NCES INT 2 QUE WITH SOL

Credits:- परमेश्वर

Explain the parameters that affect the performance of liquid flat plate collector.

(a) Selective Surface Absorber plate surfaces which exhibit the characteristics of high value of absorptivity for incoming solar radiation and low value of emissivity for outgoing re-radiation are called selective surfaces. Such surfaces are desirable because they maximize the net energy collection. Some examples of selective surface layers are copper oxide, nickel black, and black chrome.

(b) Number of Covers With the increase in the number of covers, the values of both $(\tau\alpha)_b$ and $(\tau\alpha)_d$ decrease, and thus the flux absorbed by the absorber plate decreases. The value of heat loss from the absorber plate also decreases. However, the amount of decrease is not the same for each cover. Maximum efficiency is obtained with one or two covers.

(c) Spacing Heat loss also varies with spacing between two covers and that between temperature and also varies with tilt. Since collectors are designed to operate at different locations with varying tilts and under varying service conditions, an optimum value of spacing is difficult to specify. Spacing in the range from 4 to 8 cm is normally suggested.

(d) Collector Tilt Flat plate collectors are normally used in a fixed position and do not track the sun. Therefore, the tilt angle at which they are fixed is very important. The optimum tilt depends on the nature of the application. The usual practice is to recommend a value of $(\varphi + 10°)$ or $(\varphi + 15°)$ for winter applications (e.g. water heating, space heating, etc.) and $(\varphi - 10°)$ or $(\varphi - 15°)$ for summer applications (e.g. absorption refrigeration plant, etc.).

(e) Dust on the Top of the Cover When a collector is deployed in a practical system, the dust gets accumulated over it, reducing transmitted flux through the cover. This requires continuous cleaning of the cover, which is not possible in a practical situation. Cleaning is generally done once in a few days. For this reason, it is recommended that the incident flux be multiplied by a correction factor which accounts for the reduction in intensity because of the accumulation of dust. In general, a correction factor from 0.92 to 0.99 seems to be indicated.

Explain briefly thermal analysis of liquid flat plate collector.

1 Thermal analysis of liquid flat plate collector

Let us consider a flat plate solar collector shown in Fig. 5.3 for thermal analysis. The heat flow process is shown in Fig. 5.42.

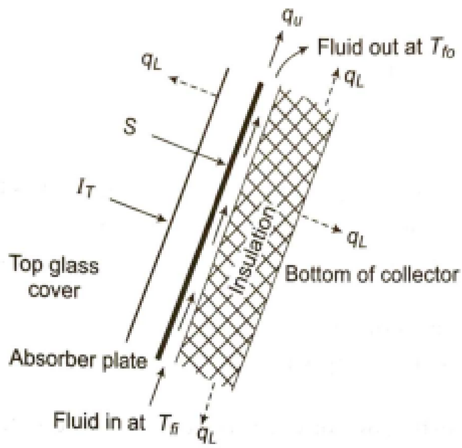


Figure 5.42 Heat transfer process in flat plate solar collector

Energy balance of the absorber plate, under steady state condition yields:

$$q_u = A_p S - q_L \tag{5.1}$$

where, q_u = useful heat gain (i.e. heat transfer rate to the working fluid), W
A_p = area of absorbing plate, m^2
S = incident solar flux absorbed in the collector plate, W/m^2
q_L = rate at which energy is lost by:
(i) convection and re-radiation from the top, and
(ii) conduction and convection from the bottom and sides of the collector

Also, the heat transfer rate to the working fluid is given by,

$$q_u = \dot{m}\ C_f (T_{fo} - T_{fi}) \tag{5.2}$$

where, $\dot{m}$ = mass flow rate of the fluid, kg/s
C_f = specific heat of the fluid, J/m^2-K
T_{fi} = fluid temperature at the input of collector, K
T_{fo} = fluid temperature at the output of collector, K

Solar flux incident on the top of the collector, is same as solar radiation received on inclined plane surface, as given in Chapter 4, Eq. (4.31), that is:

$$I_T = I_b r_b + I_d r_d + (I_b + I_d) r_r$$

where I_b and I_d are the beam and diffuse radiation components of solar radiation, r_b, r_d and r_r are "tilt factors" for beam, diffuse and reflected components respectively. Their expressions are given in Eq. (4.33), (4.34) and (4.35) respectively as follows:

$$r_b = \frac{\sin\delta \sin(\phi - \beta) + \cos\delta \cos\omega \cos(\phi - \beta)}{\sin\delta \sin\phi + \cos\delta \cos\omega \cos\phi}$$

$$r_d = \frac{1+\cos\beta}{2}$$

$$r_r = \rho\left(\frac{1-\cos\beta}{2}\right)$$

where ρ is reflection coefficient of the ground.

The flux S, absorbed in the absorber plate, can be given as,

$$S = I_b\, r_b\, (\tau\alpha)_b + \{I_d\, r_d + (I_b + I_d)\, r_r\}\, (\tau\alpha)_d \tag{5.3}$$

where,

τ = transmissivity of the glass cover system, defined as the ratio of the solar radiation coming through after reflection at the glass air interfaces and absorption in the glass to the radiation incident to the glass cover system.

α = absorptivity of the absorber plate.

$(\tau\alpha)_b$ = transmissivity-absorptivity product for beam radiation falling on the collector,

$(\tau\alpha)_d$ = transmissivity-absorptivity product for diffuse radiation falling on the collector

The **instantaneous collection efficiency**, η_i of a flat plate solar collector is given by,

$$\eta_i = \frac{\text{useful heat gain}}{\text{solar radiation incident on the collector}} = \frac{q_u}{A_c\, I_T} \tag{5.4}$$

where, I_T = instantaneous radiation energy rate incident on collector face (W/m^2)

A_c = the collector gross area (area of the topmost cover including the frame). A_c is usually 15 to 20 per cent more than A_p.

It is to be noted here, that the energy rate incident on the collector is $A_c I_T$. A fraction of this energy is lost in the cover system during transmission through it. The energy rate received on the absorber plate is $A_p S$. Out of this energy, q_u is the rate of heat (energy) transfer to working fluid while q_L is the energy loss rate from the absorber plate.

If the liquid flow rate through the collector is stopped, there is no useful heat gain and therefore, the efficiency is zero. In this case, total heat absorbed by plate is lost to ambient and the absorber plate attains a temperature according to $A_p S = q_L$. This is the highest temperature, the absorber plate can attain and is referred to as the **stagnation temperature**. Knowledge of the stagnation temperature is useful for comparing different collector designs. It also helps in proper material selection for the construction of collector.

To determine the efficiency of collector one needs to evaluate q_u, for which S and q_L are to be known. S can be evaluated using Eq. (5.3) provided the terms $(\tau\alpha)_b$ and $(\tau\alpha)_d$ are known. We shall now derive the expressions for evaluating theses quantities.

Explain briefly transmissivity – absorptivity product.

1.3 Transmissivity - Absorptivity Product ($\tau\alpha$)

The transmissivity-absorptivity product is defined as the ratio of the flux absorbed in the absorber plate to the flux incident on the cover system and is denoted by the symbol ($\tau\alpha$), an appropriate (*b* or *d*) being added to indicate the type of incident radiation.

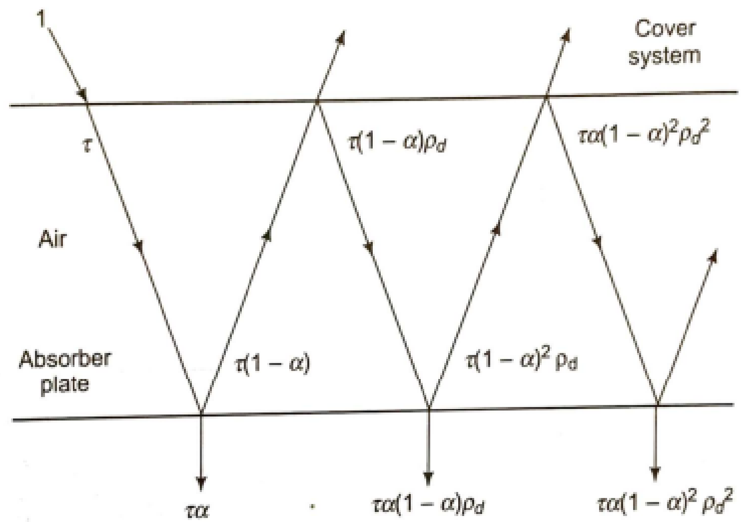


Figure 5.46 Absorption and reflection at the absorber plate

As shown in the Fig. 5.46, out of fraction τ transmitted through the cover system, a part is absorbed and a part reflected diffusedly. Out of the reflected part, a portion is transmitted out through the cover system and a portion reflected back to absorber plate. The process goes on indefinitely with successive attenuation. Thus net fraction absorbed is given by,

$$(\tau\alpha) = \tau\alpha\,[1 + (1-\alpha)\rho_d + (1-\alpha)^2\rho_d^2 + \ldots]$$

$$= \frac{\tau\alpha}{1-(1-\alpha)\rho_d} \qquad (5.20)$$

where, ρ_d represents the diffuse reflectivity of the cover system. It can be shown that:

$$\rho_d = (\tau_a)_d \{1-(\tau_r)_d\} \tag{5.21}$$

where $(\tau_a)_d$ and $(\tau_r)_d$ are calculated for diffuse radiation considering an incidence angle of 60°. Eq. (5.20) may be applied separately to both, beam radiation and diffuse radiation. However, the values of cover system transmissivities are different for beam and diffuse radiations.

Thus for beam radiation,

$$(\tau\alpha)_b = \frac{(\tau)_b \times \alpha}{1-(1-\alpha)\rho_d} \tag{5.22}$$

And for diffuse radiation,

$$(\tau\alpha)_d = \frac{(\tau)_d \times \alpha}{1-(1-\alpha)\rho_d} \tag{5.23}$$

Same value of absorptivity α applies to both beam as well as diffuse radiations.

Explain Briefly Top, Bottom and Side loss coefficient.

1.5 Evaluation of loss coefficients

1. Top Loss Coefficient, U_t

The top loss coefficient is evaluated by considering convection and re-radiation losses from the absorber plate in the upward direction. Evaluation through normal procedure requires tedious iterative calculations. Based on calculations for a large number of cases covering the entire range of conditions normally expected for flat plate collectors, Malhotra et al. [28] suggested following empirical equation for calculation of U_t.

$$U_t = \left[\frac{M}{\left(\frac{C}{T_{pm}}\right)\left(\frac{T_{pm}-T_a}{M+f}\right)^{0.252}} + \frac{1}{h_w} \right]^{-1} + \left[\frac{\sigma(T_{pm}^2+T_a^2)(T_{pm}+T_a)}{\frac{1}{\varepsilon_p+0.0425M(1-\varepsilon_p)} + \frac{2M+f-1}{\varepsilon_c} - M} \right] \tag{5.37}$$

where, $$f = \left(\frac{9}{h_w} - \frac{30}{h_w^2}\right)\left(\frac{T_a}{316.9}\right)(1+0.091M) \tag{5.38}$$

$$C = 204.429(\cos\beta)^{0.252}/L^{0.24} \tag{5.39}$$

$$h_w = 8.55 + 2.56\,V_\infty \tag{5.40}$$

= convective heat transfer coefficient at the cover (often referred to as wind heat transfer coefficient, W/m^2-k)

V_∞ = wind speed, m/s

M = Number of glass covers

σ = Stefan-Boltzmann constant, W/m^2-K^4

ε_p = Emissivity of absorber surface for long wavelength radiation

ε_c = Emissivity of cover for long wavelength radiation

L = Spacing between absorber plate and 1st glass cover (which is also equal to spacing between the two adjacent glass covers)

2. Bottom Loss Coefficient, U_b

The bottom loss component U_b is evaluated by considering conduction and convection losses from the absorber plate in the downward direction through the bottom of the collector as shown in Fig. 5.48.

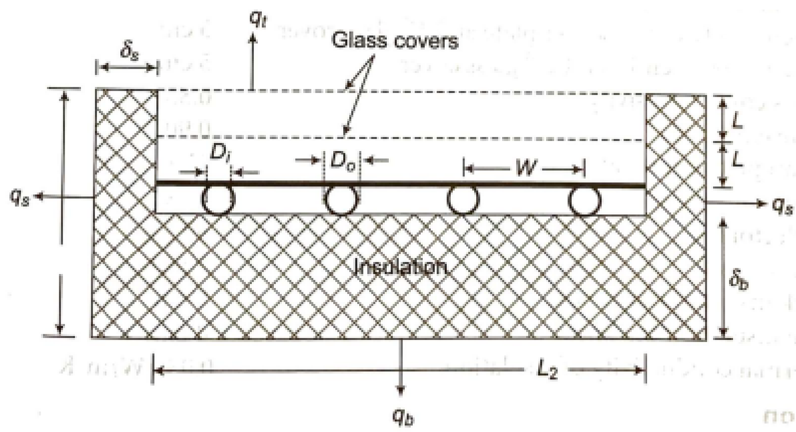


Figure 5.48 Bottom and side losses from a flat plate collector

It is assumed that the flow of heat is one dimensional and steady. In most cases, the thickness of insulation provided is such that the convection is negligible and heat loss takes place predominantly by conduction. Thus, the bottom heat loss is given by,

$$U_b = \frac{k_i}{\delta_b} \tag{5.41}$$

where, k_i = Thermal conductivity of insulation, W/m-K
δ_b = Thickness of the insulation, m

3. Side Loss Coefficient, U_s

In this case also, it is assumed that the convection is negligible, conduction losses dominate and the flow is one dimensional and steady. If the dimensions of absorber plate are $L_1 \times L_2$ and the height of collector casing is L_3, the area across which the heat flows sideways is $2(L_1 + L_2)\,L_3$. The temperature drop across which the heat flow takes place varies from $(T_{pm} - T_a)$ at the absorber level to zero, both at the top and at the bottom. Therefore, average temperature drop across the side insulation may be considered as, $(T_{pm} - T_a)/2$. The heat flow may be given as,

$$q_s = 2L_3(L_1 + L_2)k_i \frac{T_{pm} - T_a}{2\delta_s} \tag{5.42}$$

Therefore,

$$U_s = \frac{L_3(L_1 + L_2)k_i}{L_1 L_2 \delta_s} \tag{5.43}$$

where, δ_s = Thickness of the insulation, m

Explain with neat sketch photo voltaic cell.

3 Solar Cell Principles.

The photo-voltaic effect can be observed in nature in a variety of materials, but the materials that have shown the best performance in sunlight are the semi-conductors. When photons from the sun are absorbed in a semiconductor, they create free electrons with higher energies than the electrons which provide the bonding in the base crystal. Once these electrons are created, there must be an electric field to induce these higher energy electrons to flow out of the semi-conductor to do useful work. The electric field in most solar cells is provided by a junction of materials which have different electrical properties.

What is a solar cell?

Solid state device that converts incident solar energy directly into electrical energy

Advantages:

1. Efficiencies from a few percent up to 20-30%
2. No moving parts
3. No noise
4. Lifetimes of 20-30 years or more

To obtain a useful power output from photon interaction in a semi-conductor three processes are required.

1. The photons have to be absorbed in the active part of the material and result in electrons being excited to a higher energy potential.
2. The electron-hole charge carrier created by the absorption must be physically separated and moved to the edge of the cell.
3. The charge carriers must be removed from the cell and delivered to a useful load before they loose their extra potential.

For completing the above processes, a solar cell consists of:

a. Semi-conductor in which electron hole pairs are created by absorption of incident solar radiation.
b. Region containing a drift field for charge separation, and
c. Charge collecting front and back electrodes.

The photo-voltaic effect can be described easily for p-n junction in a semi-conductor. In an intrinsic semi-conductor such as silicon, each one of the four valence electrons of the material atom is tied in a chemical bond, and there are no free electrons at absolute zero. If a piece of such a material is doped on one side by a five-valence electron material, such as arsenic or phosphorus, there will be an excess electrons in that side, becomes an n-type semiconductor. The excess electrons will be practically free to move in the semiconductor lattice. When the other side of the same piece is dopped by a three-valence electron material, such as boron, there will be deficiency of electrons leading to a p-type semiconductor. This deficiency is expressed in terms of excess of holes free to move in the lattice. Such a piece of semi-conductor with one side of the p-type and the other of the n-type is called a p-n junction. In this junction after the photons are absorbed, the free electrons of the n-side will tend to flow to the p-side, and the holes of the p-side will tend to flow to the n region to compensate for their respective deficiencies. This diffusion will create an electric field E_F from the n region to the p-region. This field will increase until it reaches equilibrium for V_e, the sum of the diffusion potentials for holes and electrons. If electrical contacts are made with the two semiconductor materials and the contacts are connected through an external electrical conductor, the free electrons will flow from the n-type material through the conductor to the p-type material. Here the free electrons will enter the holes and become bound electrons; thus, both free electrons and holes will be removed. The flow of electrons through the external conductor constitutes an electric current which will continue as long as more free electrons and holes are being formed by the solar radiation. This is the basis of photovoltaic conversion, that is, the conversion of solar energy into electrical energy. The combination of n-type and p-type semiconductors thus constitutes a photovoltaic (PV) cell or solar cell. All such cells generate direct current which can be converted into alternating current if desired.

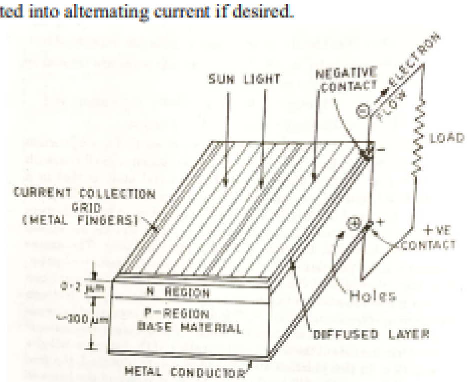


Figure 1: Schematic view of a typical solar cell

or

Photovoltaic or Solar Cell

Definition: The Photovoltaic cell is the semiconductor device that converts the light into electrical energy. The voltage induces by the PV cell depends on the intensity of light incident on it. The name Photovoltaic is because of their voltage producing capability.

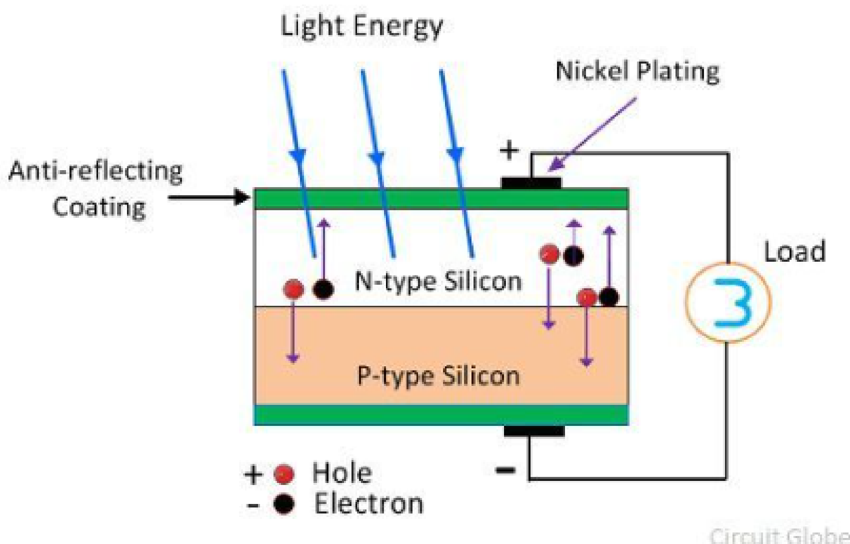
The electrons of the semiconductor material are joined together by the covalent bond. The electromagnetic radiations are made of small energy particles called photons. When the photons are incident on the semiconductor material, then the electrons become energised and starts emitting.

The energises electron is known as the Photoelectrons. And the phenomenon of emission of electrons is known as the photoelectric effect. The working of the Photovoltaic cell depends on the photoelectric effect.

Construction of Photovoltaic Cell

The semiconductor materials like arsenide, indium, cadmium, silicon, selenium and gallium are used for making the PV cells. Mostly silicon and selenium are used for making the cell.

Consider the figure below shows the constructions of the silicon photovoltaic cell. The upper surface of the cell is made of the thin layer of the p-type material so that the light can easily enter into the material. The metal rings are placed around p-type and n-type material which acts as their positive and negative output terminals respectively.



The multi-crystalline or monocrystalline semiconductor material make the single unit of the PV cell. The mono-crystal cell is cut from the volume of the semiconductor material. The multicell are obtained from the material which has many sides.

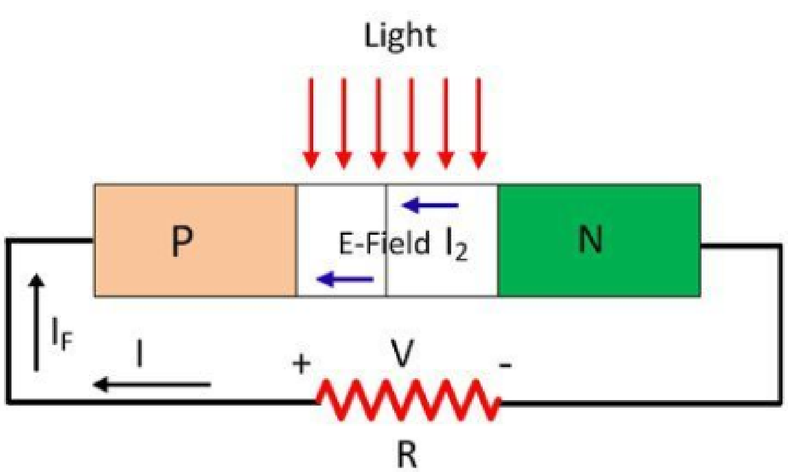
The output voltage and current obtained from the single unit of the cell is very less. **The magnitude of the output voltage is 0.6v, and that of the current is 0.8v.** The different combinations of cells are used for increasing the output efficiency. There are three possible ways of combining the PV cells.

Working of PV cell

The light incident on the semiconductor material may be pass or reflected through it. The PV cell is made of the semiconductor material which is neither a complete conductor nor an insulator. This property of semiconductor material makes it more efficient for converting the light energy into electric energy.

When the semiconductor material absorbs light, the electrons of the material starts emitting. This happens because the light consists small energise particles called photons. When the electrons absorb the photons, they become energised and starts moving into the material. Because of the effect of an electric field, the particles move only in the one direction and develops current. The semiconductor materials have the metallic electrodes through which the current goes out of it.

Consider the figure below shows the PV cell made of silicon and the resistive load is connected across it. The PV cell consists the P and N-type layer of semiconductor material. These layers are joined together to form the PN junction.



P-N Junction Solar Cell with Resistive Load

The junction is the interface between the p-type and n-type material. When the light fall on the junction the electrons starts moving from one region to another.

Explain the working principle of horizontal axis wind turbine.

1.6.1 Horizontal Axis Turbines

These are very commonly used for converting wind energy into electrical energy. These a further classified as 2-blades, 3-blades and multiblade machines.

1.6.1.1 Two blade-Rotor.

These are used for electric power generation and used in the range 1 MW to 3 MW. They are subjected to large vibrations during running. A teething-cont is provided to this machine to reduce the fatigue to the main shaft. This is because the bla in upper position experiences greater force than blade at lower position. The tip speed ratio of this rotor is 33% higher than 3-blade machines.

1.6.1.2 3-Blade Rotor.

This rotor is commonly used as its efficiency is higher than two-blade rotor but the cost is 30 - 40% high. It is used from 15 kW to 5 MW capacity range. A small scale machine of this type is roof top mounted for generating the power to run all electrical equipments in the house. Small size rotor of 2 m diameter is generally used to produce 800-1000 watts power. These units are provided with wind-vane at tail which makes the rotor to come inline with wind direction.

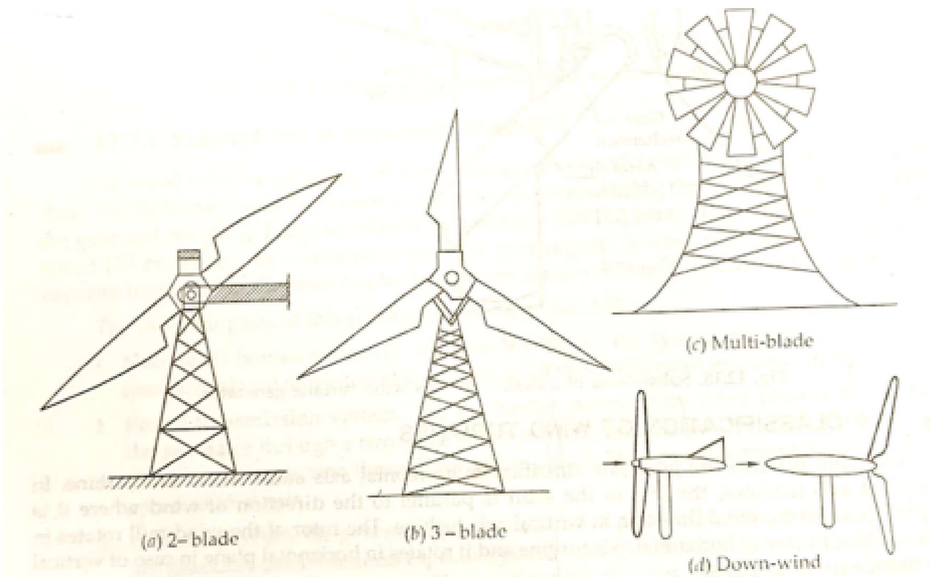
1.6.1.3 Multiblade Rotor.

This rotor has high solidity factor and generally used for water pumping purposes. This is because of high starting torque-characters which is needed for water pumping. This rotor has low tip speed ratio and therefore less noisy. The main disadvantage is less efficient.

1.6.1.4 Up-ward and Down-ward rotors.

The rotor is also classified as upward and downward machine.

In upward machine the rotor is located in front of towar whereas it is located behind the tower



Downward machine allows the use of free yaw-system and also allows the blades to deflect away from the tower when loaded. But, it suffers from wind-shadow-effect of tower on the blades (in region of separated flow).

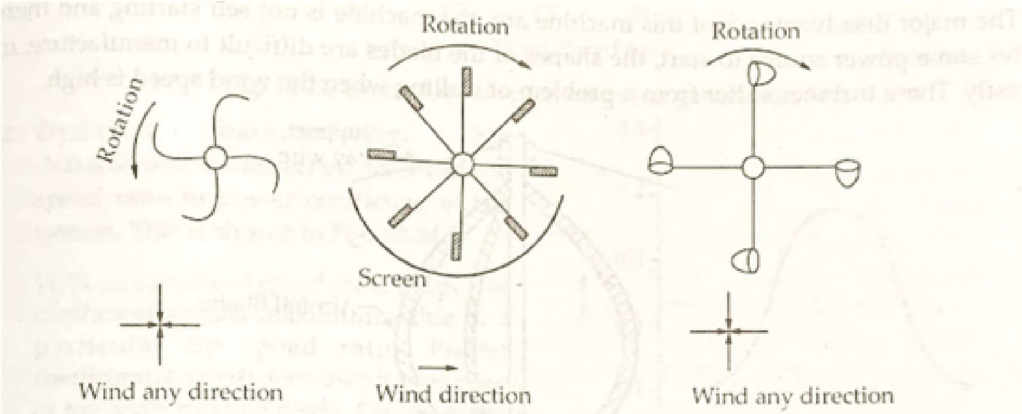
On the other hand, upward machine produces higher power as it eliminates the effect of tower shadow on the blades. This also results in lower noise, lower fatigue on the blades and smoother power output.

With neat sketch explain the working principle of Savonious and Darrius wind mill.

1.6.2 Vertical Axis Wind-Mill

In this system, the rotor is mounted on the vertical shaft. The types of the blades mounted are of different configurations as shown in Fig. Among all, two configurations described beloware commonly used.

(a) Primary Drag type



(a) Multi blades (b) Screened (c) Cuppled

1.6.2.1 Savonious wind mill.

The rotors of these turbines are S-type in shape and supported at top and bottom by two circular plates as shown in Fig. The two curved blades are fixed on central pipe and free to rotate. The air strikes on concave side of the blade, rotate through centre of rotor and glides over the convex surface of the other blade. This turbine suffers from the disadvantage that when the convex surface faces the wind, the speed of the turbine slows down. This effect is eliminated by providing 4-blades so that one concave surface will always be there to allow the air-flow irrespective of wind direction.

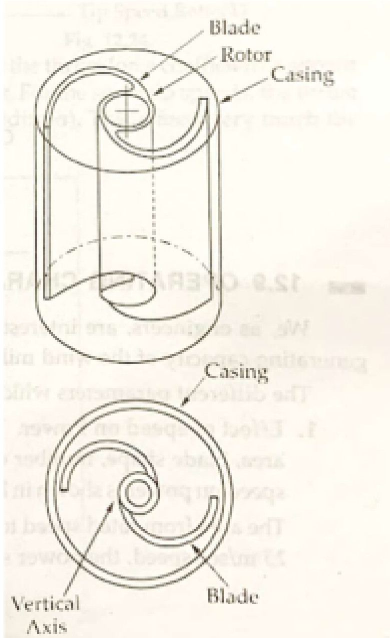


Fig. 12.21. Savonious wind turbine.

These machines are used for pumping water and grinding mills because of low speed (100 RPM). They are not preferred for electric power generating purposes because of low speed.

The advantages of this machine are:

1. Low speed wind is successfully used.
2. Pitch and yaw-controls are not required.
3. Generator can be mounted on the ground which further simplifies the tower design.

The noise is more as well as its power density is lower compared with horizontal axis and mills.

1.6.2.2 Darrieus wind-mill.

This is the only vartical axis machine used successfully on commercial basis. It is named in the honor of French engineer Georges Darrieus. This type of turbine is shown in Fig. It consists of 2 or 3 thin curved aerofoil section, C shaped blades. Both the ends of the blades are fixed to the vertical shaft. The rotor rotates on two bearings placed at top and bottom of the pipe.

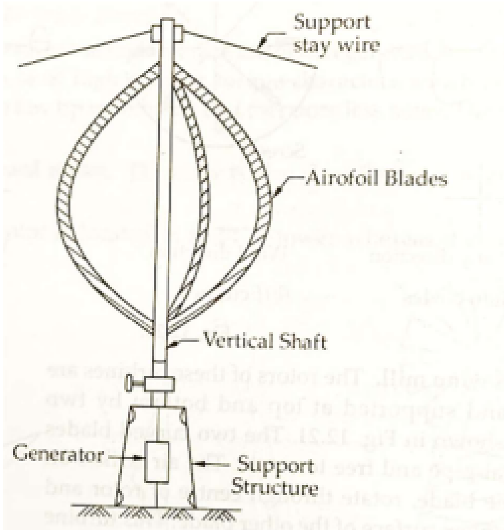


Fig. 12.22. Darrieus rotor.

It looks like an egg-beater and operates with the wind coming from any direction. This type of wind mills are available in the range of 4 to 14 MW capacity and with an efficiency of 35 - 40%.

The major advantages of this machine are, the generator can be mounted on the ground and it does not require yaw mechanism to turn the rotor as per wind direction. The major disadvantages of this machine are, the machine is not self starting and therefore requires some power source to start, the shapes of the blades are difficult to manufacture, install and costly. These turbines suffer from a problem of stalling when the wind speed is high.

What are the advantages and disadvantages of wind mill?

1.7 Advantages and disadvantages of wind energy

1.7.1 Advantages

1. The electrical energy generation is totally pollution free.
2. It is renewable form of energy and available free of cost.
3. It is more suitable in rural, offshore and onshore areas.
4. It is reliable and cost effective for large capacity units.
5. Wind does not require any transportation.
6. It does not require any water like thermal and nuclear power plants.
7. The operating cost is considerably low.
8. This plant does not require any regular man power.
9. It is economically competitive with other energy sources.

1.7.2 Disadvantages:

1. The power output is not uniform and some back-up is required. This system requires storage batteries. They are very far away from the cities and load centers.
2. Wind power density (W/m^2) is very low.
3. The wind-rotor efficiency is low (10-40%).
4. Capital cost (Rs/kW) for small unit is considerably high.
5. The weight of this system (kg/kW) is high compared with conventional system.
6. Wind energy generates noise pollution.
7. It requires large open area.
8. As it is located far away from the point of utilization, therefore transmission losses are large if connected to main grid.
9. It is observed that big wind farms change the rainfall pattern which is not desirable for crops.
10. The windmill creates interference when placed between radio and television stations as it reflects electromagnetic radiation. It is also hazardous for civil aviation.

Describe the consideration of selecting a site for wind generator.

Some of the main site selection consideration are given below:

1. *High annual average wind speed:*
2. *Availability of anemometry data:*
3. *Availability of wind V(t) Curve at the proposed site:*
4. *Wind structure at the proposed site:*
5. *Altitude of the proposed site:*
6. *Terrain and its aerodynamic:*
7. *Local Ecology*
8. *Distance to road or railways:*
9. *Nearness of site to local centre/users:*
10. *Nature of ground:*
11. *Favourable land cost:*

1. **High annual average wind speed:**

The speed generated by the wind mill depends on cubic values of velocity of wind, the small increases in velocity markedly affect the power in the wind. For example, Doubling the velocity, increases power by a factor of 8. It is obviously desirable to select a site for WECS with high wind velocity. Thus a high average wind velocity is the principle fundamental parameter of concern in initially appraising WESCS site. For more detailed estimate value, one would like to have the average of the velocity cubed.

2. **Availability of anemometry data:**

It is another improvement sitting factor. The aenometry data should be available over some time period at the precise spot where any proposed WECS is to be built and that this should be accomplished before a sitting decision is made.

3. **Availability of wind $V_{(t)}$ Curve at the proposed site:**

This important curve determines the maximum energy in the wind and hence is the principal initially controlling factor in predicting the electrical output and hence revenue return o the WECS machines.

It is desirable to have average wind speed 'V' such that V>=12-16 km/hr (3.5 – 4.5 m/sec) which is about the lower limit at which present large scale WECS generators 'cut in' i.e., start turning. The $V_{(t)}$ Curve also determines the reliability of the delivered WECS generator power, for if the $V_{(t)}$ curve goes to zero there be no generated power during that time.

If there are long periods of calm the WECS reliability will be lower than if the calm periods are short. In making such realiability estimates it is desirable to have measured $V_{(t)}$ Curve over about a 5 year period for the highest confidence level in the reliability estimate.

4. **Wind structure at the proposed site:**

The ideal case for the WECS would be a site such that the $V_{(t)}$ Curve was flat, i.e., a smooth steady wind that blows all the time; but a typical site is always less than ideal. Wind specially near the ground is turbulent and gusty, and changes rapidly in direction and in velocity. This depature from homogeneous flow is collectively referred to as "the structure of the wind".

5. Altitude of the proposed site:

It affects the air density and thus the power in the wind and hence the useful WECS electric power output. Also, as is well known, the wind tend to have higher velocities at higher altitudes. One must be carefully to distinguish altitude from height above ground. They are not the same except for a sea level WECS site.

6. Terrain and its aerodynamic:

One should know about terrain of the site to be chosen. If the WECS is to be placed near the top but not on the top of a not too blunt hill facing the prevailing wind, then it may be possible to obtain a 'speed-up' of the wind velocity over what it would otherwise be. Also the wind here may not flow horizontal making it necessary to tip the axis of the rotor so that the aeroturbine is always perpendicular to the actual wind flow.

It may be possible to make use of hills or mountains which channel the prevailing wind into a pass region, thereby obtaining higher wind power.

7. Local Ecology

If the surface is base rock it may mean lower hub height hence lower structure cost. If trees or grass or vegetation are present, all of which tend to destructure the wind, the higher hub heights will be needed resulting in larges system costs that the bare ground case.

8. Distance to road or railways:

This is another factor the system engineer must consider for heavy machinery, structure, materials, blades and other apparatus will have to be moved into any choosen WECS site.

9. Nearness of site to local centre/users:

This obvious criterion minimizes transmission line length and hence losses and cost. After applying all the previous string criteria, hopefully as one narrows the proposed WECS sites to one or two they would be relatively near to the user of the generated electric energy.

10. Nature of ground:

Ground condition should be such that the foundation for a WECS are secured. Ground surface should be stable. Erosion problem should not be there, as it could possibly later wash out the foundation of a WECS, destroying the whole system.

11. Favourable land cost:

Land cost should be favourable as this along with other siting costs, enters into the total WECS system cost.

12. Other conditions such as icing problem, salt spray or blowing dust should not present at the site, as they may affect aeroturbine blades or environmental is generally adverse to machinery and electrical apparatus.

Explain with neat sketch single and double basin tidal power plant.

2.3.2 Tidal power plants with two basins

2.3.2.1 Alternating Operating Basins

In this, two adjacent basins are operated on a normal single cycle. Basin 1 produces power on the ebb cycle and basin 2 produces power on the tide cycle as shown in Fig.

By this, continuous power generation is made possible avoiding excessive power fluctuation. There will be fluctuation only between t_1 to t_2, t_3 to t_4 t_5 to t_6 and so on but this is for a very short period. This is because of changes in power supply from one basin to another basin.

2.3.2.2 Co-operating Basins

In this case, there is a upper basin adjacent to a lower basin. The water level in the upper basin is always higher than mean sea level and that of lower basin is always lower than mean sea level. During high tide, upper basin is filled up by sluice 'I' as shown in Fig.

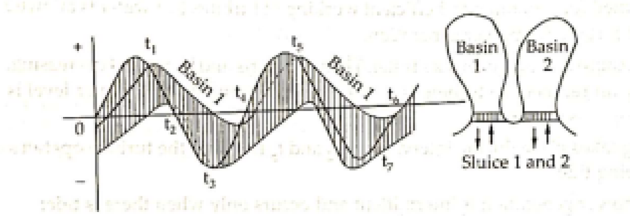


Fig. System of alternating operating basin

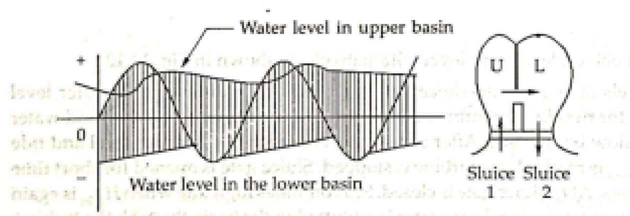


Fig. System of co-operative basin

Tide takes place from t_1 to t_2, and at this time, sluice '1' is kept open and upper basin is filled up. During t_2 to t_5 water of upper basin is allowed to flow to lower basin through power plant. Thus, cycle is repeated.

For lower basin, from t_0 to t_3, the level of the lower basin goes on increasing due to flow of

water from upper basin. At t_3, the level of sea and basin are equal, so sluice '2' is opened and level of sea further goes down, therefore, the basin water flows back to the sea. This is continued up to t_4, when again both levels are equal.

During t_4 to t_7, again water goes from the upper to lower basin. This way cycle is repeated. In this, there is a continuous flow of water from the upper basin the to lower basin the through turbine, thus, power generation is continuous, in this case.

Explain the principle of tide formation

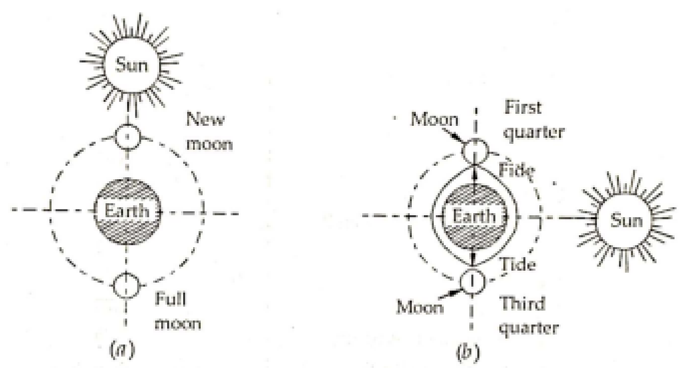
2.1 Principle of Tide Formation and its Characteristics

The generation of energy using tides is not new. Various poets have described the tides in various forms. One such interesting thought is like this. Due to the love for earth, heart of sea becomes full of emotions and these emotions can be seen in the form of flood-tides, but being of afraid of Agarti Muni, ebb tides starts occurring in the sea.

Now-a-days, scientists have found the reason of tidal generation. They have found that the tides in the sea occur due to both the sun and the moon, i.e., attraction effect of sun and moon on every water particle on the earth.

The tides are caused by the combined attraction force of sun and moon on the water surface of the revolving earth. The attraction force of moon is 2.6 times higher than that of sun. Therefore, moon influences more for creating the tides in the ocean.

The tide is a periodic rise and fall of the water level of the ocean. The water in the oceans rises and falls twice during a lunar day (24 hours and 50 minutes). The extra 50 minutes over the solar day results in the maximum water levels occurring at different times, on different days. The magnitude of water level variations at different sites on the earth depends upon latitude of the place. The earth's rotation causes two high tides and two low tides at any place daily.



The time interval between the two successive high tides increases from 12 hours to 12 hours and 25 minutes because of the revolution of the moon around the earth. The three bodies, the sun, earth and moon come in alignment after every two weeks at new moon and full moon as moon takes 28 days to complete one revolution around the earth. At these positions, the sun and moon act simultaneously to produce tides of maximum amplitude as shown in Fig. The solar pull and moon pull act along a line at new moon and full moon causing greater flow and known as spring tides and ebb tides. On the other hand, we get low tides, called neap tide when the pulls act at right angles when the sun and moon are considered in first and third quarter as shown in Fig,

The spring tide is high when the moon is at new and full position because it is the closest point of its orbit to the earth. The simultaneous rotation of moon and earth around the sun creates further variations in the tide amplitude. Because of this combined effect, the spring tide occurs at the quinones in March and September during the year as shown in Fig. The above phenomenon has an important bearing on the location and design of the tidal power plant. A high tide occurs at a point, which is directly under the moon and at the same time, there is also a high tide at diametrically opposite point due to dynamic balancing of the ocean water over the earth. The water over the earth surface bulges during the earth's rotation as shown in Fig(a). The bulging depends upon the position of moon and sun with respect to the position considered on the earth as the forces by moon and sun act *simultaneously.

Advantages & disadvantages

2.6 Advantages and Limitations of Tidal Power Plants

2.6.1 Advantages

1. The barrage provides protection to coast-line against damage by storms.
2. It does not produce green-house effect or other waste.
3. Tidal power does not require any fuel and produces electricity reliably.
4. The tides are predictable and correct design of the plant is possible.
5. The maintenance cost of the plant is less.
6. The tidal plant life is 100 years, which is much higher than thermal plant life (25 years)
7. It is more economical and provides clean energy
8. It is completely independent of the uncertainty of rains which is a common danger of conventional hydel plant.

2.6.2 Disadvantages

1. It does not produce power continuously as tides are available only for 10 hours a day.
2. There are huge effects on ecosystem by the currents in estuary.
3. The construction cost of barrage across an estuary is very high.

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4. This energy is available only at selected sites in the world as minimum tide range required to produce power economically is greater than 4 m.
5. Sedimentation and filtration of basin are the common problems.
6. The effect on ecosystem at the bay site is the biggest drawback of tidal plant.
7. The capital cost is very high, period for construction is longer and payback period is 20 years to 25 years.
8. The tidal ranges are highly variable and the turbine has to work on a wide range of head variations. This affects the efficiency of the plant largely.
9. The tidal power generating capacity depends upon the level difference in the sea and basin. It has to be an intermittent operation feasible only at a certain stage of tidal cycle. This pattern can be improved to some extent by using double cycle and multiple basins systems.
10. The duration of power cycle is reasonably constant but its time of occurrence keeps changing. This produces difficulties in every day planning of the load sharing in the grid.
11. Sea water is highly corrosive, therefore, all machine parts should be made of very special stainless steel which increases the capital cost of the plant.

3.2 Advantages and Disadvantages of Wave Energy

3.2.1 Advantages:

1. It is superior to wind and solar energy as it is naturally concentrated by accumulation over time and space.
2. The power density of wave (kW/m^2) is 100 times greater than power density in wind.
3. Wave power devices do not use large land masses like solar and wind.
4. The wave conversion devices remove a large amount energy from the waves and stops destruction of the sea shore as the water coming out remains in calm state.
5. It is free and renewable energy as well as the devices used are relatively pollution free.
6. It is more superior than solar and tidal energy as the waves are continuous (period is hardly 5 sec to S sec). Solar energy is not available at nights, cloudy weather, rainy seasons and winter. The period of tidal energy is large as it is 12 hours and 25 minutes.
7. The energy storage is not required whereas energy storage for 12 hours to 16 hours is required for solar (in night) and tidal requires storage for a few hours.
8. The power density in wave system is 800 W/m against 250 W/m for solar energy, therefore, the wave energy conversion machine is comparatively smaller (25% only).
9. Wave plants reduce the erosion and corrosion of coastal land.
10. Coastal regions which lack other energy sources can develop wave power.
11. The ocean wave energy can be usefully converted and used in remote islands, ships, light houses, drilling platforms where other alternatives are difficult and costly.

3.2.2 Disadvantages:

1. The energy is available far away from the land, therefore, the transportation is difficult and costly.
2. The wave energy converting machines have to work in a marine environment (like storm and corrosion) and this is to be taken into account during design and construction.
3. Wave machines must be able to withstand severe stresses in storms.
4. The sites of large energy availability are very less in the world.
5. The wave energy converters are relatively complicated and costly.
6. Economic factors such as capital cost, maintenance, repair and replacement are large in nature and are relatively unknown.
7. The corrosion of materials used for plant is one main problem.

4.4 Advantages and disadvantages of OTC system

4.4.1 Advantages:

1. Warm surface water and cold water from the ocean depth are used for power generation so it is considered as a clean abundant and renewable natural source. This source is available day or night.
2. The OTEC plant does not produce CO, so these is no danger of Green-House effect like conventional thermal plants. These is hardly any adverse environmental effect from discharging the used OTEC water back to the ocean. It is environmental friendly.

3. OTEC system can produce power as well as fresh drinking water. It is a significant advantage in island areas where fresh water is a problem.
4. It is considered as unlimited source of energy as the energy is received from the sun on daily basis. In future, this source, if properly developed, will remove complete dependence on fossil fuels.
5. In addition to all above, the cold water drawn from the depth has many other uses like air-conditioning of buildings, assisting agriculture and growing fishes and other sea plants.
6. OTEC can also be used to produce methanol, ammonia, chlorine and many other chemicals.
7. Sea water from the depth is rich in nutrients and it is discharged on surface around the OTEC plant. It offers the possibility of fish farming.

4.4.2 Disadvantages:

1. The cost of power produced by OTEC system is considerably high because of its very poor generating efficiency (5%) and huge capital costs.
2. OTEC plants must be located only where the difference in temperature must be 20°C and above around the year for its economic and practical operation. Ocean depths must be available fairly close to shore-based facilities for economic operation. Floating plantships can provide such flexibility.
3. Construction of OTEC plant and lying of pipes in coastal water are difficult and may cause localized damage to reefs and marine ecosystems.
4. Although successful testing of OTEC is experimentally established, this technology is not yet established on commercial basis.
5. Some additional developments of key components is essential as deep sea water pipe lines, low pressure turbines and condensers for the further development of OTEC system.