Unit - V

Chapter 7

Energy Sources

1. Define mass defect and binding energy? How is mass defect calculated?

(i) Mass defect

The difference between the calculated and experimental masses of nucleus is called mass defect. It is denoted by Δm.

$$\Delta m = \left\{ \begin{array}{c} \text{Total mass of} \\ \text{the protons, neutrons} \\ \text{and electron} \end{array} \right\} - \left\{ \begin{array}{c} \text{Experimental mass} \\ \text{of the nucleus} \end{array} \right\}$$

(or)

It is defined as the loss of mass during the formation of the nucleus of the isotope.

(ii) Binding energy

Binding energy is defined as the energy released when a given number of protons and neutrons coalesee to form nucleus.

(or)

It is the energy required to disrupt the nucleus into its constituent protons and neutrons.

Calculation of mass defect

Consider an isotope,

let its atomic number $= Z$

Mass number $= A$

If its atom contains

Z protons, Z electrons and (A-Z) neutrons

Let,

m_p = mass of proton

m_n = mass of neutron

m_e = mass of an electron

(iv) Coolants

In order to absorb the heat produced during fission, a liquid called coolant is circulated in the reactor core.

Example:

Water (act as moderator & coolant), heavy water.

Function: It cools the fuel core.

(v) Pressure vessel

It encloses the core and also provides the entrance and exit passages for coolant.

Function: It withstand the pressure as high as 200 kg/cm^2.

(vi) Protective shield

The nuclear reactor is enclosed in a thick massive concrete shield (more than 10 meters thick).

Function: The environment and operating personnels are protected from destruction in case of leakage of radiation.

(vii) Turbine

The steam generated in the heat exchanger is used to operate a steam turbine, which drives a generator to produce electricity.

4. Explain the power generation from light water nuclear reactor. *(CBE. A.U. Jan 2009)*

(or)

Explain the method of conversion of nuclear energy into electrical energy in a nuclear reactor. *(A.U June 2014)*

(or)

Explain the construction working and uses of a nuclear reactor with a neat diagram.

(A.U May 2015, Dec 2015, June 2016)

Light-water nuclear-power plant is the one, in which U^{235} fuel rods are submerged in water. Here the water acts as coolant and moderator.

Working

The fission reaction is controlled by inserting or removing the control rods of B^{10} automatically from the spaces in between the fuel rods. The heat emitted by fission of

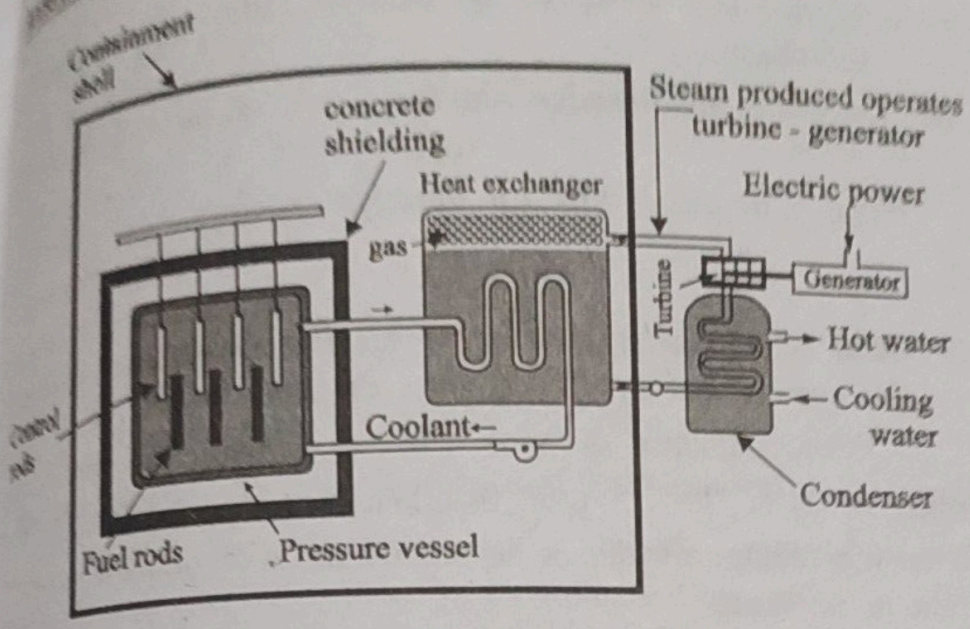


Fig. Light water nuclear power plant

U^{235} in the fuel core is absorbed by the coolant (light water). The heated coolant (water at 300°C) then goes to the heat exchanger containing sea water. The coolant here, transfers heat to sea water, which is converted into steam. The steam then drives the turbines, generating electricity.

Pollution

Though nuclear power plants are very important for production of electricity, they will cause a serious danger to environments.

Problem on disposal of reactor waste

The nuclear waste is packed in concrete barrels, which are buried deep in the sea.

Uses of nuclear reactor

1. It is used to produce electricity.
2. It is used for propulsion (nuclear marine propulsion and rocket propulsion)
3. It is used as a source of heat.
4. It is also used as production reactors for transmutation of elements (production of fissible materials, radio active isotopes and materials for nuclear weapons).

5. It provides a source of neutron radiation and positron radiation.

5. ***Describe the breeder reactor.*** *(Coim A.U. Jan 2010)*

(or)

Write a detailed note on breeder reactors

(A.U. June 2014, Dec 2014)

(or)

What is a breeder reactor? Describe with a neat diagram the conversion of U-235 into Pu-239. *(A.U July 2016)*

Breeder reactor is the one which converts non-fissionable material (U^{238}, Th^{232}) into fissionable material (U^{235}, Pu^{239}). Thus the reactor produces or breeds more fissionable material than it consumes.

Illustration

$$\underset{\text{Non-fissionable}}{U_{92}^{238}} + n_0^1 \longrightarrow + \underset{\text{Fissionable}}{Pu_{94}^{239}} + 2e^-$$

$$Pu_{94}^{239} + n_0^1 \longrightarrow \text{Fission products} + 3n_0^1$$

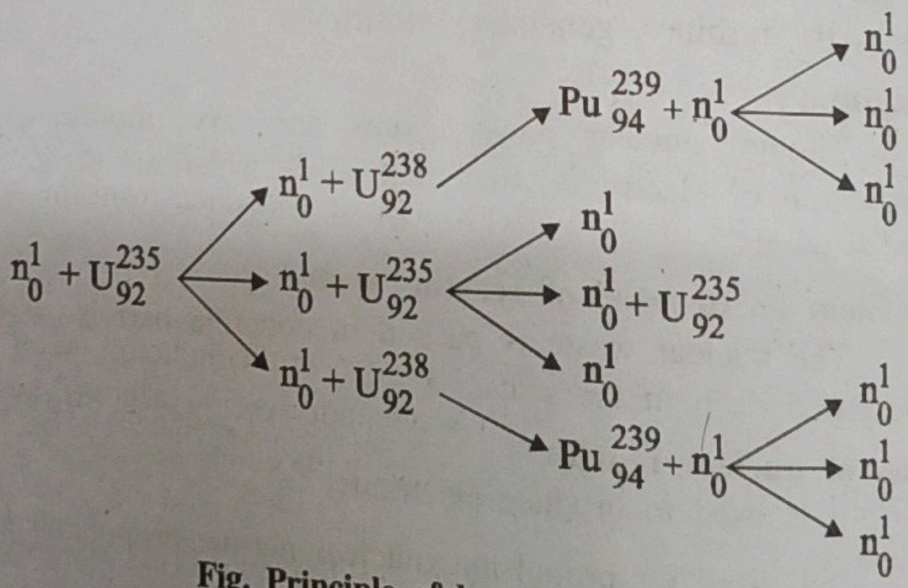


Fig. Principle of breeder reactor

In breeder reactor, of the three neutrons emitted in the fission of U^{235}, only one is used in propagating the fission chain with U^{235}. The other two are allowed to react with

Thus, two fissionable atoms of Pu^{239} are produced for one atom of U^{235} consumed. Therefore, the breeder reactor makes more fissionable material than it uses. Hence Pu^{239} is man made nuclear fuel and is known as secondary nuclear fuel.

Significance

(i) The non-fissionable nucleides, such as U^{238} & Th^{232}, called fertile nucleides, are converted into fissile nucleides. (ii) The fissionable nucleides such as U^{235} & Pu^{239} are called fissile nucleides. (iii) As regeneration of fissile nucleided takes place, its efficiency is more.

4. ***What is a photovoltaic cell? Explain the construction and working of a photovoltaic cell with a diagram.***

(A.U May 2015)

(or)

Describe the conversion of solar energy into electrical energy.

(CBE. A.U. Jan 2009)

Definition

Photogalvanic cell (or) Photovoltaic cell is the one, which converts the solar energy (energy obtained from the sun) directly into electrical energy.

Construction

Solar cells consist of a p-type semiconductor (such as Si doped with B) and n-type semiconductor (such as Si doped with P). They are in close contact with each other.

Working

When the solar rays fall on the top layer of p-type semiconductor, the electrons from the valence band get promoted to the conduction band and cross the p-n junction into n-type semiconductor. There by potential difference between two layers is created, which causes flow of electrons (i.e., an electric current). Thus, when this p and n layers are

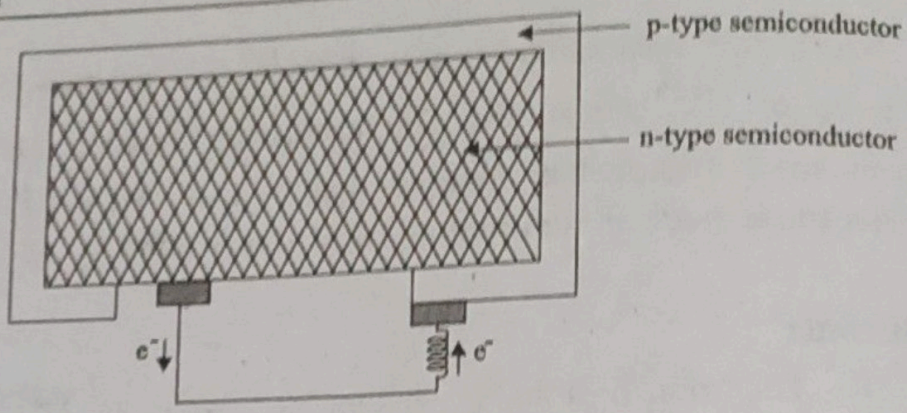


Fig. Solar cell

connected to an external circuit, electrons flow from n-layer to p-layer, and hence current is generated.

The potential difference and hence current increases as more solar rays falls on the surface of the top layer.

7. State the principle and applications of solar batteries

(A.U. Jan 2013, May 2008, Dec 2014)

Principle

The basic principle involved in the solar cells is based on the photovoltaic (PV) effect. When the solar rays fall on a two layer of semi-conductor devices, a potential difference between the two layer is produced. This potential difference causes flow of electrons and produces electricity.

Applications of solar batteries

1. Lighting purpose

Solar battery can be used for lighting purpose. Now a days electrical street lights are replaced by solar street lights.

2. Solar pumps run by solar battery

When a large number of solar cells are connected in series it form a solar battery. Solar battery produces more electricity which is enough to run, water pump, street-light, etc., They are also used in remote areas where conventional electricity supply is a problem.

3. Solar cells are used in calculators, electronic watches, radios and TVs.

4. Solar cells are superior to other type of cells, because these are non-polluting and eco-friendly.

5. Solar energy can be stored in Ni-Cd batteries and lead-acid batteries.
6. Solar cells can be used to drive vehicles.
7. Solar cells, made of silicon, are used as a source of electricity in space craft and satellites.

8. *Write a note on wind energy.*

(TNV A.U. May 2009, Chen. A.U. June 2009)

(or)

Explain how electric power is generated by using wind energy.

(A.U July 2016)

(or)

How is wind energy harnessed? What are its advantages and limitations.

(A.U May 2015)

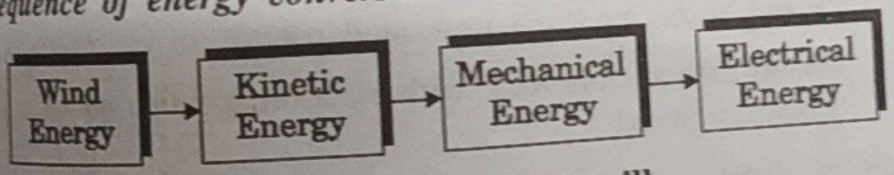
Moving air is called wind. ***Energy recovered from the force of wind is called wind energy.*** Energy possessed by the wind is due to its high speed. Kinetic energy of the wind is converted into mechanical energy.

Methods of harnessing wind energy

Wind mill

It is a device used to harness (convert) wind energy into mechanical energy.

Sequence of energy conversion



Construction and working of a wind mill

It consists of a wheel containing number of blades. The wheel rotates about an axle mounted on a pole (Fig.). The wind energy is used to rotate the wheel. One end of the axle is connected to the armature of a generator, which rotates between two poles (north and south poles) of a strong magnet. Another end of the axle is connected to the shaft of the wind mill. When wind falls on the wheel of a wind mill, it rotates

and electric current is produced. Thus, the kinetic energy of the wind is converted into electric energy.

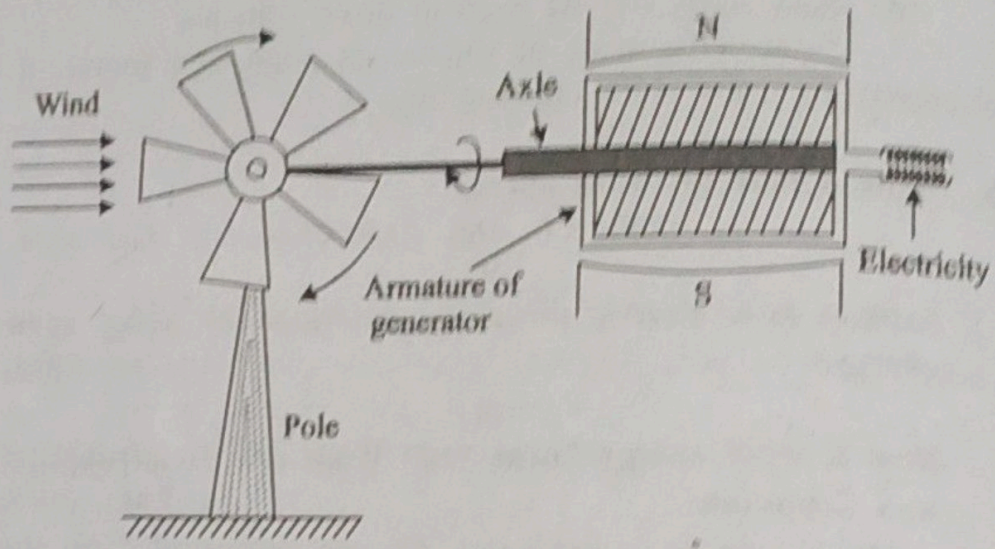


Fig. Wind Energy

Advantages (or) Merits of wind energy

(i) It does not cause any pollution.
(ii) It is very cheap and economic.
(iii) It is renewable.

Disadvantages (or) Demerits of wind energy

1. Wind farms located on the migratory routes of birds will cause hazards.
2. Wind farms produce unwanted sound.
3. Wind turbines interfere with electromagnetic signals (TV, Radio signals).

Uses of wind energy

1. Wind energy is used to move the sail boats in lakes, rivers and seas.
2. It is used to operate water pumps.
3. It is used to run the flour mill to grind the grains.
4. It is also used to produce electricity.

9. Explain various types of highly investigated solar cell materials?

1. Crystalline silicon (c-Si)

Crystalline silicon (c-Si) is the most used (90% of the global PV market) semiconducting material in solar panels. But, its efficiency is only 30%. So, solar cells with low-cost and high-efficiency materials are emerging.

Examples

(i) III-V multijunction materials: (efficiency > 30%)

(ii) Hybrid tandem III-V/Si solar cells: (efficiency > 30%)

2. Thin films

Due to their narrow design (light weight, flexibility and ease of installation) second-generation thin-film solar cells are growing as one of the most promising PV technologies. This films are 350 times smaller light absorbing layers compared to standard Si-panels.

Examples

(i) Cadmium-telluride (CdTe).

(ii) Amorphous silicon.

3. Perovskite solar cells

Among the next generation solar cells, hybrid metal halide perovskite solar cells (PSCs), play an important role due to their low price, thinner design, low temperature processing and excellent light absorption properties.

Example

Combined perovskite and Si-PV materials shows a record efficiency of upto 28%.

4. Solar paints

Solar paint is the another transformative technology. These can be coated over the polymer films.

Examples

(i) Solar paint hydrogen generates energy from photovoltaic water splitting.

(ii) Quantum dots (Photovoltaic paint)

5. Transparent solar windows

They possess highly innovative applications. Thei solar-to-electricity conversion efficiency is 10% more.

6. Thermoradiative PV devices (or) Reverse solar panels

They can generate electricity at night by utilizing the heat irradiated from the panels to the optically coupled deep space, which serves as a heat sink.

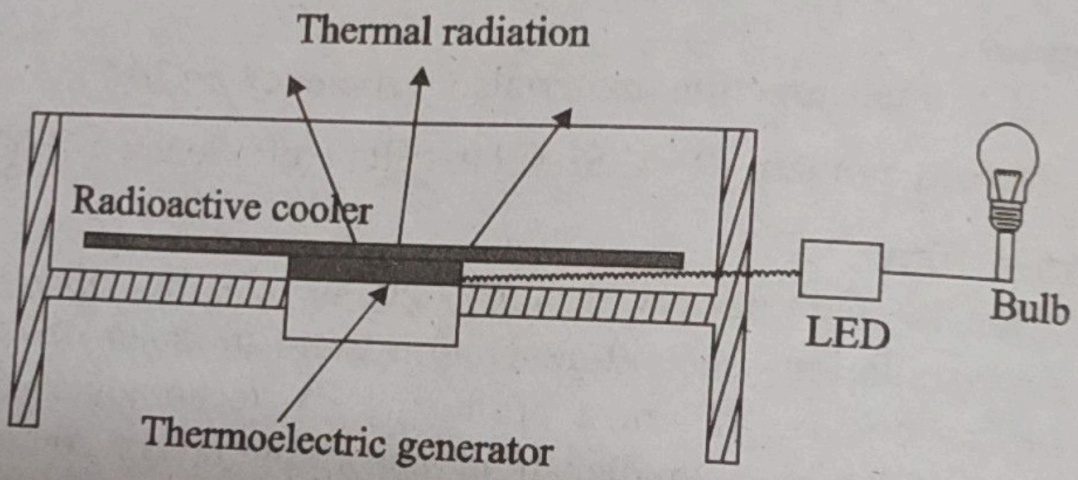


Fig. Thermoradiative PV devices