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MAGNETO HYDRODYNAMICS POWER GENERATION

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Abstract: Magneto hydrodynamic (MHD) power generation process is basically based on the physics background of space plasma. The basic principle is the Faradays Law of electromagnetic induction. In this device plasma (Ionized gas) is the working fluid similar to the mechanism that happening in the magnetosphere of our earth's atmosphere. Except here the process is controlled and we increase the fluid density and pressure to get maximum efficiency in the generating power. Most problems come from the low conductivity feature in the gas at high temperature. High temperature gaseous conductor at high velocity is passed through a powerful magnetic field and a current is generated and extracted by placing electrodes at suitable position in the gas stream, and hence the thermal energy of gas is directly converted in to electrical energy. In this paper the process involved in MHD power generation will be discussed in detail along with the simplified analysis of MDH system and recent developments in magneto hydrodynamics and their related issues.

Keywords: Electromagnetic induction, Hall Effect, Magneto hydrodynamics, MHD generator, Plasma

I. INTRODUCTION

MHD is a device which converts heat energy of an ionized fluid at high temperature directly through the applied magnetic field, without a conventional electric generator. In such systems power generation is based on the Faraday's law of electromagnetic induction. In such condition when plasma passes through a strong magnetic field then force begin to act on its ions, this force act on plate P1 for +ions and towards P2 for –ions. Due to migration of these charges a potential difference creates between the plates. If a load is connected between these plates then electricity begin to flow. This process takes place in MHD channel.

II. WORKING PRINCIPLE

When a charged particle moving in a magnetic field B, having charge q and velocity v, then the force acting on it:

$F=q\,(v\times B)$

If E is the electric field acts, then the total force:

$F=q\,(E+ v\times B)$

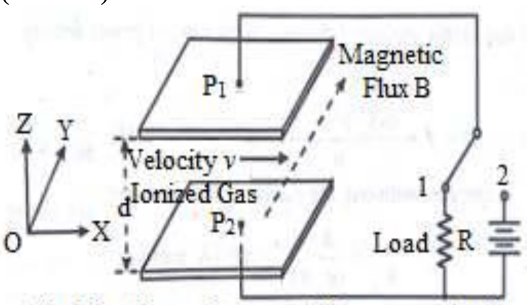

Fig: Directions of magnetic flux, gas velocity and force in MHD system

For magneto hydrodynamic power generation, the solid conductor of a conventional generator isreplaced by a fluid conductor.

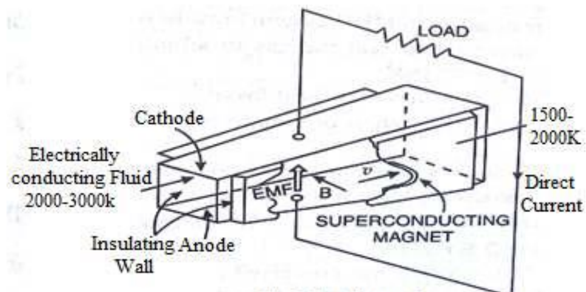

Fig: MHD Channel

Fig2 the motion of gas is in *x*-direction, magnetic field *B* is in *y*-direction and the force on the particle is in *z*-direction.

The fluid can be a liquid metal or heated and seeded noble gas. Inan 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 cesium). This element is thermally ionized at the combustion temperature (usually over 2500K) producing sufficient free electrons eg (K→ K ++) 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

$$\mathbf{W = K\sigma v2B2}$$

Where,

Σ	stands for the conductivity
N	stands for its velocity
B	stands for the magnetic flux density
K	is a constant.

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III. MHD CYCLES & WORKING FLUIDS

(i) Open Cycle MHD Systems: In an open cycle system the working fluid is used on the once through basis. The working fluid after generating electrical energy is discharged to the atmosphere through a stack. Generally coal is used as fuel as it produces more conductive plasma; this is because of more carbon atom as compared to hydrogen atom. The working temperature of such MHD generators lies approximately in the range above 3000C.
The different parts of open cycle
generator is:

(a)Compressor: Compressor is used to raise the pressure of the air supplied in combustion chamber for efficient burning of fuel. The pre-cooled air is compressed in compressor before being supplied in the pre-cooler.

(b) Pre-heater: The compressed air pre-heated in the pre-heater at 11000C from the exhaust gases of the generator to increase the combustion efficiency of working fluid.

(c) Combustor: The fluid is burnt in this section of generator in the presence of hot air coming from pre-heater & gas is seeded with cesium to ionize the gas.

(d) Nozzle: The high temperature gases after combustor pass through convergent-divergent nozzle to increase its velocity of order of 1000 m/s.

(e) Generator Dust: It is made of heat resisting & insulating material. The high magnetic flux is applied in this section of the duct at perpendicular to flow direction of gases. As the moving gas cuts the line of magnetic flux the induced electric field produces DC current through generator in this section. The duct is water cooled to remove the heat.

(f) Inverter: The generated DC is converted into AC by using the inverter before supply to grid.

(g) Gas Chamber: The exhaust hot gasses passes through the air cleaner to control the pollution & remove harmful gases.

(h) Speed Recovery System: Seed material is expensive & need recovery system along with open MHD power cycle for further use.
The removed seeds are supplied back in the combustor.

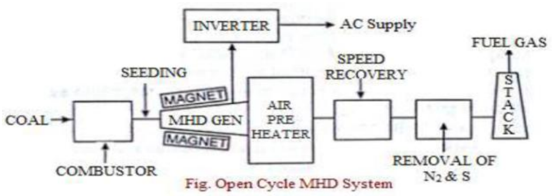

Fig. Open Cycle MHD System

(ii) Closed Cycle MHD System: In this system the very highthermal efficiency isachieved with low cycle costin closed plant & providesmore useful power at lowtemperature at 16000C. The ducts of these units are smallbecause of high pressure.Helium or argon is used asworking fluid, heated in heatexchanger & get ionized,alkali metals is mixed withinert gas to provide thenecessary conductivity is closed cycle plant, where recovery is possible.The working fluid in closed cycle is seeded with Cesium and circulated in a closed loop. Gas is burned in the combustor is supplied in the heat exchanger, where the heat is transferred to the working fluid.
The ionized gas passes through the magnetic field to produce DC power. The combustion products are discharged to the atmosphere after removal of heat in heat exchanger. It shows the schematic of liquid metal MHD generator. The superheated metallic vapour is expanded through the supersonic nozzle and enters in the generator in liquid form with velocity of 150 m/s. The electrical conductivity of metallic vapour is poor. That brings the overall conversion efficiency lower than that of gas as a working substance.

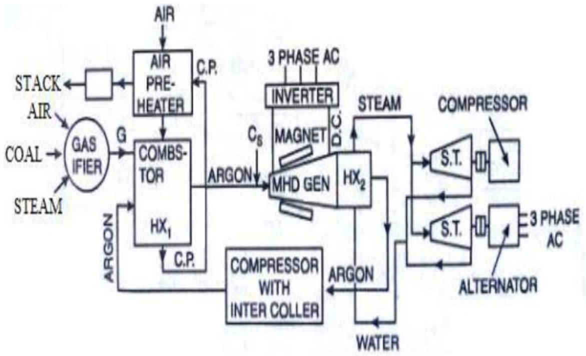

Fig. Closed Cycle MHD System
HX_1 - Heat Exchanger 1, HX_2 - Heat Exchanger 2, G- Gas, C.P- Combustion products, Cs-Cesium injection, ST- Steam turbine, P- removal of nitrogen and sulphur

(iii) Hybrid MHD Generator: The hybrid MHD generator is developed to improve the thermal efficiency of plant. The efficiency up to 60% is achieved in the hybrid system. The working gas enters in the MHD at 30000C and will leave at 20000C through the steam turbine coupled with generator. A steam power plant is connected along with MHD generator to use the remaining energy of exhaust gases of MHD generator and converted it into electrical energy. The MHD plant may be open or a closed type. This steam power plant works on Rankine cycle.

IV. ADVANTAGES & DISADVANTAGES OF MHD SYSTEM

I. ADVANTAGES: In MHD the thermal pollution of water is eliminated. (Clean Energy System) Use of MHD plant operating in conjunction with a gas turbine power plant might not require to reject any heat to cooling water. These are less complicated than the conventional generators, having simple technology. There are no moving parts in generator which reduces the energy loss. These plants have the potential to raise the conversion efficiency up to 55-60%. Since conductivity of plasma is very high (can be treated as infinity). It is applicable with all kind of heat source like nuclear, thermal, thermonuclear plants etc. Extensive use of MHD can help in better fuel utilization. It contribute greatly to the solution of serious air and thermal pollution faced by steam plants.

II. DISADVANTAGES: The construction of superconducting magnets for small MHD plants of more than 1kW electrical capacity is only on the drawing board. Difficulties may arise from the exposure of metal surface to the intense heat of the generator and form the corrosion of metals and electrodes. Construction of generator is uneconomical due to its high cost. Construction of Heat resistant and non conducting ducts of generator & large superconducting magnets is difficult. MHD without superconducting magnets is less efficient when compared with combined gas cycle turbine.

CONCLUSION

All the conventional thermal and hydro power plants are associated with immense losses due to thermo mechanical and hydro mechanical operating systems. This causes various efficiency losses i.e. mechanical breakage, thermal leakage, frictional losses. The MHD power generation is in advanced stage today and closer to commercial utilization. Significant progress has been made in development of all critical components and sub system technologies. Coal burning MHD combined steam power plant promises significant economic and environmental advantages compared to other coal burning power generation technologies. It will not be long before the technological problem of MHD systems will be overcome and MHD system would transform itself from non-conventional to conventional energy sources. The conventional conversion systems have significant losses (thermodynamics conversion) and these traditional systems are also failed to fulfill the needs of energy of the modern world. So, the performance from the point of efficiency and reliability is limited which can be improved by the combined operation with MHD generators. MHD generator has no moving part which allows working at higher temperature around 3000 degree C without any mechanical losses. In near future, MHD power generation system can improve the efficiency of other conventional systems.

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