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Importance of Magneto Hydro Dynamic Generation

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ABSTRACT: In magneto hydro dynamic power generation heat is directly converted into electrical energy. The basic principle of MHD generation is the same as that of conventional electrical generator i.e. the motion of a conductor through a magnetic field induces an e.m.f. in it. In MHD generation, electrical energy is directly generated from hot combustion gases produced by the combustion of the fuel without moving parts. MHD generator is a heat engine operating on a turbine cycle and transforming the internal energy of gas directly into electrical energy. So an MHD generator is a device for converting heat energy of a fuel directly into electrical energy without a conventional electric generator. In an MHD generator, electrically conducting gas at a very high temperature is passed at high velocity through a strong magnetic field at right angles to the direction of flow, thereby generating electrical energy. The concept of MHD power generation was introduced for the very first time by Michael Faraday in the year 1832 in his Bakerian lecture to the Royal Society.

KEYWORDS: Air preheater, Closed cycle MHD generation, Combustor, Electromagnetic induction, MHD generator, Open cycle MHD generation.

I. INTRODUCTION

Development of MHD programmes has been undertaken by different countries during the last two decades. Russia have constructed a pilot plant of 75 MW installed capacity, 25 MW is provided by the MHD generator. The fuel used is natural gas. The plant is designated as "U-25". A 5-15 MW thermal input pilot plant is being setup in India at Tiruchirapalli. This plant uses fluidised bed combustion. Major countries involved with MHD activities are Russia, USA, Japan, Australia, China, India, Italy, Israel, Poland etc.

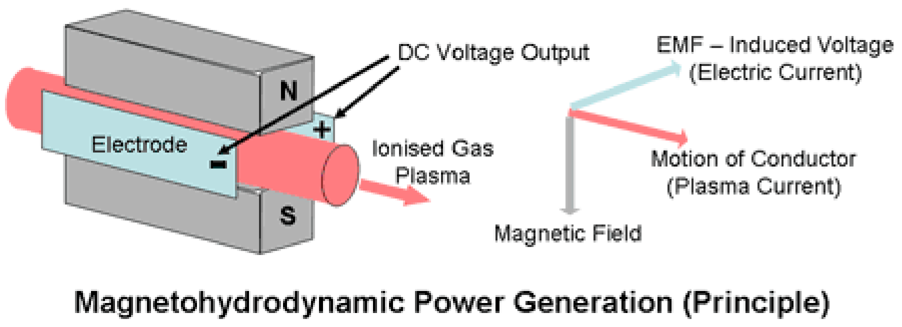

Fig. 1: Principle of MHD Generation

- MHD systems suffer from the reverse flow of electrons through the conducting fluids around the ends of the magnetic field.
- There will be high friction losses and heat transfer losses. The friction loss may be as high as 12% of the input.
- The MHD system operates at very high temperatures to obtain high electrical conductivity. But the electrodes must be relatively at low temperatures and hence the gas in the vicinity of the electrodes is cooler. This increases the resistivity of the gas near the electrodes and hence there will be a very large voltage drop across the gas film. By adding the seed material, the resistivity can be reduced.
- The MHD system needs very large magnets and this is a major expense.

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- Coal, when used as a fuel, poses the problem of molten ash which may short circuit the electrodes. Hence, oil or natural gas are considered to be much better fuels for this system. This restriction on the use of fuel makes the operation more expensive.
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II. METHODOLOGY

In MHD power generation conversion process depends upon Faraday's law of electromagnetic induction, which states that when a conductor and a magnetic field move relative to each other, a voltage is induced in the conductor. This induced voltage produces an electric current. The conductor may be solid, liquid or gas. In MHD generator solid conductors are replaced by hot ionized gas. The hot ionized gas (3000 c) is passed through the MHD duct across which a strong magnetic field is applied. Since the gases are hot and ionised they form an electrically conducting medium moving in a magnetic field, thus a voltage is generated. The power generated by MHD generator is in the direct current form. Now if the electrodes are placed in a suitable position then generated current can be extracted.

MHD systems may be classified as:
i) Open cycle systems, ii)Closed cycle systems.
In an open cycle system, the working fluid after doing useful work (generating electrical energy) is discharged to the atmosphere through a stack while in a closed cycle system the working fluid is recycled to the heat source and thus used again and again. The operation of MHD generators directly on combustion products is an open cycle system using air as working fluid. In closed cycle systems gases used on the working fluid are helium or argon.

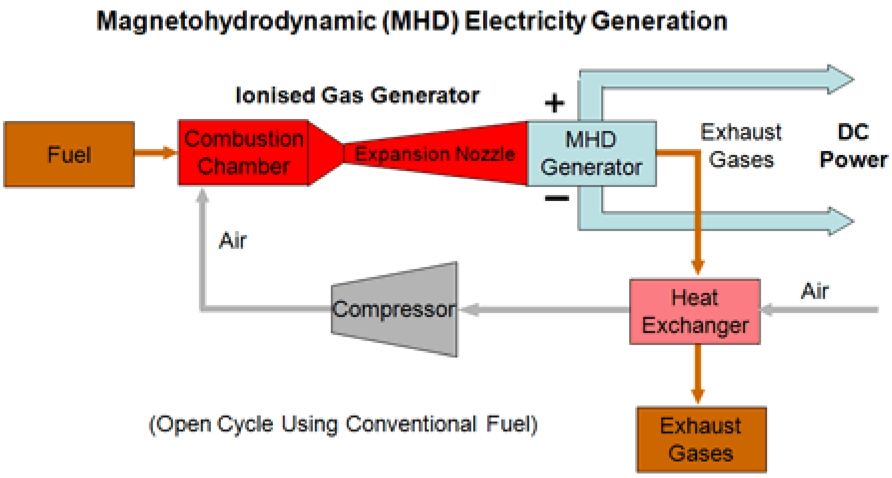

Fig. 2: Open cycle MHD generation

Coal is processed and burnt in the combustor at a high temperature of about 2600 c and pressure of about 12 atmosphere with preheated air to form the plasma. Then a seeding material, such as potassium carbonate, is injected to the plasma in order to increase the electrical conductivity. The resulting mixture having an electrical conductivity of about 10 siemens/m, is expanded through a nozzle, so as to have high velocity, and then passed through the strong magnetic field of about 5-7T of the MHD generator. During the expansion of gas at high temperature, the positive and negative ions move to the electrodes and so constitute an electric current. This current is d.c. and an inverter is employed for its conversion into a.c. The gas leaving the MHD generator is still very hot. The heat from the exhaust gases of the MHD generator is utilized in preheating the air supplied to the combustor. The seed material is recovered from the gas for successive use and harmful emissions (such as nitrogen and sulphur) are removed from the gas, for pollution control, and the gas is finally discharged to the atmosphere through a stack. The open cycle MHD system is not suitable for commercial use. For making this process efficient, it is necessary to combine the MHD unit with steam turbine alternator unit.

The working fluid, in a closed cycle, is circulated in a closed loop. The closed cycle MHD system may be either a plasma converter or a liquid metal converter. The plasma converter uses an ionized gas (helium or argon) seeded with cesium and the liquid metal converter uses the vapour of the metal or the metal in liquid form. The complete system has

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three distinct but interlocking loops. Coal is gasified and the gas so produced has heat value of about 5.35 MJ/Kg and temperature of about 520 c. This gas is burnt in a combustor to generate heat. This heat is transferred to the working fluid (argon) of MHD cycle in a heat exchanger HX1.The combustion products are passed through the air preheater (for recovery of a part of heat of combustion products) and purifiers and then discharged to the atmosphere.

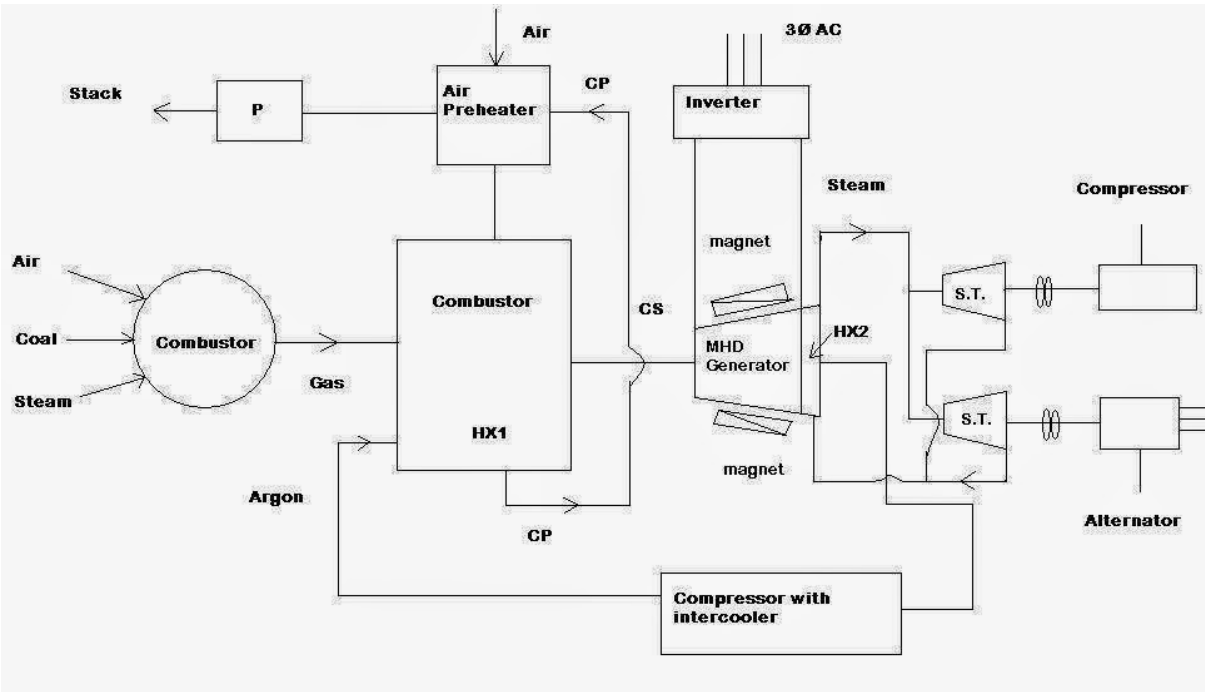

Fig. 3: Closed cycle MHD generation

The hot argon gas is seeded with cesium and passed through the MHD generator, that produces direct current. This d.c. output is converted into a.c. by means of inverter and then supplied to the grid. For further recovery of heat from the working fluid and its use in generating of steam, the working fluid is slowed down, in a diffuser, to a low subsonic speed and then this fluid is passed through the heat exchanger HX2.In this heat exchanger HX2, the fluid imparts it heat to water and so generates steam. This steam is used partly for driving a steam turbine operating the compressor and partly expanded in a steam turbine driving three phase alternator. The working fluid is then passed through compressor and intercooler and returned back to the heat exchanger HX1.

A closed cycle system can provide more useful power conversion at lower temperature of about 1600 c but this system has not taken practical shape so far. The difficulties with such a system are the design of heat exchanger, requirement of absolute purity of the working fluid, the problems posed by electrical stability of the flow in the generator.

III. RESULTS

- Since high temperatures are involved, operation efficiency is high.
- No moving part, so more reliable.
- Lesser thermal pollution.
- Conceptually such generators are simpler.
- Ability of reaching the full power level instantly.
- The more efficient heat utilization reduces the amount of heat discharged to environments and thus the cooling water requirements are reduced.
- The capital costs of the MHD plants are estimated to be competitive with those of coal fired steam power plants.

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- The overall costs of the MHD power generation are also estimated to be lower (roughly 20%) than those of conventional power plants. This is because of higher efficiency of MHD power generation.
- The reduced fuel consumption, that is obtained because of higher efficiency or better fuel utilization, offer additional economic and social benefits and also lead to conservation of energy sources.
- All kinds of heat sources such as coal, oil, gas, solar and nuclear can be used with MHD generators.
- MHD generators have low specific weight, rapid start, high power density and compact.

IV. CONCLUSION

Inspite of the several inherent advantages the MHD system has not been accepted commercially because numerous technological advancements are needed prior to its commercialisation. Most of these are related to material problems caused by high temperature and highly corrosive and abrasive environment. The MHD channel operates under extreme conditions of temperature. MHD conversion has also been considered for ship propulsion, air borne applications, hypersonic wind tunnel experiments and for many other defence applications.

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