There are many way to generate the electrical energy by using this MHD generator, one of them is by harvest the ocean wave (tidal) into electrical energy. If this method can be promote to replace all the generator that use petrol, natural gas, char coal and nuclear as a fuel to produce the electrical energy, this MHD generator can contribute as a solution to reduce the greenhouse effect and can save our earth from global warming (Vishal 2013). Beside the system also don’t have a moving/rotating component, so there are no friction loses and this lead tp higher efficiency is compare to others type of generator as per table 1.0 below, the efficiency of MHD generator is the highest. This research are focus on the parameter that effecting the current produce by MHD generator like a magnetic strength, intensity of salt water and the speed of salt water to harvest the Ocean wave energy. This study is very important because there are less no of research have been done on implement of MHD generator on Ocean based energy.
### Table 1.0 Efficiency of Power Generation

| NO | METHOD                          | EFFICIENCY |
|----|--------------------------------|------------|
|    |                                | PRESENT    | FUTURE    |
| 1. | MHD Power generation (electromagnet) | Around 50% | Up to 60% |
|    | Superconducting magnet          |            | 80%       |
| 2. | Thermo-electric power generation | Around 3%  | Up to 13% |
| 3. | Thermonic converters            | Around 15% | Up to 40% |
| 4. | Photo-voltaic or solar cells    | Around 15% |            |
| 5. | Fuel cell technologies          | Around 50% | Up to 60% |
| 6. | Solar power generation          | Around 30% | Up to 50% |
| 7. | Wind power generation           | Around 30% |            |
| 8. | Geo-thermal power generation    | Around 15% |            |

2. **Method of Harvesting Energy Using MHD Generator**

The method to produce the electrical energy are depend on the type of magneto-fluid use, the type of magneto-fluid are ion plasma (Hot gasses), liquid metal and salt water. Below are list of method to harvest the energy by using the MHD generator:

A) Hot gasses – Install the MHD system on the exhaust system or chimney
   i. The MHD system can be install on the exhaust of the vehicle that are produce hot gasses with high speed for example in turbine system of aeroplane or jet, exhaust of car, lorries or motorcycle.
   ii. MHD system also can be install on the chimney of industries that are produce hot gasses as a waste.
   iii. Integrated with the gas or steam turbine, these types of configuration are commonly apply on the power plant. There are several type of MHD integrated system like CF-MHCC (Coal Fired MagnetoHydrodynamic Combined Cycle), IG-MHCC, (Integrated Gasification MagnetoHydrodynamic Combined Cycle) (Salvatore P. Cicconardi, 2013).
   iv. Install on HVAC (Heating, Ventilation and Airconditioning) system, where there are hot gasses flow.

B) Ocean Energy – Clean Energy that can reduce the environment pollution.
   i. The system can be install to harvest the ocean wave energy near the beach or in the middle of Ocean (L.Z Zhao, 2012)
   ii. The system also can be install on the seabed to harvest the energy from the flow stream.
   iii. Lastly the MHD generator system can be install on the moving ship to harvest the energy from the ocean as the ship is moving.

All the system are depend on speed of magneto-fluid as the speed increase the current produce will increase, because the moving fluid is needed as the conductor to cut the magnetic field to produce the current as explain on the introduction above.
3. History
The first idea of magneto hydrodynamic phenomenon was conceived by Michael Faraday in 1832, during his original investigation of electromagnetic induction (Steven, 2007). Then the MHD pump was design by Northrup in 1907. Follow by Karlovitz and Halacz in 1910 was invented and patented the MHD generator by inverting the operating principle of the MHD pump. In 1930, Williams published the result of the first laboratory studies of MHD flows and in pipe and ducts. In early 1940s a large and otherwise sophisticated Hall - current type MHD generator was built by Westinghouse Electric Corp, which failed due to insufficient knowledge of the properties of the ionized gases by Mather and Sutton. In 1959, an experimental MHD generator was built at the Avco Everett Research Laboratory that produced 11.5kW of power and obtained an appreciable pressure drop with the interaction between the gas and magnetic field (Samim, Girish, 1995).

4. Methodology
Experimental setup
Figure 2.0 showed the setup for MHD generator with use of salt water solution as the magneto-fluid. The pump hose was fitted in the system to produce the desire flowrate of salt water solution into MHD generator. The flow of salt water is varied with control the speed of pump. The MHD device has been fitted by pair of magnet opposite each other and pair of electrode perpendicular to the magnetic field, the flow of salt water will pass through this magnetic field then current will produce as the salt water cut the magnetic field. Then the digital multi meter has been use in order to read the amount of current produce.

![Figure 2.0](image)

**Figure 2.0** a) actual experimental setup, b) schematic diagram for experimental setup

Experiment procedure
Preparation for salt water solution
Salt water solution is conductor in this experiment for copy real condition sea water. Therefore, mix between salt and water was determined according the following ratio:

- 20% mass of salt, 80% mass of water
- 40% mass of salt, 60% mass of water
- 60% mass of salt, 40% mass of water
- 80% mass of salt, 20% mass of water

The effect of intensity of salt water to the current produce will study.
Design of MHD generator

Figure 3.0 below shown the Cad model and schematic diagram of MHD device, consist of pair of several magnet and pair of Copper plate (electrode) was place perpendicular to the magnetic field.

![Figure 3.0](image)

**Type of magnet use in this experiment is N50. Dimension 50 mm (L) X 20 mm (W) X 10 mm**

The effect of magnetic strength to the current produce are studies by varies strength of magnetic field. Below are the configuration numbers of arrangement for pair of magnet. The number of magnet indicate the strength of magnetic field, the strength of magnetic field increase as increase the number of magnet install on MHD device. For configuration C, D and E, the number of magnet use are same, but the magnetic strength with varies the distance between two magnet.

- A = 6 bar magnet put both side
- B = 4 bar magnet put both side
- C = 2 bar magnet put both side

| Intensity of Salt Water | Magnet Arrangement | Flow rate of Salt water $m^3/s$ |
|------------------------|--------------------|-------------------------------|
| 80% Salt               | A, B, C,           | 1.48, 2.96, 4.44              |
| 60% Salt               | A, B, C,           | 1.48, 2.96, 4.44              |
| 40% Salt               | A, B, C,           | 1.48, 2.96, 4.44              |
| 20% Salt               | A, B, C,           | 1.48, 2.96, 4.44              |

**Table 2.0 Summaries of experiment configuration**

5. Result & Discussion

In order to design the efficient MHD generator as an electric power generator to generate the current based on the salt water flow through the magnetic fields, some importance parameter was analyzed. The intensity of salt in the sea water is difference between each location, so it is important to study the effect of salt intensity in the water to the current produce by using the MHD generator. Figure 4.0 has shown the effect of intensity of salt water and the strength of magnetic field to the current produce by using the MHD generator. The results reveal that the intensity of salt water give a significant effect to the current produce, where the 40% to 60% of salt intensity give the high value of current then, for intensity below and above this range the value of current produce are reduce. The same pattern for effect of intensity to current produce also shows for difference of magnetic strength. Table also shown that the magnetic strength also affect the value of current produce where the increase the magnetic strength result in increased the current produce. The design MHD A that use 6 numbers of magnet give the higher value of current follow by design B that use 4 numbers of magnet compare with the lowest value of current produce via the MHD C that are use only 2 magnet.
velocity = 1.48 \times 10^{-4} \text{ m}^3/\text{s}

\textbf{Current Vs Intensity}

velocity = 2.96 \times 10^{-4} \text{ m}^3/\text{s}

\textbf{Current Vs Intensity}

velocity = 4.44 \times 10^{-4} \text{ m}^3/\text{s}

\textbf{Current Vs Intensity}

\textbf{Figure 4.0} Effect of Intensity of salt water and magnetic strength to the Current produce
Beside the intensity of salt and magnetic strength, the flow rate of salt water also is importance parameter, because of current produce depend on the flow of salt water solution in order to cut the magnetic flux to generate the current. Result on Figure 5.0 below show the Effect of flow rate of salt water for difference intensity of salt to the Current produce. It was found that the current produce linearly increase as the increase of salt water flow rate, the result also show that the pattern same for every intensity and magnetic strength, this is because the current will be generate when the magnetic flux is been cut by a moving salt water, as the flow rate of salt water increase the frequency of magnetic flux have been cut will increase as result the current produce also will be increase.

Intensity of Salt = 20%

Intensity of Salt = 40%
6. Conclusion
Based on the result reveal above, it show that all the parameter give a significant effect on the current produce, because of that the highly consideration needs to take place to design the MHD generator as an electric power generator in order to support the demand for energy. In the same time, it also provide a solution to the critical environment pollution because the source of energy is clean if the mass application of this energy generation can be replace all the conventional power generation that are using hydrocarbon fuel as a source of energy. Besides, the higher efficiency and the lower the cost to run this generator also the interesting benefit when dealing with the MHD generator, because people always concern with this two factor, Therefore, usage of MHD generator is a brilliant idea for generate power for use by citizen.
7. Reference

1. Samim Anghaie, Girish Saraph, Conceptual Design Analysis of A MHD Power Conversion System for Droplet - Vapor Core Reactors, 1995

2. Steven Errede, A Brief History of The Development of Classical Electrodynamics, 2007.

3. Vishal. D. Dhareppagol & Anand Saurav., The Future Power Generation with MHD Generation, 2013.

4. Ajith Krishnan R, Jinshah B S, Magneto hydrodynamic Power Generation, 2013.

5. Mohan, L. L., Electric Generators Handbook (Butterworth's 1990).

6. A.R Kantrowitz, T.R Brogan, R.J. Rosa and J.F Louis, The The Magnetohydrodynamic Power Generator-Basic Principles, State of the Art, and Areas of Application, IRE Transactions on military electronic, Jan 1962

7. Vishal. D. Dhareppagol, Anand Saurav, The Future Power Generation with MHD Generator Magneto Hydro Dynamic generation, ISSN (Print) : 2278-8648, Volume-2, Issue-6, 2013

8. Salvatore P. Cicconardi, Alessandra Perna, Performance Analysis of Integrated Systems Based on MHD Generator, 68th Conference of the Italian Thermal Machines Engineering Association. ATI, 2013

9. L.Z Zhao, Y.peng, J.Li, R.Li, Y.Y. Xu, B.L.Liu, and C.W.Sha, Numerical Analysis on a Helical – Channel Seawater MHD generator, IEEE PES ISGT ASIA 1569527047, 2012