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Paper: Direct Energy Conversions

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Q1 :Magneto hydrodynamics (MHD) is a direct energy conversion technique. What are the basic differences in working principle of this system as compared to conventional hydro power systems. How is the output power obtained from this system.

Ans)

Magneto hydro dynamic (MHD) power plants offer the potential for large-scale electrical power generation with reduced impact on the environment. Since 1970, several countries have undertaken MHD research programs with a particular emphasis on the use of coal as a fuel. MHD generators are also attractive for the production of large electrical power pulses.

Working principle:

In the turbo generator, the gas interacts with blade surfaces to drive the turbine and the attached electric generator. In the MHD system, the kinetic energy of the gas is converted directly to electric energy as it is allowed to expand.the interaction of a plasma with a magnetic field could occur at much higher temperatures than were possible in a rotating mechanical turbine. The basic structure of an MHD generator is shown in the figure. In an MHD generator the hot gas is accelerated by a nozzle and injected into a channel. A powerful magnetic field is set up across the channel. In accordance with Faraday’s law of induction, an electric field is established that acts in a direction perpendicular to both the gas flow and the magnetic field. The walls of the channel parallel to the magnetic field serve as electrodes and enable the generator to provide an electric current to an external circuit.

Power output :

The turbine blades of a gas-turbine power system are unable to operate at such temperatures. An adequate value of electrical conductivity—10 to 50 Siemens per meter—can be achieved if an additive, typically about 1 percent by mass, is injected into the hot gas. This additive is a readily ionizable alkali material, such as cesium, potassium carbonate, or sodium, and is referred to as the “seed.” While cesium has the lowest ionizing potential (3.894 electron volts), potassium (4.341 electron volts) is less costly. Even though the amount of seed material is small, economic operation requires that a system be provided to recover as much of it as possible.

Hydro power Working:

In order to generate electricity from the kinetic energy in moving water, the water has to move with sufficient speed and volume to spin a propeller-like device called a turbine, which in turn rotates a generator to generate electricity. Roughly speaking, one gallon of water per second falling one hundred feet can generate one kilowatt of electricity. To increase the volume of moving water, impoundments or dams are used to collect the water. An opening in the dam uses gravity to drop water down a pipe called a penstock. The moving water causes the turbine to spin, which causes magnets inside a generator to rotate and create electricity. There are a variety of types of turbines used at hydropower facilities, and their use depends on the amount of hydraulic head (vertical distance between the dam and the turbine) at the plant. The most common are Kaplan, Francis, and Pelton wheel designs. Some of these designs, called reaction and impulse wheels, use not just the kinetic force of the moving water but also the water pressure.

Q2 :

(a)	Thermo-electric systems are emerging as a popular alternate to conventional thermal power systems. What are the main factors involved in the technology that determine the output power of thermos-electric generator. How can the maximum power be obtained from this system.

Ans)Thermo electricity:

Electricity produced by the direct action of heat (as by the unequal heating of a circuit composed of two dissimilar metals) Thermoelectricity is a two-way process. It can refer either to the way a temperature difference between one side of a material and the other can produce electricity, or to the reverse: the way applying an electric current through a material can create a temperature difference between its two sides, which can be used to heat or cool things without combustion or moving parts. It is a field in which MIT has been doing pioneering work for decades.

Thermoelectric Generators Working:

thermoelectric generators are used to produce power, thermoelectric coolers are used for removing or adding heat. Thermoelectric cooling has many applications in cooling, heating, refrigeration, temperature control and thermal management. The focus of the rest this post is thermoelectric generators. The basic building block of a thermoelectric generator is a thermocouple. A thermocouple is made up of one p-type semiconductor and one n-type semiconductor. The semiconductors are connected by a metal strip that connects them electrically in series. The semiconductors are also known as thermo elements, dice or pellets.

The See beck effect is a direct energy conversion of heat into a voltage potential. The Seebeck effect occurs due to the movement of charge carriers within the semiconductors. In doped n-type semiconductors, charge carriers are electrons and in doped p-type semiconductors, charge carriers are holes. Charge carriers diffuse away from the hot side of the semiconductor. This diffusion leads to a buildup of charge carriers at one end. This buildup of charge creates a voltage potential that is directly proportional to the temperature difference across the semiconductor.

Main Factor involve :

EFFECTS OF TEMPERATURE:

if the temperature dependence of thermoelectric properties is not considered. On the other hand the power improves very slowly whereas the efficiency decreases after its maximum with the increase of temperature difference, considering the influence of temperature dependence of thermoelectric properties.[1][15] Effects of temperature dependence on power versus electrical current and Effects of temperature dependence on efficiency versus electrical current.

DESIGN CONSIDERATIONS

EFFECTS OF CONTACT RESISTANCE

Good thermoelectric material properties are inevitable requirements for a thermoelectric module exhibiting high efficiency. Rowe et al. [11] describe the impact of the module's contact resistance on the performance of thermoelectric generators. Even with very good thermoelectric material, the device performance can be rather poor, if the contact resistances of the module are too large. The figure of merit *ZT* of a thermoelectric generator is a measure of the performance and is closely related to the efficiency of a module [3]. It is strongly affected by the modules resistance and is given by.

SEEBACK EFFECTS

The important design parameters for a power generator device are the efficiency and the power output. The efficiency is defined as the ratio of the electrical power output. The efficiency is defined as the ratio of the electrical power output Po to the thermal power input qh to the hot junction.

Q3:The Thermionic generator has two main types (i) Vacuum Convertor and (ii) Cesium Gas Convertor. Explain in detail why which convertor is more efficient, has more life-time and is easier to construct/operate.

Ans)

A thermionic generator (converter) converts heat energy di¬rectly to electrical energy by utilizing thermionic emission effect. All metals and some oxides have free electrons which are released on heating.

Vacuum converters:

Energy conversion based on vacuum thermionic emission has been explored for many years and prototype systems have been developed and tested. The operation is based on
the thermionic emission of electrons from a hot surface and the collection of the electrons
at a cooler collector. The emitter and collector are separated by a small vacuum gap. Since the thermionic emission involves hot electrons, these electrons carry excess energy
which can be converted into electrical power

Gas-filled: Comparison of the analytical results with experimentally observed performance indicates that emission processes largely determine the required operating temperatures and cesium pressures in cesium diode converters. The performance characteristics and relative usefulness of various classes of emitter materials is estimated, leading to the conclusion that high work function refractory metals with adsorbed cesium have the greatest general utility. Criteria for the choice of emitter materials giving maximum efficiency at a given emitter temperature and spacing in the cesium diode converter are given, as well as relations permitting the choice of compatible emitter and ionizer materials in the surface ionization triode. (auth)

Efficiency:

The benefits of thermionic energy application make it desirable for a number of applications. One such application is increasing the efficiency of power plants that burn fossil fuels. These plants operate at temperatures over 2000°K, but the turbines generally need only 800-1300°K. [5] The extra heat could then be used to power a thermionic converter, increasing the overall efficiency of the plant. In 1973, Rasor Associated estimated that the efficiency of a nuclear fusion plant could be increased from 41.3% to 47% by implementing thermionic converters. [5] Another application of thermionic energy is optimizing energy expenditure in a house. Excess heat from water boilers or natural gas burners could be used as electricity, simultaneously conserving energy while saving homeowners money on utilities. Several companies on the west coast are currently attempting to commercialize thermionic energy conversion for both utility and residential applications.

Q4 :Thermo-electric and Thermionic are DEC techniques. What are the common principle in both systems. What are the main differences between both the systems. Explain in detail.

Ans)

A thermionic generator (converter) converts heat energy di¬rectly to electrical energy by utilizing thermionic emission effect. All metals and some oxides have free electrons which are released on heating. In a thermionic converter, electrons act as the working fluid in place of a vapour or gas. In this device electrons are emitted from the surface of heated metal. The energy required to extract an electron from the metal is known as work function and expressed in electron volts Thermoelectricity means the direct conversion of heat into electric energy, or vice versa. The term is generally restricted to the irreversible conversion of electricity into heat described by the English physicist James P. Joule and to three reversible effects named for Seebeck, Peltier, and Thomson, their respective discoverers.

Difference between both:

In thermionic free electrons are emitted from the surface of a metal when external heat energy is applied emission occurs in metals that are heated to a very high temperature when the large amount of external energy is applied. Thermoelectricity means the direct conversion of heat into electric energy direct conversion of temperature differences to electric voltage devices create a voltage when there is a different temperature on each side. Conversely, when a voltage is applied to it, heat is transferred from one side to the other, creating a temperature difference. So it works on the basis of potential difference.

Q5:Thermo-Nuclear fusion has the potential to provide unlimited clean power. But the technology has not been mainstreamed due to technical difficulties. What are the main issues with the system. How can they be solved.

Ans)

High-temperature plasma:

In order to achieve positive energy balance in a thermonuclear reactor based on controlled fusion reactions, high-temperature plasma must have appropriate concentration and life-time. To produce and heat up plasma one can use different methods. The most simple is a powerful electrical discharge between electrodes placed inside a vacuum chamber and supplied form a high-voltage condenser bank.

thermonuclear reactors:

But fusion reactors have other serious problems that also afflict today's fission reactors, including neutron radiation damage and radioactive waste, potential tritium release, the burden on coolant resources, outsize operating costs, and increased risks of nuclear weapons proliferation.

power nuclear fission produced:

With current technology, the reaction most readily feasible is between the nuclei of the two heavy forms (isotopes) of hydrogen – deuterium (D) and tritium (T). Each D-T fusion event releases 17.6 MeV (2.8 x 10-12 joule, compared with 200 MeV for a U-235 fission and 3-4 MeV for D-D fusion).

Fusion fuel

. Power deposited by fast fusion-produced neutrons in the neutron blanket can be extracted by means of an appropriate heat exchange circuit and delivered to conventional electrical generators. Hence, one can easily image a scheme of a future thermonuclear power station. Pure deuterium can be obtained from electrolysis of heavy water (D_2O), which can relatively easily be separated from ordinary water, or from isotopic exchange in a hydrogen-sulphate gas.