The Future Power Generation with MHD Generators Magneto Hydro Dynamic generation…

Vishal. D. Dhareppagol & Anand Saurav

VP.Dr.P.G.Halakatti College of Engineering & Technology, Bijapur-586103.India
E-mail : vishal.dhareppagol@gmail.com, vishu.inspire@gmail.com & anandsrv95@gmail.com

Abstract **-Since a decade the demand for electricity is increasing at alarming rate and the demand for power is running ahead of supply. The present day methods of power generation are not much efficient & it may not be sufficient or suitable to keep pace with ever increasing demand. The recent severe energy crisis has forced the world to rethink & develop the Magneto Hydro Dynamic (MHD) type power generation which remained unthinkable for several years after its discovery. It is a unique & highly efficient method of power generation with nearly zero pollution. It is the generation of electric power directly from thermal energy utilizing the high temperature conducting plasma moving through an intense magnetic field. In advanced countries this technique is already in use but in developing countries it's still under construction. Efficiency matters the most for establishing a power plant. MHD power plants have an overall efficiency of 55-60% but it can be boosted up to 80% or more by using superconducting magnets in this process. Whereas the other non conventional methods of power generation such as solar, wind, geo-thermal, tidal have a highest efficiency not more than 35%. Hence by using MHD power generation method separately or by combined operation with thermal or nuclear plants we hope to bring down the energy crisis at a high rate.**

Keywords- **Magneto hydro dynamics (MHD), plasma, ionization, high temperature, super conductivity and super conducting magnets.**

I. INTRODUCTION

MHD power generation is elegantly simple technique. Magneto Hydro Dynamics (magneto-fluid-dynamics or hydro-magnetics) is the academic discipline which studies the dynamics of electrically conducting fluids. Examples of such fluids include plasmas, liquid metals, and salt water. The generator used in this process is called Magneto Hydro Dynamic Generator. It resembles the rocket engine surrounded by enormous magnet. It has no moving parts & the actual conductors are replaced by ionized gas (plasma) .Hence it has a very high efficiency. Although the cost cannot be predicted very accurately it has been reported that capital cost of MHD plants will be competitive with those of conventional steam plants.

II. HISTORY

The conversion process in MHD was initially described by Michael Faraday in 1893. However the actual utilization of this concept remained unthinkable.

The first known attempt to develop an MHD generator was made at Westing house research laboratory (USA) around 1938.

The first MHD-steam power plant U-25 was put into operation was of 75MW unit in USSR of which 25MW is generated by MHD means in early 1970's & this work has been progressing fruitfully.

The first pilot plant was set up in Tiruchirapalli (by BARC). A five year plan was signed in February 1975 which included 22 spheres of applied science and technology connected with the MHD energy generation.

The Japanese program in the late 1980s concentrated on closed-cycle MHD.

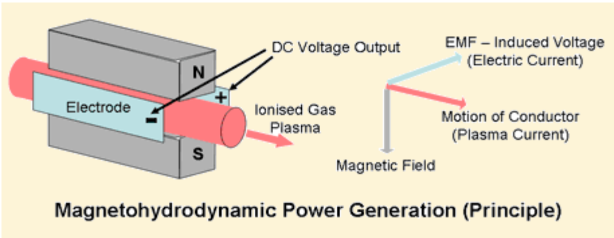
In 1986, Professor Hugo Karl Messerle at The University of Sydney researched coal-fueled MHD.

The Italian program began in 1989 with a budget of about 20 million $US, and had three main development areas:

- MHD Modeling.
- Superconducting magnet development.

III. PRINCIPLE

MHD power generation process is governed by M.Faradays law of Electromagnetic Induction. (i.e. when the conductor moves through a magnetic field, it generates an electric field perpendicular to the magnetic field & direction of conductor). The flow of the conducting plasma through a magnetic field at high velocity causes a voltage to be generated across the electrodes, perpendicular to both the plasma flow and the magnetic field according to Flemings Right Hand Rule



The Lorentz Force Law describes the effects of a charged particle moving in a constant magnetic field. The simplest form of this law is given by the vector equation.

$$\mathbf{F} = Q \cdot (\mathbf{v} \times \mathbf{B})$$

where

- **F** is the force acting on the particle.
- Q is the charge of the particle,
- **v** is the velocity of the particle, and
- **B** is the magnetic field.

The vector **F** is perpendicular to both **v** and **B** according to the right hand rule.

IV. CONSTRUCTION

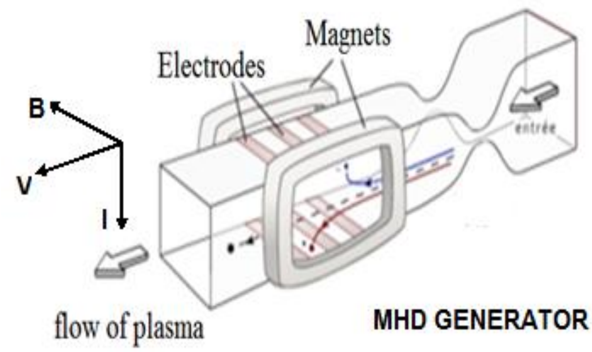
Its construction is very simple. MHD generator resembles the rocket engine surrounded by enormous magnet. It has no moving parts & the actual conductors are replaced by ionized gas (plasma). The magnets used can be electromagnets or superconducting magnets. Superconducting magnets are used in the larger MHD generators to eliminate one of the large parasitic losses. As shown in figure the electrodes are placed parallel & opposite to each other. It is made to operate at very high temperature, without moving parts.

Since the plasma temperature is typically over 2000 °C, the duct containing the plasma must be constructed from non-conducting materials capable of withstanding this high temperature. The electrodes must of course be conducting as well as heat resistant.

Because of the high temperatures, the non-conducting walls of the channel must be constructed from an exceedingly heat-resistant substance such as yttrium oxide or zirconium dioxide to retard oxidation.

It can be considered as fluid dynamo similar to mechanical dynamo.

The key component is Superconducting Magnets

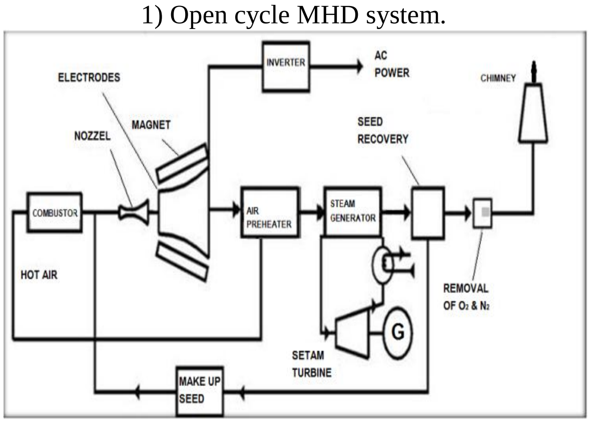


There are two types of MHD power generation

i. Open cycle MHD.

ii. Closed cycle MHD.

1) Open cycle MHD system.



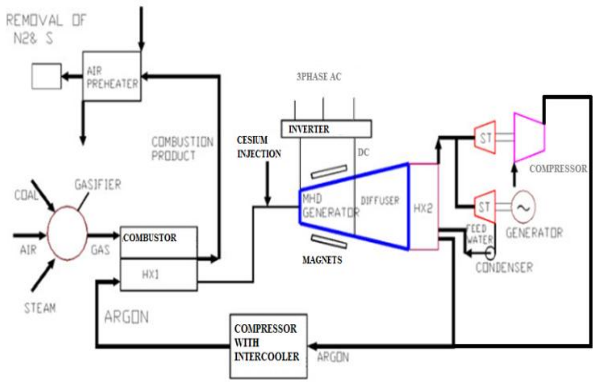
Working fluid-potassium seed combustion product.

Temperature in OC MHD is about 2500°C.

DC Superconducting magnets of 4~6Tesla are used.

Here exhaust gases are left out to atmosphere & the capacity of these plants are about 100MW.

2) Closed cycle MHD system



Working fluid-cesium seeded helium.

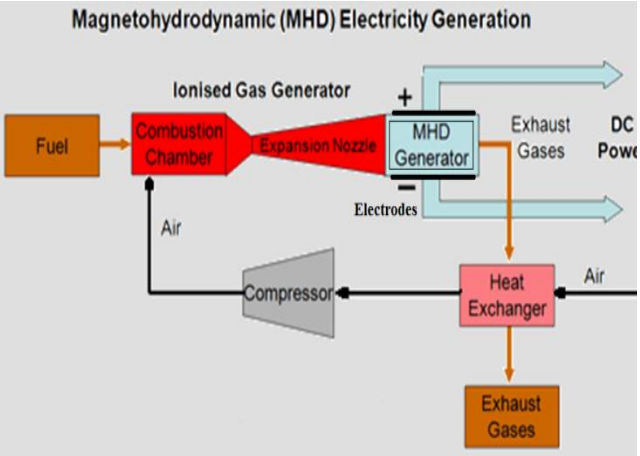
ISSN (Print) : 2278-8948, Volume-2, Issue-6, 2013

Temperature of CC MHD plants is very less compared to OC MHD plants. It's about 1400^{o}C.

DC Superconducting magnets of 4~6Tesla are used.

Here exhaust gases are again recycled & the capacities of these plants are more than 200MW.

V. WORKING PROCEDURE



It is the generation of electric power utilizing the high temperature conducting plasma (stream of high temp working fluid) moving through an intense magnetic field. It converts the heat energy of fuel (thermal energy) directly into electrical energy.

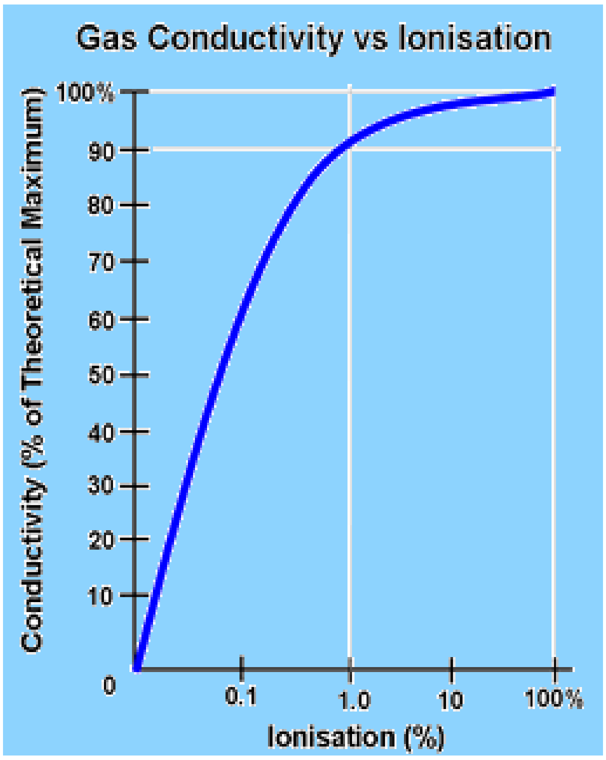
The fuel is burnt in the presence of compressed air in combustion chamber. During combustion seeding materials are added to increase the ionization & this ionized gas (plasma) is made to expand through a nozzle into the generator. Magnetic field, a current is generated & it can be extracted by placing electrodes in a suitable stream. This generated EMF is DC

Ionization of GAS:

Various methods for ionizing the gas are available, all of which depend on imparting sufficient energy to the gas. The ionization can be produced by thermal or nuclear means. Materials such as Potassium carbonate or Cesium are often added in small amounts, typically about 1% of the total mass flow to increase the ionization and improve the conductivity, particularly combustion of gas plasma.

90% conductivity can be achieved with a fairly low degree of ionization of only about ***1%***.

(Note also logarithmic scale).

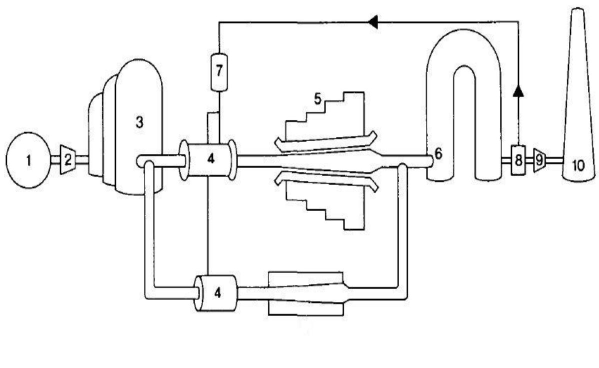


I. Few MHD Generator setup around globe.

U-25 of USSR (1975).

Capacity=25MW,

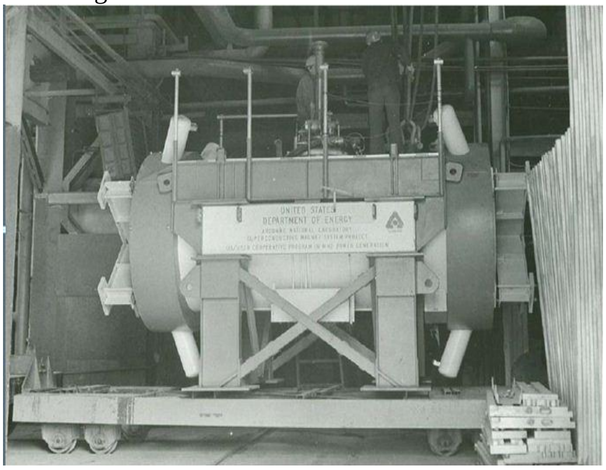
Working medium mass flow rate=50kg/s.



Schematic of U-25 MHD power facility with by-pass loop for superconducting magnet system. (1) Natural gas source, (2) compressor, (3) air preheater, (4) combustor, (5) MHD generator, (6) steam generator, (7) seeding system, (8) seed regenerator system, (9) stack exhaust blower, (10) discharge stack

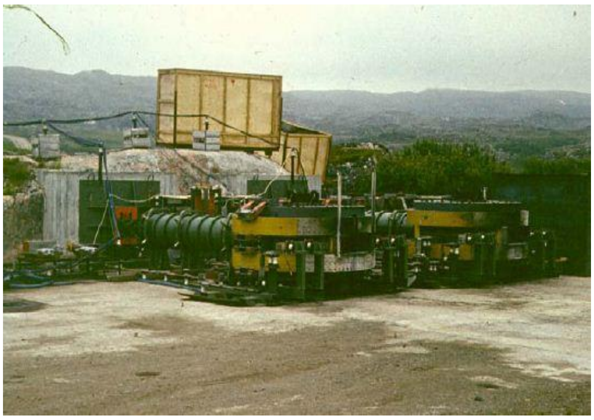
Joint US-Russia effort Open cycle MHD generator. (1979).

Capacity=10MW, Working medium Capacity mass flow rate=50kg/s



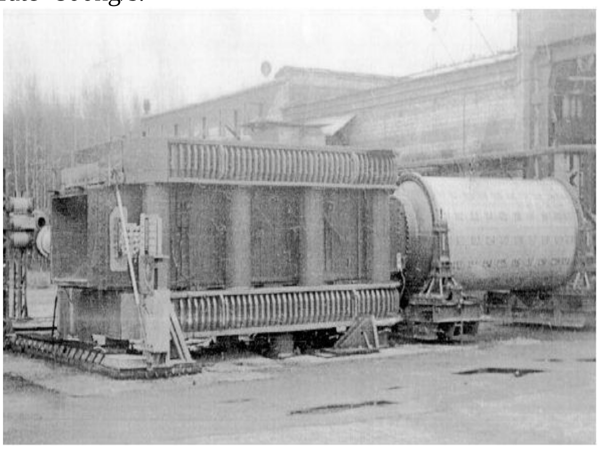
Khibiny generator.

Capacity=120 MW,Working medium mass flow rate=200kg/s



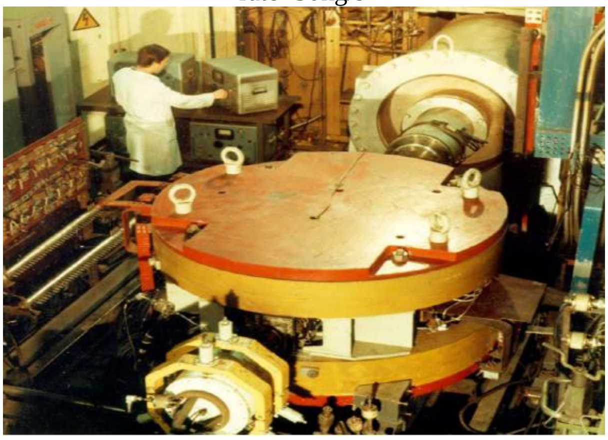
Shakhalin generator

Capacity=500MW,Working medium mass flow rate=800kg/s.



Pamir generator (MOSCOW).

Capacity=20MW, Working medium mass flow rate=50kg/s



II. Comparison

SL: no	METHOD	EFFICIENCY PRESENT	FUTURE
1.	MHD Power generation (electromagnets) Superconducting magnets	Around **50%** ___	Up to **60%** **80%**
2.	Thermo-electric power generation	Around 3%	Up to 13%
3.	Thermionic 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%	___

VI. 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.

VII. 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.

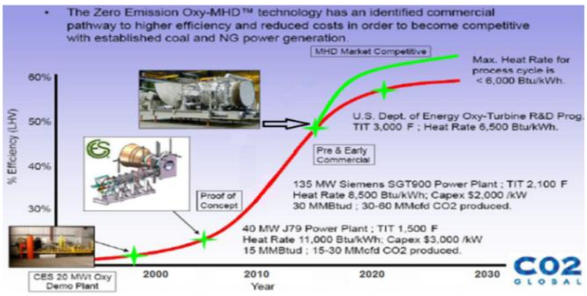
VIII. CONCLUSION.

Improvement in corrosion science & superconducting magnets can make rapid commercialization possible.

Saving billions of dollars towards fuel prospects of much better fuel utilization.

It can therefore be claimed that the development of MHD for electric utility power generation is an objective of national significance.

The practical efficiency of this type of power generation will not be less than 60%. Hence it will be most significant in upcoming decade.



Development Roadmap forCommercial Deployment of the CES and MHD Technologies. If we solve this (making MHD cost effective]), we will succeed, otherwise MHD will be in proceedings and papers”

It is expected to overcome all the demerits till the end of 2020.

IX. REFERENCE

[1] M.S.Tillack and N.B.Morley MAGNETOHYDRODYNAMICS, McGraw Hill 14th Edition, 1998.

[2] R.J. Rosa, "Magnetohydrodynamic Energy Conversion", Hemisphere Publishing, Washington D.C, 1987.

[3] Shioda, S. "Results of Feasibility Studies on Closed-Cycle MHD Power Plants", Proc. Plasma Tech. Conf, Sydney, Australia, 1991.

[4] Hugo K. Messerle, "Magnetohydrodynamic Power Generation", John Wiley, Chichester, 1994.

[5] J. A. Shercliff, “A Textbook of Magnetohydrodynamics,” Pergamon Press, Oxford, 1965.

[6] G. W. Sutton and A. Sherman, “Engineering Magnetohydrodynamics,” McGraw-Hill, New York, 1965.

[7] Anwari, M., Harada, N. and Takahashi.S, "Performance of a magnetohydrodynamic accelerator using air-plasma as working gas", Elsevier paper, Energy Conversion Management, Vol. 4, pp. 2605-2613, 2005.

[8] T. N. Aitov, et al., “Flow of Electrically Conducting Fluid in a Thin Layer with a Free Surface Under the Action of a Strong Magnetic Field,” *Magnetohydrodynamics,*Vol. 21, No. 3, pp 71-76, 1985.

[9] W. Murgatroyd, “Experiments on magneto-hydrodynamic channel flow,” *Philosophical Magazine*, Vol. 44, p. 1348, 1953

❖❖❖