Energy Recovery from Engine Exhaust Using Magneto-Hydrodynamic (MHD) Principle

Karthik.L

37b, vikrama flats, 2nd main road, purushotham nagar, chromepet, Chennai- 600044

Kishore.D

No:9/31, Krishna Nagar, 4th Street, Virugambakkam, Chennai-600092

A.Kishore Bala Guru
No:17/14, Sabarmathi apartment, Ananda Velu Street, Perambur Chennai-600011

S.Karthikeyan

No:55, Kumudham Street, Ambal Nagar, Porur, Chennai-600116

Abstract

The increase in demand for electricity has created a need for the invention of new method to produce electricity. The method should be efficient, non polluting and less harmful to the environment. Considering all these factors, we have fabricated a small device working on MHD principle, to generate electricity using the engine exhaust gas. Since the moving fluid in the MHD should be hot and conducting, we have picked a similar fluid, the engine exhaust. The device is attached inside the silencer of a four wheeler between engine exhaust and catalytic converter. This is done because, catalytic converter absorbs all the sulphur and nitrogen ions when the exhaust gas passes through it. Exhaust coming from engine is not only rich in sulphur and hydrogen ions, but also posses fairly high temperature.

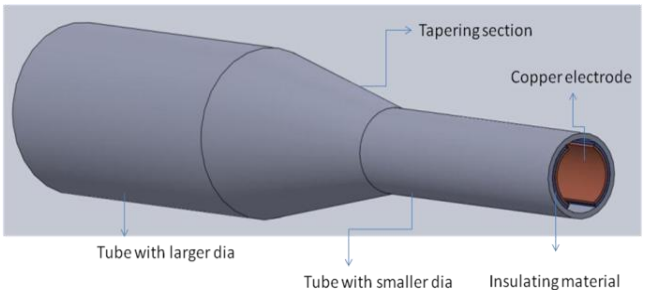
Intoduction

Magneto hydrodynamics is the academic discipline which studies the dynamics of electrically conducting fluids Examples of such fluids include plasma , salt water etc. In advanced countries MHD generators are widely used but in developing countries like INDIA, it is still under construction .This work is in progress at TRICHY in TAMILNADU, under the joint efforts of Bhabha atomic research center and Russian technologists. As the name implies, magneto hydro dynamics (MHD) is concerned with the flow of a conducting fluid in the presence of magnetic and electric field. The fluid may be gas at elevated temperatures or liquid metals like sodium or potassium

Working Principle

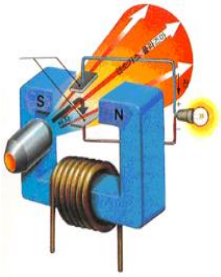
In an MHD generator, electrically conducting fluid at a very high temperature is passed at high velocity through a strong magnetic field at right angles to the direction of flow. Due to the magnetic field, the ions present in the fast moving fluid begins to trace a spiral path. These ions are captured by electrodes placed perpendicular to both direction of flow and magnetic field, there by generating electrical energy. This electrical energy is then collected from stationary electrodes placed on the opposite sides of the channel. The current so obtained is direct current which can be converted into ac by an inverter.

3D Model of our MHD Generator



Principle of MHD

When an electric conductor moves across a magnetic field, a voltage is induced in it which produces an electric current. An MHD generator is a device for converting heat energy of a fuel directly into electrical energy without conventional electric generator. The principle can be explained as follows. An electric conductor moving through a magnetic field experiences a retarding force as well as an induced electric field and current.

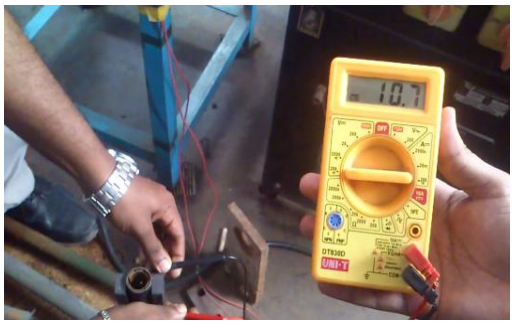


Fabrication of MHD

The system consists of a tapering section tube made up of mild steel , with major dia 41 mm ,and minors dia 25mm .The major dia side is has an extruded pipe for 100mm and the minor dia side is also has an extruded pipe of nearly 90 mm. The side with larger dia is connected with engine exhaust, whereas the other pipe is used for current extraction. The configuration used here is “CONTINOUS ELECTRODE FARADAY GENERATOR”. The electrode used here is made up of copper plate. Copper is insulated from the tube with the help of a insulating material like mica. This is done to prevent the electrodes from getting internally connected. The plates are bent such a way that they fit inside the tube without touching each other.12 bar magnets are mounted on the small diameter pipe such that the face of the magnets are perpendicular to the flow of fluid and also to the face of the electrodes.

Experimental Result

The fabricated model of the MHD was tested in the thermal engineering lab at college using “four stroke single cylinder diesel engine”. The larger diameter of the MHD was connected to the engine exhaust pipe. Multimeter was used to check the voltage produced in MHD. As soon as the wires were made to touch the electrodes, there was a deflection in the multimeter showing the production of voltage .The obtained output voltage was 10.7 milli volts.



Design Calculation

- Idling speed of engine = 1500rpm .
- Revolution per second = (1500/60) = 25 .
- In a 4-stroke engine exhaust gas is given out in two revolutions so the exhaust gas is given out , in two revolution of the crank.
- The engine has 2.0 liters of tank capacity. So total volume of gas coming out in one second = (2*25/2) =25 litres/sec
- Dia of the exhaust pipe = 2.6cm .
- Cross section area = $\pi(1.3*1.3) = 6.15\ cm^2$
- To carry one litre of exhaust gas , there should to be 188.67cm of exhaust pipe .
- To displace one litre of exhaust gas per second , it has to flow at 188.67cm/sec .
- To displace 25 litres of exhaust gas per second , it has to flow at 47.16 m/sec .
- So the velocity of the exhaust gas of the engine = 47.16 m/s

- Average magnetic moment of the magnet = 1.06wm
- Magnetic field intensity of the magnet $(B)=\frac{\mu_o}{4\pi} * \frac{m}{(d^2+l^2)^{\frac{3}{2}}}$
- $B= ((4*\pi*10^{-7})/(4*\pi))*(1.06/((0.013^2+0.0055^2)^{(3/2)}))=0.037 w/m^2$
- As two magnets are parallel , the magnetic field gets doubled .
- Magnetic field intensity of the magnet = $0.037*2 = 0.075 w/m^2$
- Output voltage = velocity of exhaust gas*field intensity *dia of pipe
  = 47.16 *0.075*.026 = 0.092V
- Current density J = output voltage /(resistivity * dia of the exhaust pipe)
  = $0.092/(.03*2.8*10^{-2}) = 110.02\ amp/m^2$
- Output current = Area of the electrode * current density
  = $(3.93 * 10^{-3} *110.02) = 0.432$ amps .

Problems with Present Day Power Generation Methods

Emissions of pollutants and greenhouse gases from fossil fuel-based electricity generation account for a significant portion of world greenhouse gas emissions. In the United States, fossil fuel combustion for electric power generation is responsible for 65% of all emissions of sulphur dioxide, the main component of acid rain. Though PV generation is positioned as environmentally friendly, fabrication of PV cells utilizes substantial amounts of water in addition to toxic chemicals such as phosphorus and arsenic.

Advantages

Although the cost cannot be predicted very accurately, yet it has been reported that capital costs of MHD plants will be competitive to conventional steam plants. It has been estimated that the overall operational costs in a plant would be about 20% less than conventional steam plants. Direct conversion of heat into electricity permits to eliminate the turbine (compared with a gas turbine power plant) or both the boiler and the turbine (compared with a steam power plant) elimination reduces losses of energy. These systems permit better fuel utilization. The reduced fuel consumption would offer additional economic and special benefits and would also lead to conservation of energy resources.

Conclusion

The threat of disappearing of the fossil fuels within few decades compel the human beings to search for new energy sources will last for a longer time. The magneto hydro dynamic power generation is one of the examples of a new unique method of generation of electricity. Coal burning MHD combined steam power plants promise significant economic and environmental advantages compared to other coal based power generating technologies. It will not be long before the technological problem of MHD generators are overcome and MHD power generation transform itself from non-conventional to conventional energy sources.

Reference

"Principles of Magneto hydrodynamics" -J. P. Hans Goedbloed

"Magnetic field generation in electrically conducting fluids" -H.K.Moffatt

"MAGNETOHYDRODYNAMICS" - M. S. Tillack and N. B. Morley"

"Magneto hydrodynamics: Future Power Process?" - P. Sporn and A. Kantrowitz,

"Engineering Magneto hydrodynamics,"- G.W. Sutton and A. Sherman, McGrawHill,

"Magneto hydrodynamic Flow in Ducts," -H. Branover, Keter Publishing House