UNIT I – ELECTRIC DRIVES AND TRACTION

PART - A

1. List the advantages and disadvantages of electric traction. (Nov – 2017/Nov - 2014)

Advantages

- It has great passenger carrying capacity at higher speed.
- High starting torque.
- Less maintenance cost.
- Cheapest method of traction.

Disadvantages

- High capital cost.
- Problem of supply failure.
- Additional equipment is required for achieving electric braking and control.

2. Define gear ratio. (Nov - 2017)

Gear ratio = (Input Speed)/ (Output Speed) = (Diameter of output gear) / (Diameter of input gear)

3. What are the merits and demerits of DC system of track electrification? (May - 2017)

Merits

- Better torque-speed characteristic.
- Low maintenance cost.
- The weight of d.c motor per H.P is less in comparison to a.c motors.
- Efficient regenerative braking as compared to single phase a.c series motors.

De – merits

- The overall cost is more because of heavy cost of additional substation equipment
- This system is preferred for suburban services and road transport where there are frequent stops and distance is less.

4. Give the expression for total tractive effort. (Nov- 2016/May – 2014/May 2012)

Total tractive effort required to run a train on track = (Tractive effort to produce acceleration +
Tractive effort to overcome effect of gravity +
Tractive effort to overcome train resistance)

$$F_T = F_a + F_g + F_r$$

5. What are the recent trends in electric traction? (Nov – 2016/Nov -2014/May - 2014)

Magnetic levitation, Maglev (Or) Magnetic suspension and Pseudo - Levitation

6. What are the factors governing scheduled speed of a train? (May - 2016)

- Acceleration and braking retardation
- Maximum or Crest speed
- Stopping time or Duration of stop

7. What are the different systems of traction?

- Direct team engine drive
- Direct internal combustion engine drive
- Steam electric drive
- Internal combustion engine electric drive
- Petrol electric traction
- Battery electric drive

8. Define specific energy consumption and discuss the factors which effect the specific energy consumption. (May - 2015)

Specific Energy Consumption = (Specific Energy Output at driving wheel)/ (Over all efficiency of the motors and gearing)

Factors

- Distance between the stops
- Train resistance
- Acceleration and retardation
- Gradient
- Train equipment

9. What are the various methods for controlling the speed of d.c series motor? (May - 2015)

- Rheostatic control
- Series parallel control
- Field control
- Buck and boost method
- Metadyne control
- Thyristor control

10. List the requirements of ideal traction system. (Nov - 2013)

- The starting tractive effort should be high so as to have rapid acceleration.
- The wear on the track should be minimum.
- The equipment should be capable of withstanding large temporary loads.
- Speed control should be easy.
- Pollution free.

11. What are the requirements of a braking system?

- It should be simple, robust ,quick and reliable in action
- Easy to use for driver to operator
- Maintenance should be minimum
- The braking system should be inexhaustible
- In case of emergency braking, safety consideration is taken into account.
- Kinetic energy of the train must be storable during braking which could be used subsequently during acceleration of the train.

12. Name the various systems of current collection system and where they employed?

- Trolley collector.
- Bow collector
- Pantograph collector

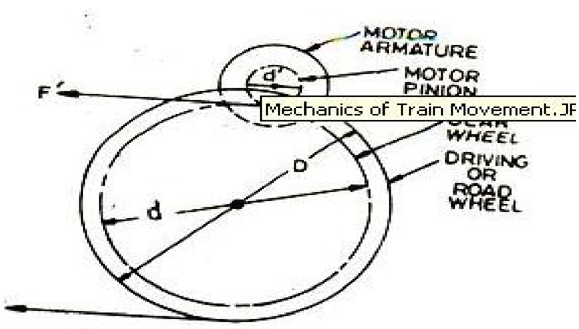
13. Name the advanced methods of speed control of traction motors.

- Tape changer method
- Thyristor control
- Chopper control
- Microprocessor control

PART - B

1. Describe the mechanism of train movement with the aid of transmission of tractive effort. (Nov - 2017)

Essential driving mechanism of an electric locomotive is shown in below.



Transmission of Tractive Effort

The armature of the driving motor has a pinion diameter d" attached to it. The tractive effort at the edge of the pinion is transferred to the driving wheel by means of a gear wheel.

$F = \eta F (d/D0 = \eta 2T/D) = \eta T (2/D) (d/d) = \eta T 2y/D$

Where T is the torque exerted in N-m, by the driving motor

d is the diameter of gear wheel in metres

D is the diameter of driving wheel in metres

η is the transmission efficiency

γ is the gear ratio and is equal to d/d

Total tractive effort required to run a train on track = (Tractive effort to produce acceleration +

Tractive effort to overcome effect of gravity +

Tractive effort to overcome train resistance)

$$\mathbf{F_T = F_a + F_g + F_r}$$

2. Explain in detail about different methods of traction motor control. (Nov- 2017)

The control of traction motors for starting and for smooth acceleration is very much essential to avoid damage to the motors. The control equipment is provided for manual and automatic operation. Usually a master controller is used for the purpose.

1. D.C series motor control or plain rheostat control
2. Series –Parallel control
   i. Open circuit transition
   ii. Shunt transition control
   iii. Bridge transition control
3. Metadyne control
4. Multiple unit control

3. Discuss in detail about series parallel control of electric traction motor with example. (Nov-2017)

Two motors are used. At starting they are connected in series for full speed, they are connected in parallel.

- Shunt or short circuit transition method
- Bridge transition method

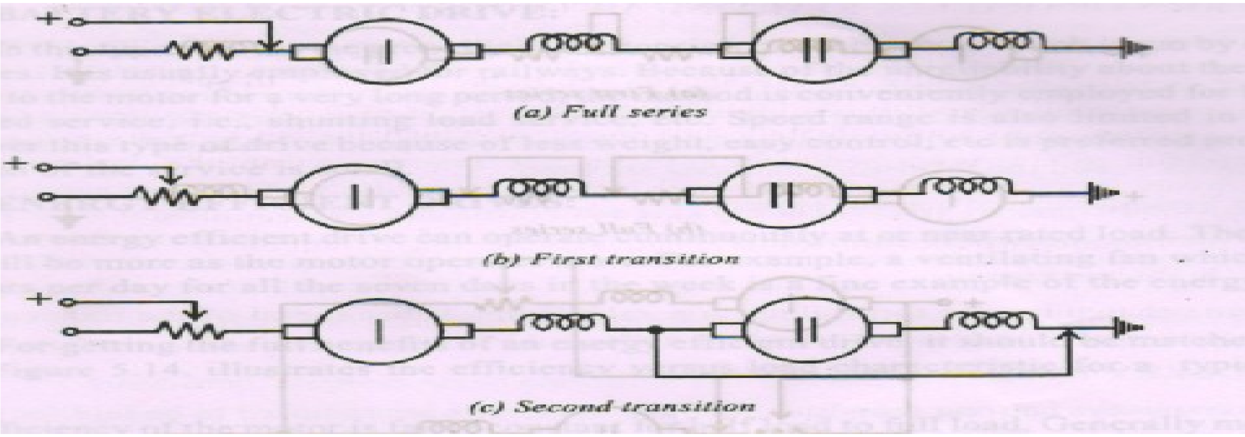
Shunt transition methods

- Full series
- First transition
- Second transition

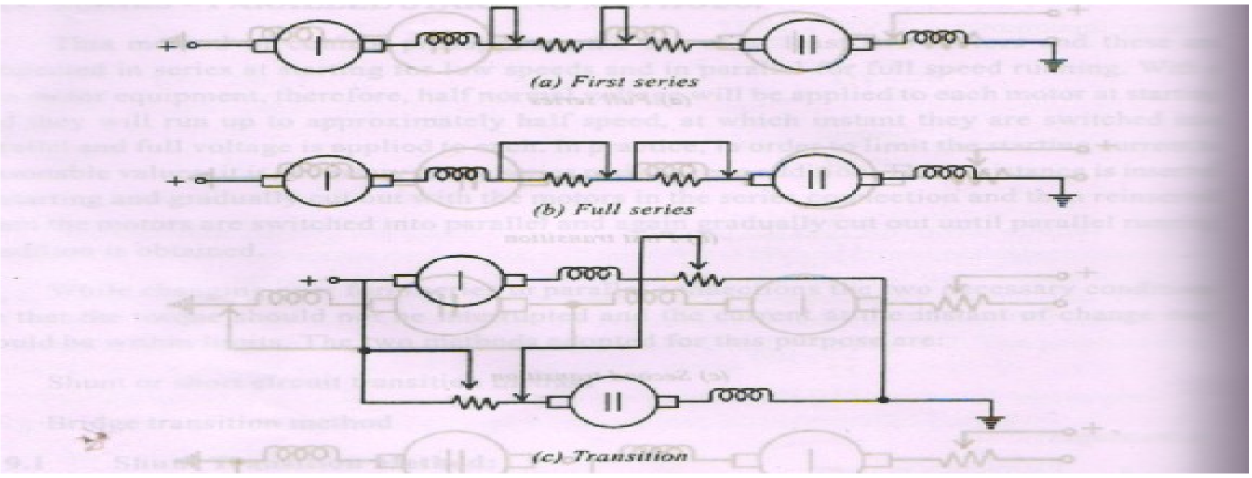
Bridge transition method

- First series
- Full series
- Transition

Shunt transition methods



Bridge transition method



4. What are the factors influencing the choice of electric drives? (May - 2017)

An electric drive is defined as a form of machine equipment designed to convert electric energy into mechanical energy and provide electrical control of this process.

- Steady state requirements
- Transient operation requirements
- Environmental effects
- Effects of supply variation
- Power factor
- Braking requirements
- Power / Weight Ratio
- Capital cost

5. State the principle of regenerative braking. Explain regenerative braking in respect of DC motors. (May - 2017)

In this type of braking the motor is not disconnected from the supply but remains connected to it and its feeds back the braking energy or its kinetic energy to the supply system. The essential condition for this is that the induced emf should be slightly more than the supply voltage. This method of braking cannot be used for synchronous motors.

- In a DC machine where energy will be taken from the supply or delivered to it depends upon the induced emf, if it in less than the line voltage the machine will operate as motor and if it is more than the line voltage, the machine will operate as generator.
- The e.m.f induced in turn depends upon the speed and excitation that is when the field current or the speed is increased the induced e.m.f exceeds the line voltage and the energy will be field into the system. This will quickly decrease the speed of the motor and will bring it to rest.

6. State the requirements of an ideal traction system. (Nov - 2016)

- High adhesion coefficient, so that high tractive effort at the start is possible to have rapid acceleration.
- The locomotive or train unit should be self contained so that it can run on any route.

- Minimum wear on the track.
- It should be possible to overload the equipment for short periods.
- The equipment required should be minimum, of high efficiency and low initial and maintenance cost.
- It should be pollution free.
- Speed control should be easy.
- Braking should be such that minimum wear is caused on the brake shoes, and if possible the energy should be regenerated and returned to the supply during braking period.

7. List the various sources for Electric traction.(Nov-2016)

All traction systems, broadly speaking, can be classified as follows:

Non-electric traction systems:

- These systems do not use electrical energy at some stage or the other.
- Examples: Steam engine drive used in railways at some stage or the other.

These are further sub divided into the following two groups:

a) Self contained vehicles or locomotives

Examples:

i) Battery-electric drive

ii) Diesel-electric drive

b) Vehicles which receive electric power from a distribution network or suitably placed sub-stations.

Examples:

i) Railway electric locomotive fed from overhead A.C supply;

ii) Tramways and trolley buses supplied with D.C.supply.

Electric traction systems may be broadly categorized as those operating on:

- Alternating current supply
- Direct current supply.

In general following electric traction systems exist:

a) AC 3 phase 3.7 kV system

b) AC single phase 15/16 kV -161/25 Hz

c) AC single phase 20/25 kV - 50/60 Hz

d) DC 600 V

e) DC 1200 V

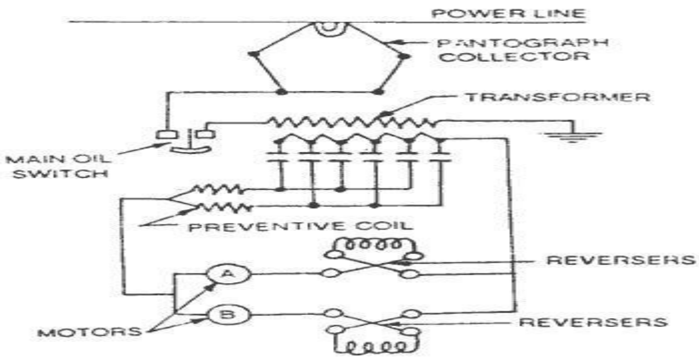
f) DC 1.5 kV

g) DC 3 kV.

8. Explain about the types of supply system used in traction system. (May - 2016)

Ac single phase system:

- In this supply is taken from a single overhead conductor with the running rails. A pantograph collector is used for this purpose. The supply is transferred to primary of the transformer through on oil circuit breaker. The secondary of the transformer is connected to the motor through switchgear connected to suitable tapping on the secondary winding of the transformer.
- The switching equipment may be mechanically operated tapping switch or remote controlled contractor of group switches. The switching connections are arranged in two groups usually connected to the ends of a double choke coil which lies between the collections to adjacent tapping points on the transformer. Thus the coil acts as a preventive coil to enable tapping change to be made without short circuiting sections of the transformer winding and without the necessity of opening the main circuit.



Direct current systems:

- The transformation and high voltage generation of dc is very inconvenient to the dc supply used is at normally 600 V and this voltage is almost universal for use in urban and suburban railways.
- For direct current equipment, the series motor is universally employed as its speed-torque characteristics are best suited to traction requirements. Generally two or more motors are used in single equipment and these are coupled in series or in parallel to give the different runningspeeds required.
- The motors are initially connected in series with starting rheostats across the contact line and rails, the rheostats are then cut out in steps, keeping roughly constant current until the motors are running in full series. After this the motors are rearranged in parallel, again with rheostats, the rheostats are cut out in steps, leaving the motors in full parallel.

9. What are the various types of electric braking used in traction? Discuss in detail. (May - 2015)

1. Magnetic braking:

- In this case the excitation of the armature is disconnected from the supply but the excitation remains on. When the armature rotates in the fixed field, there is reversal of flux in the armature and the iron losses are fed from the kinetic energy of the rotating components and the machine retards. This method can be adopted for shunt, compound and synchronous motors. In case of series motors the field cannot stand the full rated voltage, so separate battery has to provide for excitation during braking.

2. Plugging:

- In this case the connections of excitation are reversed. The motor tends to rotate in the reverse direction. Care should be taken to disconnect the motor when it has just stopped this method can be used for small motors and is not suitable for traction motors which are generally of large size.

3. Resistance braking:

- In this the motor after switching off is made to run as a generator. The output of generator is consumed in resistance thereby causing retardation.

4. Regenerative braking:

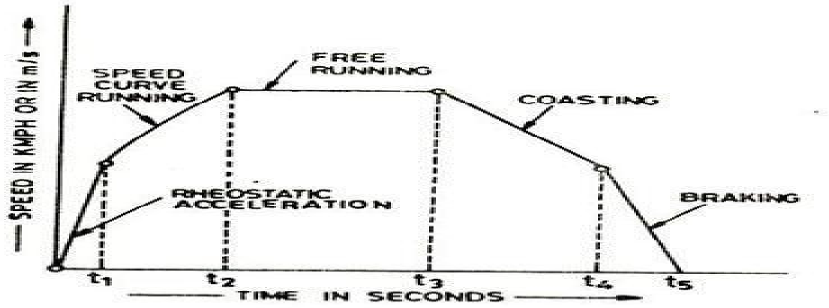
- In this method although motor is made to run as a generator but the current instead of being fed to a resistance is fed to the mains. The essential condition for this is that the induced emf should be slightly more than the supply voltage. This method of braking cannot be used for synchronous motors.

10. Sketch the typical speed-time curve for main line service and to sub urban services in electric traction

(May - 2017)

Speed-Time Curves:

The curve drawn between speed and time is called the speed-time-curve. The speed-time curve gives complete information of the motion of the train. The curve gives the speed at various instants after the start of run directly. Slop of the curve at any point gives the acceleration at the corresponding instant or speed. The area covered by the curve, the time axis and the ordinates through the instants between which the time is taken, represents the distance covered in the corresponding time interval



Speed-time curve mainly consists of

1) Initial acceleration
2) Constant speed run or free run
3) Coasting and
4) Retardation or braking

1. Acceleration period:

From starting to the stage when locomotive attains maximum speed, the period is known as acceleration period, as the vehicle is constantly accelerated. This is represented by OA portion of the curve and time duration is t1.

2. Free running:

During this period the motor develops enough torque to overcome the friction and wind resistance and hence the locomotive runs at constant speed. This is shown by the portion AB of the curve.

3. Coasting:

When the locomotive is running at certain speed, if the motor is switch off, due to inertia the vehicle will continue to run, of course with little deceleration due to friction and windage.

4. Braking:

The locomotive is retarded to stop it within short distance and at a particular spot. The shape of the curve will change depending upon the distance between consecutive stations.

11. A 250 tones train with 10% rotational inertia effect is started with uniform acceleration and reaches a speed of 50kmphps in 25 seconds on level road. Find the specific energy consumption if the journey is to be made according to trapezoidal speed – time curve. Acceleration = 2kmphps; Tracking retardation=3kmphps; Distance between the station =2.4km; Efficiency =0.9; Track resistance=5 Kg/tones. (May - 2017)

Accelerating Period = $t_1 = V_m/\alpha = 50/2 = 25$Sec

Braking Period = $t_3 = V_m/\beta = 50/3 = 16.67$Sec

Free running Period = $t_2 = T-(t_1+t_3) = 265-(25+16.67) = 223.33$Sec

Tractive Effort $F_t = 277.8W_e\alpha + 98.1WG + Wr = 189687.5$N

Free running= 14273.55N

Total Energy output=21.438kWh

Total Energy Consumption = (Total Energy Output)/(Efficiency)=23.82kWh

Specific Energy Consumption = (Total Energy Consumption)/(Weight in tonnes*Distance of run in

km)=39.7wh/ton-km

UNIT II – ILLUMINATION

PART - A

1. Why tungsten is selected as the filament material? (Nov – 2017/Nov - 2016)

- Voltage fluctuation has comparatively more effect on the light output.

- Initial cost is low.
- It gives light close to natural light; therefore objects are properly seen.
- Its brightness is more.

2. Define the term MSCP and lamp efficiency. (Nov – 2017)

The mean of candle power in all directions and in all planes from the source of light is termed as Mean Spherical Candle Power.

Lamp efficiency is defined as the ratio of the luminous flux to the power input. It is expressed in lumens per watt.

3. What do you understand by polar curves as applied to light source?(May - 2017)

A curve is plotted between candle power and the angular position. The luminous intensity in all the directions can be represented by polar curves.

Uses: To determine the MHCP, MSCP and the actual illumination of a surface by employing the candle power in that particular direction.

4. What is flood lighting where is it generally used? (May - 2017)

Flood lighting means flooding of large surfaces with light from powerful projectors. It is employed to serve for the following purposes.

- Aesthetic Flood Lighting
- Industrial and Commercial Flood Lighting
- Advertising

5. Specify any four energy efficient lamps.(Nov - 2016)

- Compact Fluorescent Lamp (CFL)
- Metal Halides Lamps
- High Pressure Sodium Vapor Lamp
- LED

6. Define the term luminous efficacy. (May -2016)

It is a measure of how well a light source produces visible light. It is the ratio of luminous flux to power.

7. Suggest suitable lamps for sports ground lighting application. (May - 2016)

High Pressure and Low Pressure Sodium Vapor Lamps.

8. Define the term luminous flux. (Nov - 2015)

It is the rate of energy radiation in the form of light waves and is denoted by $\Phi = Qt$ where Q is the radiant energy. Its unit is lumen.

9. State the different types of electrical lamps used for illumination. (Nov – 2015 / May - 2014)

- Arc lamps
- High temperature lamps
- Gaseous discharge lamps
- Fluorescent lamps.

10. List the types of lighting system. (Nov-2014)

- Direct lighting
- Indirect lighting
- Semi-direct lighting
- Semi-indirect lighting

11. Define lumen. (Nov – 2014 / May - 2014)

One lumen is defined as the luminous flux emitted by a source of one candle power in a unit solid (i.e.)

lumen = candle power of source × solid angle

12. What are the requirements of good lighting?

- Provide sufficient illumination
- Provide uniform light distribution all over the working plane
- Provide light of suitable colour

- Avoid glare and shadow

PART- B

1. Explain the detail the principle of operation of fluorescent lamp. (Nov – 2017/ Nov - 2016)

Circuit Diagram

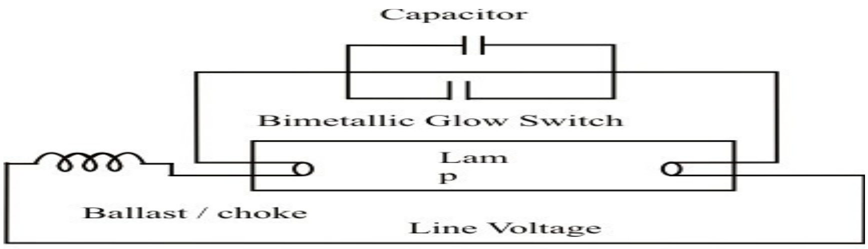


Fig. 1: Fluorescent Lamp

Working

- Employs transformation of UV radiation due to low pressure mercury vapor. Luminescent Powder in tubular vapor Lamps Enhances brilliancy of light. Radiation from Low Pressure Mercury Vapor (which is in UV region) is impinged on Luminescent Materials and re – radiated at longer wavelengths of visible spectrum.
- In a Glass Tube small drop of Mercury and small amount of Argon gas are placed for initiation of discharge. Pressure, voltage and current are so adjusted that 253.7 nm lines is excited. This re-radiates at longer wavelength.
- Typically a 40W lamp requires 2-3g of phosphors. Maximum sensitivity is around 250 – 260 nm.

2. Describe and prove laws of illumination. (Nov -2017/May -2017/May-2015/May 2014/May-2013)

Law of inverse squares

It states that illumination of a surface is inversely proportional to the square of the distance of the surface from the source of light; under the condition that source is the point source.

$$E_2 = \frac{I}{r_2^2}$$ Lumens/unit area

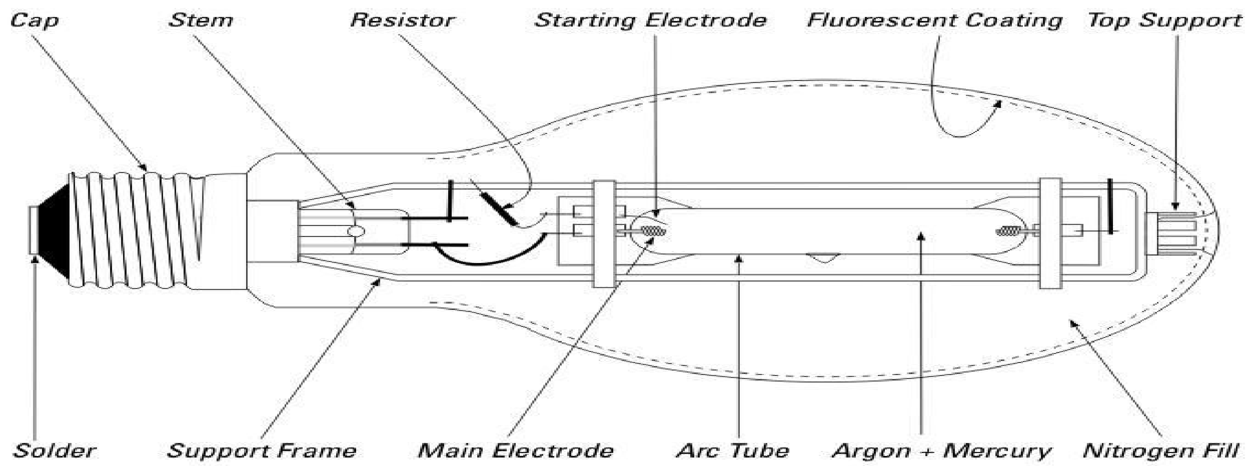
Lambert's cosine Law

It states that illumination of a surface at any point is dependent upon the cube of cosine of the angle between the line of flux and the normal at that point.

$$E_{RS} = \frac{I}{h^2}\cos^3\theta$$

3. Explain the working of a sodium vapour lamp with in a neat sketch. (May – 2017/Nov-2015)

Circuit



Working

- Principally sodium vapour lamp consists of a bulb containing a small amount of metallic sodium, neon gas and two sets of electrodes connected to a pin type base.

- The lamp operates at a temperature of about 300°C and in order to conserve the heat generated and assure the lamp operating at normal air temperatures the discharge envelope is enclosed in special vacuum envelope designed for this purpose.
- The efficiency of a sodium vapour lamp under practical conditions is about 40-50 lumens/watt. Such lamps are manufactured in 45, 60, 85 and 140 W ratings.
- The average life is about 3000 hours and is not affected by voltage variations. The major application of this type of lamp is for highway and general outdoor lighting where colour discrimination is not required, such as street lighting, parks, rail yards, storage yards etc.

4. Show different types of indoor and outdoor lighting with neat sketches. (May - 2017)

Road Lighting:

Conventionally by they are arranged in a column, mounted on a wall or suspended by a span wire. Plane of Symmetry being in vertical plane perpendicular to the axis of the road along the road.

Flood Lights:

- Rain Proof Lamp holder with wide / narrow beam Reflectors are used for flood light. They are usually High wattage Incandescent Lamps, Halogen Lamps, High Pressure Mercury Vapor Lamp or Low / high Pressure Sodium Lamp.
- Spot lights / down lights are usually used with Screens, Reflectors, Filters, Colored envelope and Closed Lamps.

Interior Lighting:

Interior Lighting is a complex problem depending on various factors such as

- Purpose intended service,
- Class of Interiors.
- Luminary best suited,
- Colour effect and
- Reflection from ceiling, walls, floors.

Sports Lighting:

- Lighting for sports facility looks for comfort of four user groups namely Players, Officials, Spectators and Media. Players and officials should see clearly in the play area to produce best possible results the object used in the game.
- Spectators should follow the performance of the players. In addition to play area surroundings also need to be illuminated. Lighting should be such that it enables safe entry and exit. With increasing crowd level safety becomes more and more important.
- Media include TV and film, for which lighting should provide lighting such that conditions are suitable for color picture quality as per CIE 83. This should be suitable for both general pictures as well as close up of players and spectators. Additionally, it should have provisions for emergency power supply to provide continuous transmission.
- Criteria relevant for sports lighting are Horizontal Illuminance, Vertical Illuminance, Illuminance Uniformity, Glare restrictions, Modeling & shadows and Color appearance & rendering

5. List the various types of lamps commercially available. Also specify the energy efficient lamps for domestic and industrial lighting applications. (May -2016)

Arc lamps

- Carbon arc lamp
- Flame arc lamp
- Magnetic arc lamp

Applications

- Outdoor lighting,
- Flashlight in camera
- Flood lights
- Projectors
- Endoscopy etc.,

High temperature lamps

- Halogen lamp
- Commercial lighting

Gaseous discharge lamps

- Sodium Vapor lamp
- Street lighting

Fluorescent lamps

- Residential lighting

CFL – Compact Fluorescent Lamp

LED – Light Emitting Diode

Benefits

- Long lasting
- Durable
- Mercury free
- Cost effective
- Reduces air and water pollution

6. Explain the various steps involved in designing of lighting system. (May – 2016/Nov-2015)

Watt – per square metre method

It is more adaptive for rough calculation or checking and its simple calculation.

Lumen (or) Light Flux Method

Lumens received on the working plane = Number of lamps X wattage of each lamp X lamp efficiency (lumens/watt) X coefficient of utilization/depreciation factor.

- Co-efficient of utilization
- Maintenance factor
- Depreciation factor

Point to Point / Inverse square law method

Calculation of illumination

$$N = \frac{E * A}{\phi * UF * MF}$$

7. Explain flood lighting calculation with necessary definitions. (May -2014)

Flood lighting means flooding of large surface with light from powerful projectors.

Aesthetic Flood Lighting: Beauty of buildings at night, religious buildings on festive occasions

Industrial and Commercial: Railway yards, Sports stadium, Car Parks, Construction sites etc.,

Advertising: Showcases and advertisement board

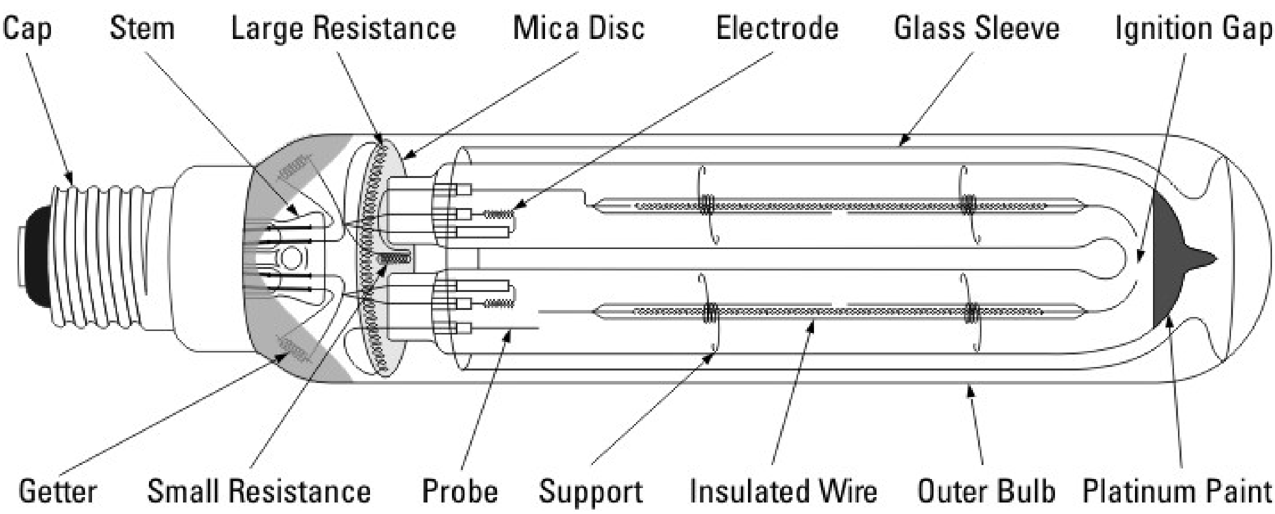
Three steps – Calculation

- Illumination level required
- Types of projector
- Number of projectors

$$N = \frac{A * E * DF * Wastelight factor}{UF * Wastage of lamp * Luminous efficiency}$$

8. Explain the working of a high pressure mercury vapour lamp with a neat sketch. (May – 2011)

Circuit



Working

- The mercury vapour lamp in construction is similar to sodium vapour lamp. It gives greenish blue colour light, which causes colour distortion.
- The efficiency is about 30-40 lumens per watt. These lamps (MA type) are manufactured in 250 and 400 W ratings for use on 200-250 Vac supply.
- Lamps of this type are used for general industrial lighting, railway yards, ports, work areas; shopping centres etc where greenish-blue colour light is not objectionable.
- Another type, which is manufactured in 300 and 500 W ratings for use on ac as well as dc supply mains, is MAT type. This is similar to MA type except that it does not use choke as ballast. Lower wattage lamps, such as 80 and 125 W, are manufactured in a different design and using high vapour pressure of about 5-10 atmospheres. These are known as MB type lamps.

9. Lighting schemes

Direct lighting:

Lighting provided from a source without reflection from other surfaces. In day lighting, this means that the light has travelled on a straight path from the sky (or the sun) to the point of interest. In electrical lighting it usually describes an installation of ceiling mounted or suspended luminaires with mostly downward light distribution characteristics.

Indirect lighting:

Lighting provided by reflection usually from wall or ceiling surfaces. In day lighting, this means that the light coming from the sky or the sun is reflected on a surface of high reflectivity like a wall, a window sill or a special redirecting device. In electrical lighting the luminaries are suspended from the ceiling or wall mounted and distributes light mainly upwards so it gets reflected off the ceiling or the walls.

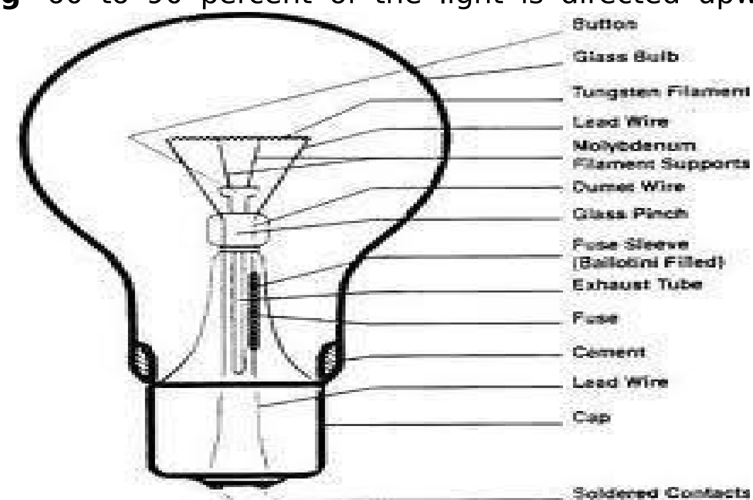
Indirect Lighting= 90 to 100 percent of the light is directed to the ceilings and upper walls and is reflected to all parts of a room.

Semi-Direct Lighting=60 to 90 percent of the light is directed downward with the remainder upward

Semi-indirect Lighting=60 to 90 percent of the light is directed upward with the remainder directed downward.

Highlighting Lighting= the beam projection distance and focusing ability characterize this luminaries

10. Incandescent lamp – Construction and Working Circuit



Working

- The incandescent light bulb, incandescent lamp or incandescent light globe produces light by heating a metal filament wire to a high temperature until it glows. The hot filament is protected from oxidation in the air with a glass enclosure that is filled with inert gas or evacuated.
- In a halogen lamp, filament evaporation is prevented by a chemical process that redeposit’s metal vapor onto the filament, extending its life. The light bulb is supplied with electrical current by feed-through terminals or wires embedded in the glass. Most bulbs are used in a socket which provides mechanical support and electrical connections. Incandescent bulbs are manufactured in a wide range of sizes, light output, and voltage ratings, from 1.5 volts to about 300 volts.
- They require no external regulating equipment, have low manufacturing costs, and work equally well on either alternating current or direct current. As a result, the incandescent lamp is widely used in household and commercial lighting, for portable lighting such as table lamps, car headlamps, and flashlights, and for decorative and advertising lighting.

UNIT III – HEATING AND WELDING

PART - A

1. State the requirements of a good heating material. (Nov – 2017 / May – 2017/May -2016)

- High resistivity
- High melting point
- Free from oxidation
- Low temperature coefficient

2. Differentiate between core type and coreless type induction furnace. (Nov -2017)

Core type

- Leakage reactance is high
- Frequency converter is required
- Odd shape of crucibles is not convenient

Core less type

- No dust, smoke and noise
- Fast in operation
- Any shape of crucibles can be used
- Erection and operating cost is low

3. Compare AC and DC sources as source of supply for arc welding. (May - 2017)

S. No	Factors	DC Welding	AC welding
1.	Equipment	Motor-generator set or rectifier is required in case of availability of AC supply; otherwise oil engine set is required.	Only a transformer is required.
2.	Prime cost	Two or three times of transformer.	Comparatively low.
3.	Operating efficiency	Low	High 85%
4.	No-load voltage	Low	Too high
5.	Power factor	High	Low
6.	Heating	Uniform heating	Non-uniform heating

7.	Arc stability	Higher	-
8.	Arc blow	Pronounced	Not so pronounced with AC
9.	Electrodes	Non-coated cheap electrodes can be used.	Only coated electrodes- expensive ones.

4. List the advantages of electric heating. (Nov - 2016)

- Economical
- Cleanliness
- Absence of flue gases
- Ease of control or adaptation
- Automatic protection
- Upper limit of temperature
- Special heating features
- High efficiency of utilization
- Better working conditions
- Safety
- Heating of non-conducting materials

5. What is meant by resistance welding? (Nov -2016)

A heavy current is passed through the joint required to be welded. The resistance of the joint generates enough heat due to I^2R loss to melt the metal and causes fusion at the point of contact.

6. Mention the merits of dielectric heating. (May - 2016)

- Uniform electric field and uniform heat
- Higher quality of products
- Economic, easy and automatic
- Heat takes place in the material itself.

7. Define squeeze time. (Nov - 2015)

It is the time that elapses between the initial application of the electrode pressure or the work and the first application of current.

8. In electric arc welding what types of electrodes are used in DC supply and AC supply. (Nov - 2015)

- DC - Non-coated cheap electrodes can be used
- AC - Only coated electrodes- expensive ones

9. Mention the factors which limit the choice of frequency in induction and dielectric heating? (May - 2015)

Dielectric heating

- Non metals like wood, plastics etc.,
- 10 and 30MHz and the voltage up to 20KV.

Induction heating

- Low temperature : 50-500Hz
- Heating metal pieces : 1 – 50 MHz
- Melting : 500 Hz – 10 KHz

10. What is meant by arc welding, also list its type? (May - 2015)

An electric arc is the flow of electric current through gases accompanied by heat and bright glow due to ionization and dissipation of energy of the surrounding medium. The electric arc is struck by short circuiting two electrodes and then withdrawing them apart.

Types

- Carbon Arc welding
- Metal Arc welding
- Gas Metal Arc welding
- Gas tungsten Arc welding

- Atomic-hydrogen Arc welding
- Plasma Arc welding
- Submerged Arc welding
- Flux-cored Arc welding
- Electro slag Arc welding

11. What is the basic principle of induction heating?

It works on the principle of electromagnetic induction as same as a transformer. A metal disc is surrounded by a copper coil in which A.C supply is flowing. The disc has a finite value of diameter and thickness and is spaced a given distance from the coil and concentric to it. We find that a secondary current is caused to circulate around the outer surface of the disc.

12. What are the modern welding techniques?

Drawbacks of convention welding methods

- Excessive melting
- Diffusion
- Formation of inter metallic compounds
- Tower ductility
- Lower shock resistance capability

Modern welding techniques are,

- Ultrasonic welding
- Laser welding
- Electron beam welding

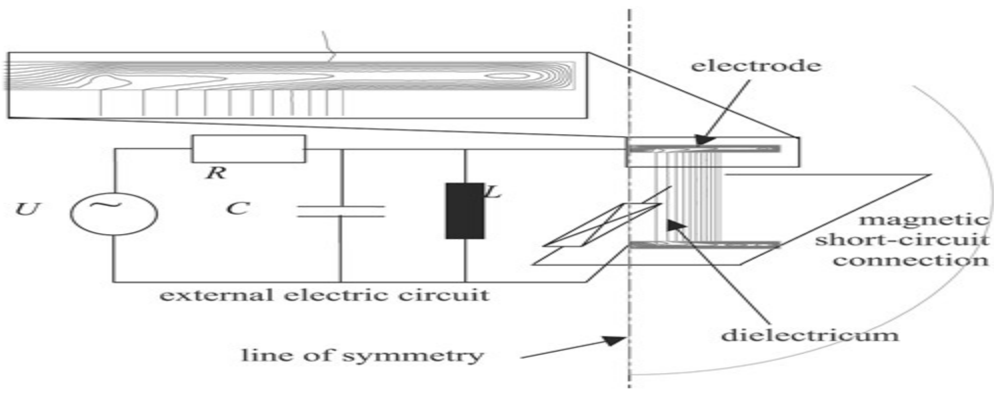
13. What is LASER welding?

LASER (Light Amplification Simulated Emission of Radiation) welding is a welding process that uses the heat from a laser beam impinging on the joint. The process is without a shielding gas and pressure.

PART - B

1. Describe the construction and working principle of dielectric heating. (Nov -2017/ May - 2017)

- Dielectric heating is also sometimes called as high frequency capacitance heating.
- If non metallic materials i.e., insulators such as wood, plastics, china clay, glass, ceramics etc are subjected to high voltage A.C current, their temperature will increase in temperature is due to the conversion of dielectric loss into heat.
- The dielectric loss is dependent upon the frequency and high voltage. Therefore for obtaining high heating effect high voltage at high frequency is usually employed.
- When A.C supply is connected across the two electrodes, the current drawn by it is leading the voltage exactly 90˚.
- The angle between voltage and current is slightly less than 90˚
- But at high frequencies, the loss becomes large, which is sufficient to heat the dielectric.



Advantages:

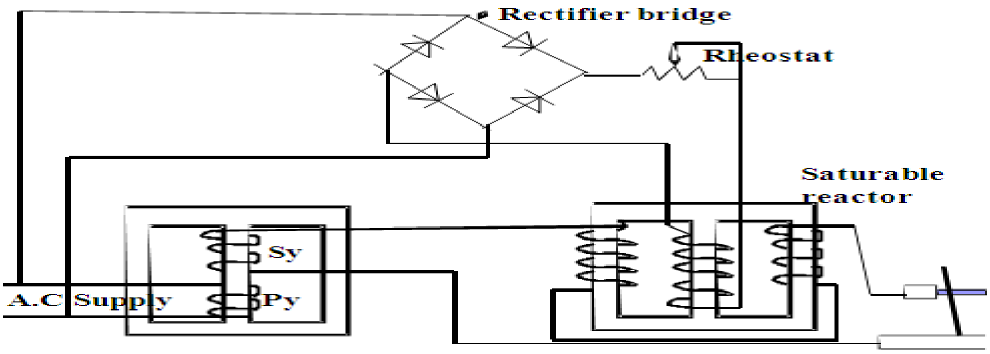
- Uniform heating is obtained.
- Running cost is low.
- Non conducting materials are heated within a short period.
- Easy heat control.

Applications:

- For food processing.
- For wood processing.
- For drying purpose in textile industry.
- For electronic sewing.

2. Explain the principle and working of welding transformer. (Nov - 2017)

The impedance of a welding transformer may be higher that the impedance of a transformer designed for some other purpose. The transformer impedance may play a role in the process of establishing an arc and controlling the current.



- A welding transformer is a step down transformer that reduces the voltage from the source voltage to a lower voltage that is suitable for welding, usually between 15 and 45 volts.
- The secondary current is quite high. 200 to 600 amps would be typical, but it could be much higher. The secondary may have several taps for adjusting the secondary voltage to control the welding current.
- The taps are typically connected to a several high-current plug receptacles or to a high current switch. For welding with direct current (DC) a rectifier is connected to the secondary of the transformer.
- There may also be a filter choke (inductor) to smooth the DC current. The entire transformer and rectifier assembly may be called a transformer or welder, but "welding power supply" would be more appropriate term.

Special Features:

- Stepless current control within single range from front panel
- For its high permitted load, it’s ideal for fematic welding
- Phase compensation facility optional. It’s a good investment as the primary current and rated output can be reduced, resulting in reduced fuse size and cable diameter
- Provided with wheels and handle for easy mobility
- Sturdy design for all working environments
- Horizontal shunt core travel ensures precise setting after prolonged use
- Class 'H' insulation provides longer coil life

3. Describe different types of arc welding with neat diagram. (Nov - 2017)

- An electric arc is the flow of electric current through gases.
- An electric arc is struck by short circuiting two electrodes and then with drawing them apart by small distance.
- The current continue to flow across the small gap and give intense heat.
- The heat developed by the arc is also used for cutting of metal.
- The electrode is made of carbon or graphite and is to be kept negative with respect of work.
- The work piece is connected to positive wir. Flux and filler are also used.
- Filler is made up of similar metal as that of metal to be welded.

- If the electrode is made positive then the carbon contents may flow into the weld and cause brittleness.
- The heat from the arc forms a molten pool and the extra metal required to make the weld is supplied by the filler rod.
- This type of welding is used for welding copper and its alloy.

Metal arc welding:

- In metal arc welding a metal rod of same material as being welded is used as an electrode.
- The electrode also serves the purpose of filler. For metal arc welding A.C or D.C can be used.
- Electric supply is connected between electrode and work piece.
- The work piece is then suddenly touched by the electrode and then separated from it a little. This results in an arc between the job and the electrode.
- A little portion of the work and the tip of the electrode melts due to the heat generated by the arc.
- When the electrode is removed the metal cools and solidifies giving a strong welded joint.

4. What are the different types of resistance welding? Describe any one type. (May – 2017)

In resistance welding heavy current is passed through the metal pieces to be welded. Heat will be developed by the resistance of the work piece to the flow of current.

The heat produced for welding is given by

$$H = I^2 R t$$

Where,

H= Heat developed at the contact area.

I= Current in amperes.

R= Resistance in ohms.

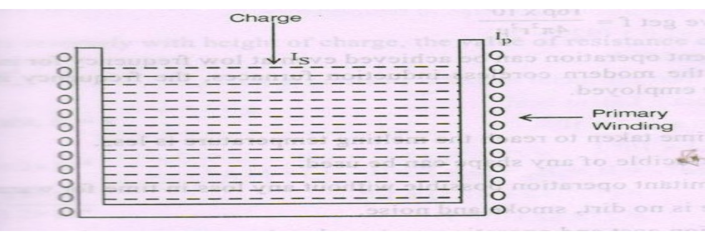
t= time of flow of current.

Butt welding:

- In this process heat is generated by the contact resistance between two components.
- In this type of welding the metal parts to be joined end to end. Sufficient pressure is applied along the axial direction.
- A heavy current is passed from the welding transformer which creates the necessary heat at the joint due to high resistance of the contact area.
- Due to the pressure applied, the molten metal forced to produce a bulged joint.
- This method is suitable for welding pipes, wires and rods.

5. Describe the construction and operation of the coreless induction furnaces. (May - 2017)

- Coreless induction furnace also operates on the principle of transformer. In this furnace there is no core and thus the flux density will be low.
- Hence for compensating the low flux density, the current supplied to the primary should have sufficiently high frequency.
- The flux set up by the primary winding produces eddy currents in the charge. The heating effect of the eddy currents melts the charge.
- Stirring of the metals takes place by the action of the electromagnetic forces. Coreless furnace may be having conducting or non conducting containers.
- The container acts as secondary winding and the charge can have either conducting or non conducting properties.
- Thus the container forms a short circuited single turn secondary. Hence heavy current induced in it and produce heat.
- The flux produced by the primary winding produces eddy currents in the charge. The heating effects of the eddy currents melt the charge.
- Stirring action in the metals takes place by the action of the electromagnetic forces.



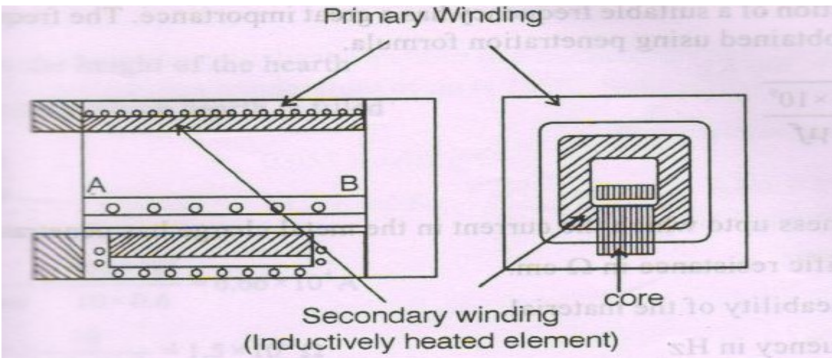
Advantages:

- Time taken to reach the melting temperature is less.
- Accurate power control is possible.
- Any shape of crucible can be used.
- The eddy currents in the charge results in automatic stirring.
- Absence of dirt, smoke, noise, etc.
- Erection cost is less.

6. Draw a neat sketch of induction furnace and explain its working. (Nov -2016)

Indirect core type induction furnace:

- In this type of furnace induction principle has been used for heating metals.
- In such furnace an inductively heated element is made to transfer its heat to the change
- When the primary winding is connected to the supply, current is induced in the secondary of the metal container.
- So heat is produced due to induced current. This heat is transmitted to the charge by radiation.
- The portion AB of the magnetic circuit is made up of a special alloy and is kept inside the chamber of the furnace.
- The special alloy will lose its magnetic properties at a particular temperature and the magnetic properties are regained when the alloy will cooled.
- As soon as the furnace attains the critical temperature the reluctance of the magnetic circuit increases many times and the inductive effect correspondingly decreases thereby cutting off the heat supply.
- The bar AB is removable type and can be replaced by other, having different critical temperature. Thus the temperature of the furnace can be controlled very effectively.

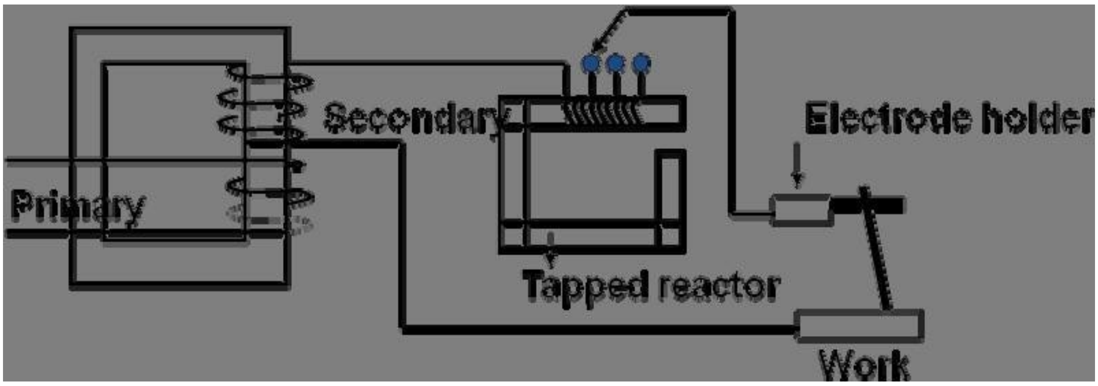


Coreless induction furnace:

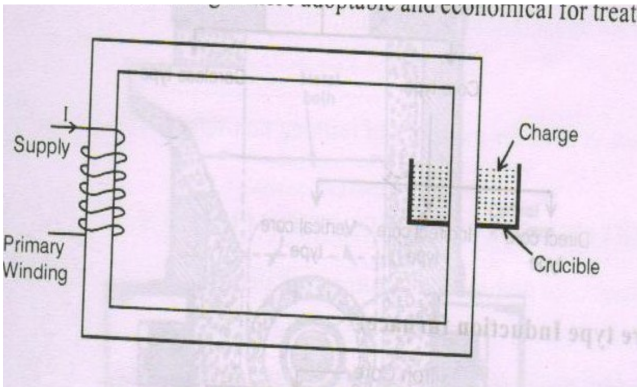
- Coreless induction furnace also operates on the principle of transformer. In this furnace there is no core and thus the flux density will be low.
- Hence for compensating the low flux density, the current supplied to the primary should have sufficiently high frequency.
- The flux set up by the primary winding produces eddy currents in the charge. The heating effect of the eddy currents melts the charge.
- Stirring of the metals takes place by the action of the electromagnetic forces. Coreless furnace may be having conducting or non conducting containers.
- The container acts as secondary winding and the charge can have either conducting or non conducting properties.
- Thus the container forms a short circuited single turn secondary. Hence heavy current induced in it and produce heat.
- The flux produced by the primary winding produces eddy currents in the charge. The heating effects of the eddy currents melt the charge.
- Stirring action in the metals takes place by the action of the electromagnetic forces.

7. Explain the characteristics of a welding generator. (Nov - 2016)

- In tapped reactor method, output current is regulated by taps on the reactor. This has limited number of current settings.
- In the moving coil method of current control, relative distance between primary and secondary windings is changed. When coils are more separated out current is less.
- In magnetic shunt method, position of central magnetic shunt can be adjusted. This changes the magnitude of shunt flux and therefore, output current. When central core is more inside, load current will be less and vice versa.
- In continuously variable reactor method, output current is controlled by varying the height of the reactor. Greater the core insertion, greater the reactance and less the output current. Reverse is true for less height of core insertion
- In saturable reactor method, the reactance of the reactor is adjusted by changing the value of d.c excitation obtained from bridge rectifiers by means of rheostat. When d.c current in the central winding of reactor is more, reactor approaches magnetic saturation. This means the reactance of reactor becomes less.



8. With a conceptual diagram, explain the process of induction heating. (May - 2016)



- Induction heating processes make use of currents induced by electromagnetic action in the material to be heated.
- Induction heating is based on the principle of transformers. There is a primary winding through which an a.c current is passed.
- The coil is magnetically coupled with the metal to be heated which acts as secondary.
- An electric current is induced in this metal when the a.c current is passed through the primary coil.

The following are different types of induction furnaces

1. Core type furnaces
   - a. Direct core type induction furnace
   - b. Vertical core type induction furnace
   - c. Indirect core type induction furnace
2. Core less type furnaces

Applications of Induction Heating

- Induction furnace
- Induction welding
- Induction cooking

- Induction brazing
- Induction sealing
- Heat treatment

Advantages of Induction Heating

- Optimized Consistency
- Maximized Productivity
- Improved Product Quality
- Reduced Energy Consumption

9. Discuss in details about any two types of resistance welding. (Nov - 2014)

This method is based upon the I2R loss. Whenever current is passed through a resistive material heat is produced because of I2 R loss.

Direct Resistance Heating:

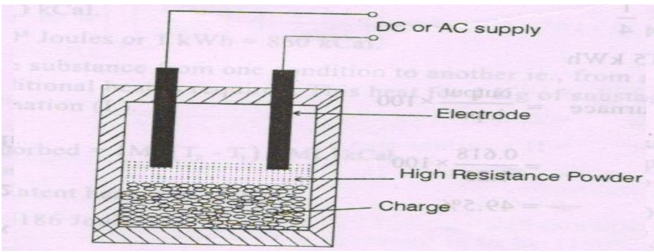
- In this method of heating the material or change to be heated is taken as a resistance and current is passed through it.
- The charge may be in the form of powder pieces or liquid. The two electrodes are immersed in the charge and connected to the supply.
- In case of D.C or single phase A.C two electrodes are required but there will be three electrodes in case of three phase supply.
- When metal pieces are to be heated a powder of high resistivity material is sprinkled over the surface of the charge to avoid direct short circuit.
- But it gives uniform heat and high temperature. One of the major applications of the process is salt bath furnaces having an operating temperature between 500˚C to 1400˚C.
- An immersed electrode type medium temperature salt bath furnace is shown in figure
- The bath makes use of supply voltage across two electrodes varying between 5 to 20 volts.
- For this purpose a special double wound transformer is required which makes use of 3Φ primary and single phase secondary. This speaks of an unbalanced load.

Advantages:

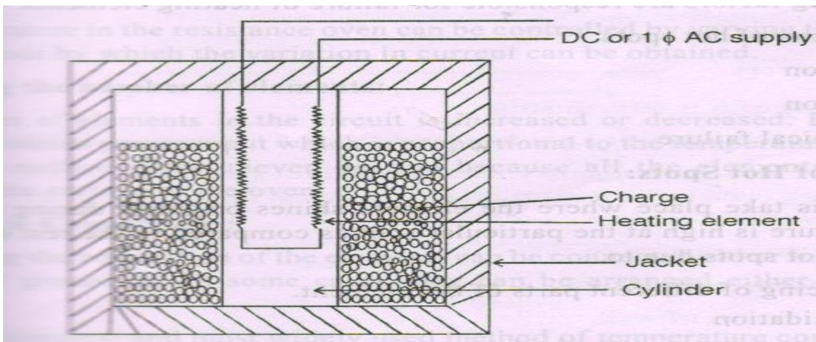
- High efficiency.
- It gives uniform heat and high temperature.

Application:

- It is mainly used in salt bath furnace and water heaters.



Indirect Resistance Heating:



- In this method the current is passed through a highly resistance element which is either placed above or below the over depending upon the nature of the job to be performed.
- The heat proportional to I2R losses produced in heating element delivered to the charge either by radiation or by convection.

- Sometimes in case of industrial heating the resistance is placed in a cylinder which is surrounded by the charge placed in the jackes. The arrangement provides as uniform temperature.
- Automatic temperature control can be provided in this case.

Applications

- This method is used in room heater, in bimetallic strip used in starters, immersion water heaters and in various types of resistance ovens used in domestic and commercial cooking.

10. Requirement of Heating Material

i) Low Temperature Coefficients of Resistance

Resistance of conducting element varies with the temperature; this variation should be small in case of an element. Otherwise when switched ON from room temperature to go upto say 1200˚C, the low resistance at initial stage will draw excessively high currents at the same operating voltage.

ii) Resistance coefficient Positive

If temperature is negative the element will draw more current when hot. A higher current means more voltage, a higher temperature or a still lower resistance, which can instability of operation.

iii) High Melting Point

Its melting point should be sufficiently higher than its operating temperature. Otherwise a small rise in the operating voltage will destroy the element.

iv) High Specific Resistance

The resistivity of the material used for making element should be high.

v) High Oxidizing Temperature

Its oxidizing temperature should higher than its operating temperature. To have convenient shapes and sizes, the material used should have high ductility and flexibility. It should not be brittle and fragile.

vi) Should with stand Vibration

In most industrial process quite strong vibrations are produced. Some furnaces have to open or rock while hot. The element material should withstand the vibrations while hot and should not break open.

vii) Mechanical Strength

The material used should have sufficient mechanical strength of its own.

UNIT IV – SOLAR RADIATION AND SOLAR ENERGY COLLECTORS

PART - A

1. Define collector efficiency. (Nov - 2017)

It is defined as the ratio of the energy actually absorbed and transferred to the heat transport fluid by the collector (useful energy) to the energy incident on the collector.

2. List the advantage of solar concentrators. (Nov - 2017)

- It increases the intensity by concentrating the energy available over a large surface onto a smaller surface (absorber)
- Due to concentration on a smaller area, the heat loss area is reduced. Further, the thermal mass us much smaller than that of a flat plate collector and hence transient effects are small.

- The delivery temperatures being high, a thermodynamic match between the temperature level the task occurs.
- It helps in reducing the cost by replacing an expensive large receiver by a less expensive reflecting or refracting area.

3. Write down the energy balance equation for solar collector. (May - 2017)

$$A_c[\{HR(\tau\alpha)_b + HR(\tau\alpha)_d\}] = Q_u + Q_l + Q_s$$

4. What is solar constant? (May -2017)

Solar constant is defined as the amount of energy received in unit time on a unit area perpendicular to the sun's direction at the mean distance of the earth from the sun.

5. What are the applications of solar energy?

- Heating and cooling residential building
- Solar water heating
- Solar distillation Solar engines for water pumping
- Food refrigeration.

6. What is meant by solar collector? Mention its types.

A solar collector is a device for collecting solar radiation and transfers the energy to a fluid passing in contact with it.

There are two types of collectors:

1. Non- concentrating or flat plate type solar collector.
2. Concentrating (focusing) type solar collector.

7. What is meant by solar photo voltaic?

The direct conversion of solar energy into electrical energy by means of the photovoltaic effect, that is, the conversion of light (or other electromagnetic radiation) into electricity. The photovoltaic effect is defined as the generation of an electromotive force as a result of the absorption of ionizing radiation.

8. What are the disadvantages of solar cell?

Compares with other sources of energy solar cells produce electric power at very high cost Solar cell output is not constant and it varies with the time of day and whether They can be used to generate small amount of electric power.

9. What is Green house effect?

The energy we receive from sun in the form of light is a shortwave radiation (not visible to human eye). When this radiation strikes a solid or liquid it is absorbed and transformed in to heat, the material becomes heat and conducts it to surrounding materials (air, water or liquids) or reradiates in to other materials of low temperature as long wave radiation.

10. Define solar time.

Solar time (Local Apparent Time) is measured with reference to solar noon, which is the time when the sun is crossing the observer's meridian.

PART – B

1. Explain the operation of solar cell using equivalent circuit and I-V characteristics. (Nov-2017)

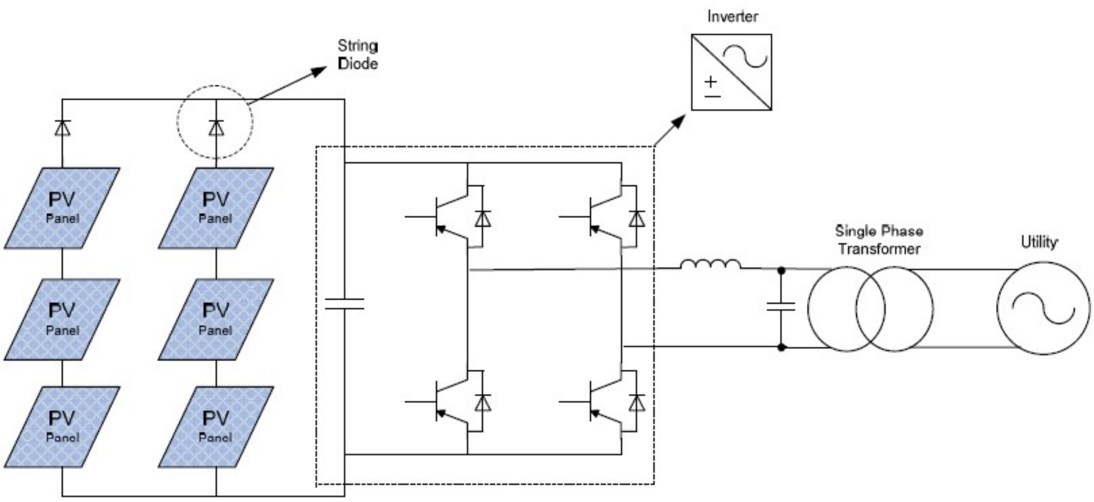
- Photovoltaic (PV) technology involves converting solar energy directly into electrical energy by means of a solar cell. A solar cell is typically made of semiconductor materials such as crystalline silicon and absorbs sunlight and produces electricity through a process called the photovoltaic effect.
- The efficiency of a solar cell is determined by its ability to convert available sunlight into usable electrical energy and is typically around 10%-15%. Therefore, to produce significant amount of electrical energy, the solar cells must have large surface areas.
- PV modules are connected together into arrays to produce large amounts of electricity. The array is then connected with system components such as inverters to convert the DC power produced by the arrays to AC electricity for consumer use. The inverter for PV systems performs many functions.
- It converts the generated DC power into AC power compatible with the utility. It also contains the protective functions that monitor grid connections and the PV source and can isolate the

PV array if grid problems occur. The inverter monitors the terminal conditions of the PV module(s) and contains the MPPT for maximizing the energy capture.

- The MPPT maintains the PV array operation at the highest possible efficiency, over a wide range of input conditions that can vary due to the daily (morning-noon-evening) and seasonal (winter-summer) variations.

Single Phase – Single Stage

- The most fundamental topology for a PV inverter is a single-phase, self commutated PV system as shown in below. The DC output of the PV array is connected across a filter capacitor. The capacitor is used to limit the harmonic currents in the array.
- The output of the capacitor connects to a full-bridge converter and the output of the converter is connected to an inductor, limiting the high frequency harmonics injected into the AC system.
- A synthesized AC output voltage is produced by appropriately controlling the switches and consists of a controlled series of positive and negative pulses that correspond to the positive and negative half cycles of a sinusoid.
- The PV array is then connected to the utility grid through an electrical isolation transformer. There are several drawbacks of this topology, one being that all of the modules are connected to the same MPPT device. This causes severe power losses during partial shadowing.



2. Discuss in detail about the performance of cylindrical and parabolic concentrating collector. (Nov - 2017)

C=(Effective Aperture Area) / (Absorber Tube Area)

$$C=(W-D_o)/(\pi D_o)$$

$$dq_u = I_b r_b (W - D_0)\rho\gamma(\tau\alpha)_b + I_b r_b (\tau\alpha)_b - U_l \pi D_0 (T_p - T_a) Dx$$

Dq_u=Useful heat rate for a length dx

ρ = Specular reflectivity of the concentractor surface

γ=Intercept factor

The instantaneous collector efficiency η_i is given by,

$$\eta_i = \frac{q_u}{(I_b r_b + I_d r_d)WL}$$

Ground – Reflected radiation is neglected.

$$\eta_{ib} = \frac{q_u}{I_b r_b WL}$$

Effects

- Performance over a day with different tracking modes
- Effect of inlet temperature

- Effect of mass flow rate

3. Explain the basic phenomenon of solar energy conversion with suitable diagram. (May - 2017)

Conduction

Thermal conduction is the transfer of heat by the vibrations of atoms, molecules and electrons without bulk movement. It is the only mechanism of heat transfer in opaque solids, but transparent media also pass heat energy by radiation. Conduction also occurs in liquids and gases, where, however, heat transfer is usually dominated by convection, as heat is carried by the fluid circulating or moving in bulk. Consider the heat flow *P* by conduction through a slab of material, area *A*, thickness d*x*, surface temperature difference *dT*.

$$q = -KA\frac{dt}{dx}$$

Radiation

It is a process by which heat flows from a body at a higher temperature to a body at a lower temperature when the bodies are separated in space or even a vacuum exists between them. It is the mode of heat transfer by which the sun transfers energy to the earth.

$$q = A\sigma T^4$$

Convection

It is a process that transfers heat from one region to another by motion of fluid. The rate of heat transfer by convection between a surface and a fluid can be calculated from the relation.

$$q_c = h_c A(T_s - T_f)$$

4. Explain the solar radiation geometry at earth surface. (May - 2017)

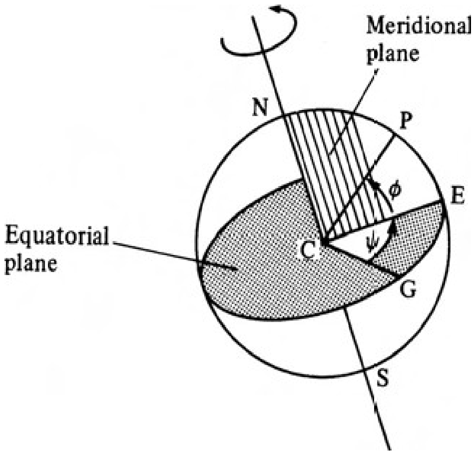


Fig shows the Earth as it rotates in 24 h about its own axis, which defines the points of the north and south poles N and S. The axis of the poles is normal to the earth's *equatorial plane*. C is the centre of the Earth. The point P on the Earth's surface is determined by its *latitude* and *longitude.*

Latitude is defined positive for points north of the equator, negative south of the equator. By international agreement longitude is measured positive eastwards from Greenwich, England.1 The vertical north– south plane through P is the local *meridional plane.*

Local Apparent Time (LAT) =Standard time +4(Standard time longtitude – Longtitude of location) + (Equation of time correction)

- Absorption
- Scattering

5. What are the main components of a flat plate solar collector, explain the function of each. (May - 2017)

A solar collector is a device for collecting solar radiation by absorbing the energy with the help of an absorber. Then the absorbed energy is transferred to a working fluid passing in contact with it.

Non concentrating – Flat plate Collector

- It consist of flat surface with high absorptive for collecting solar radiation, transparent cover, copper tubing and a thermally sealed tight container.
- Solar radiation first passes through transparent covers and falls on the absorber plate. The absorbed radiation is partly transferred to the working heat transfer fluids passing through the tubes.
- The conduction losses are reduced by using thermal insulation on the back and the edges.

Advantages

- It uses both beam and diffuses radiation
- It needs little maintenance

Disadvantages

- Efficiency is low
- Heavy heat loss occur

Applications

- Heating buildings
- Heating green house
- Heat source for a heat engine

6. What are the merits and demerits of concentrating collectors over a flat plate collector? (May - 2017)

Advantages

- No fuel cost
- Predictable 24/7 power
- No pollution and global warming effects
- Using existing industrial base

Disadvantages

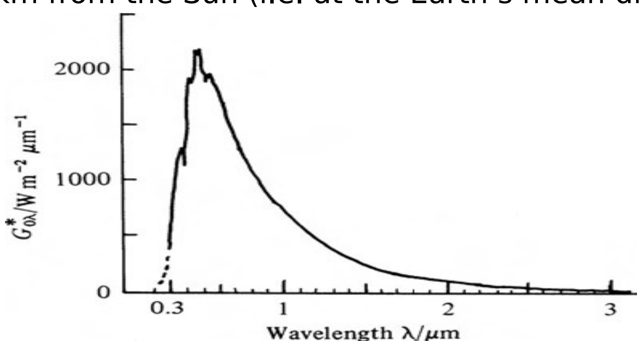
- High costs
- CSP obsolete
- Water issue
- Ecological and Cultural Issue
- It can focus only direct solar radiation, this performance is poor.

7. **Estimation of solar radiation**

- Temperatures of about 107 K and an inner radiation flux of uneven spectral distribution. This internal radiation is absorbed in the outer passive layers which are heated to about 5800K and so become a source of radiation with a relatively continuous spectral distribution.
- The radiant flux (W/m2) from the Sun at the Earth's distance varies through the year by ±4% because of the slightly non-circular path of the Earth around the Sun. The radiance also varies by perhaps ±0_3 per cent per year due to sunspots; over the life of the Earth, there has been probably a natural slow decline of very much less annual significance.
- None of these variations are significant for solar energy applications, for which we consider extra-terrestrial solar irradiance to be constant.

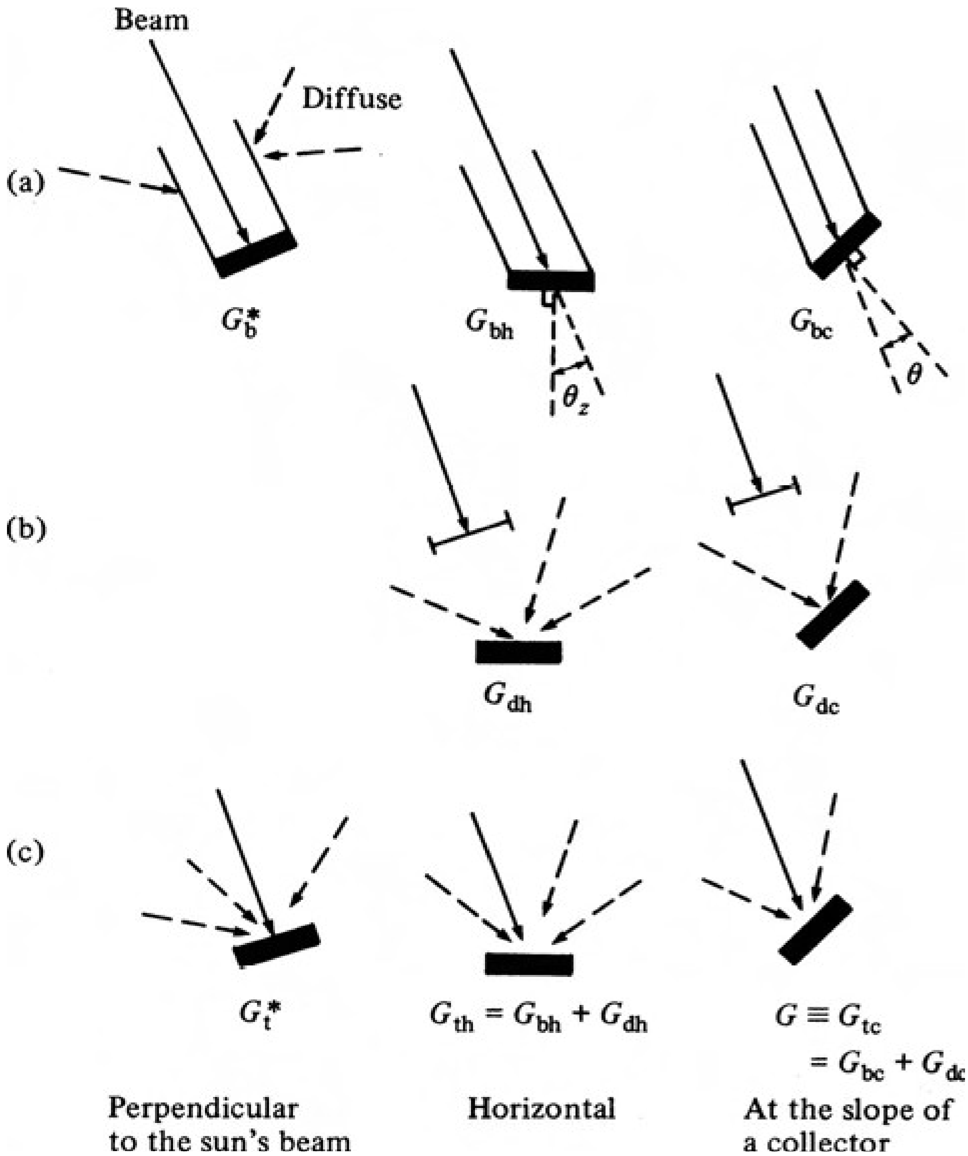
Figure shows the spectral distribution of the solar irradiance at the Earth's mean distance, uninfluenced by any atmosphere. Note how similar this distribution is to that from a black body at 5800K in shape, peak wavelength and total power emitted.

- The area beneath this curve is the *solar constant* $G*0$ = 1367Wm−2. This is the RFD incident on a plane directly facing the Sun and outside the atmosphere at a distance of 1_496×108 km from the Sun (i.e. at the Earth's mean distance from the Sun).



Components of radiation

- Solar radiation incident on the atmosphere from the direction of the Sun is the solar extraterrestrial beam radiation. Beneath the atmosphere, at the Earth's surface, the radiation will be observable from the direction of the Sun's disc in the *direct beam*, and also from other directions as *diffuse radiation*.
- Note that even on a cloudless, clear day, there is always at least 10% diffuse irradiance from the molecules in the atmosphere.
- The practical distinction between the two components is that only the beam radiation can be focused. The ratio between the beam irradiance and the total irradiance thus varies from about 0.9 on a clear day to zero on a completely overcast day. It is important to identify the various components of solar radiation.



(a)Diffuse blocked. (b) Beam blocked. (c) Total.

UNIT V – WIND ENERGY

PART - A

1. What are the causes of aerodynamic force? (Nov - 2017)

- The normal force due to the pressure on the surface of the body
- The shear force due to the viscosity of the gas, also known as skin friction.

2. List the factors responsible for distribution of wind energy on the surface of earth. (Nov - 2017)

- Atmospheric Pressure
- Coriolis Effect
- Topography

3. Write down the condition for maximum power generation in wind energy conversion system. (May- 2017)

$$\frac{dP}{dV_e} = 0 = 3V_e^2 + 2V_iV_e - V_i = 0$$

4. List the types of wind turbines. (May - 2017)

- Horizontal-axis turbines.
- Vertical-axis turbines.

5. Define power coefficient

The fraction of the free flow wind power that can be extracted by a rotor is called the power-coefficient.

- Power coefficient = Power of wind turbine/Power available in the wind

6. Name the characteristics in which the speed of a wind turbine rotor depends.

The speed of a wind turbine rotor depends principally on Wind speed Pitch of the turbine blades Mechanical and electrical load i.e., shaft load, friction, breaking force etc., Orientation of yaw with reference to the wind.

7. What are the main Environmental aspects due to wind turbines? The main environmental aspects are:

- Indirect energy use and emissions
- Bird life
- Noise
- Visual impact
- Telecommunication interference
- Safety
- Effects on ecosystem

8. What are the types of wind power plants?

- Remote
- Hybrid
- Grid connected system.

9. What are the advantages of wind energy systems?

- Inexhaustible fuel source
- No pollution
- Often an excellent supplement to other renewable sources
- Reduces fossil fuel consumption
- Wind power plant create may jobs
- Increases local tax revenues

10. What are the disadvantages of wind energy systems?

- Large areas are needed
- Suitable for wind power generation
- Relatively expensive to maintain
- Large numbers of wind generators are required to produce useful amount of heat or electricity.

PART – B

1. Give some important factors that are considered for site selection of WECS. (May - 2017)

Four types

- Plain land sites
- Hill top sites
- Sea shores sites
- Off shore shallow water sites

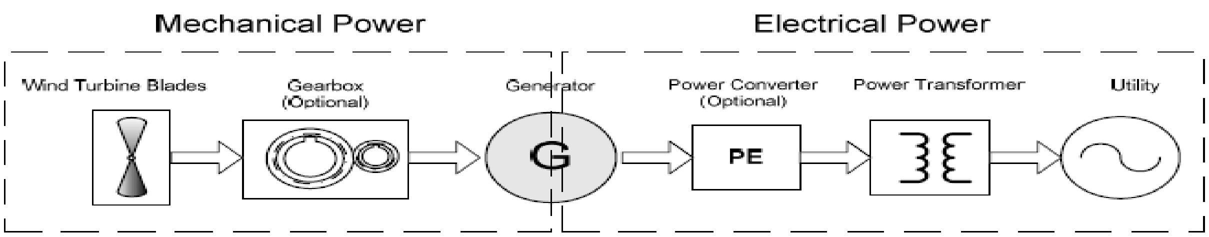
- It is important to consider the technical, environmental, social, economic and other factors before erecting the wind energy conversion system.
- As the building, forest offers the resistance to the air movement; the wind mills are located away from cities and forest.
- As the wind velocities are high in flat open area, plain land sites should be selected.
- Ground surface should be stable.
- If small trees, grass or vegetation are present then the height of the tower will increase, which increase the cost of the system.
- Approach roads up to site for the movement of erection equipments structures, materials, blades.
- Site selected should be nearer to the customer, which minimizes the cost and losses.
- Cost of the land for the site should be favourable.
- Other conditions such as icing problem, salt spray or blowing dust should not present at the selected site. Because they may affect the turbine blades.
- The site selected should have adequate and uniform average wind velocity throughout year.
- Altitude of the proposed site should be considered.

2. Write short notes on Components of WECS.

The wind power system comprises one or more wind turbine units operating electrically in parallel. Each turbine is made of the following basic components:

Tower structure

- Rotor with two or three blades attached to the hub
- Shaft with mechanical gear
- Electrical generator
- Yaw mechanism, such as the tail vane
- Sensors and control



In a modern wind farm, each turbine must have its own control system to provide operational and safety functions from a remote location. It also must have one or more of the following additional components:

- Anemometers, which measure the wind speed and transmit the data to the controller.
- Numerous sensors to monitor and regulate various mechanical and electrical parameters. A 1-MW turbine may have several hundred sensors.

- Stall controller, which starts the machine at set wind speeds of 8 to 15 mph and shuts off at 50 to 70
  mph to protect the blades from overstressing and the generator from overheating.
- Power electronics to convert and condition power to the required standards.
- Control electronics, usually incorporating a computer.
- Battery for improving load availability in a stand-alone plant.
- Transmission link for connecting the plant to the area grid.

The following are commonly used terms and terminology in the wind power industry:

Low-speed shaft: The rotor turns the low-speed shaft at 30 to 60 rotations per minute (rpm).High-speed shaft: It drives the generator via a speed step-up gear.

Brake: A disc brake, which stops the rotor in emergencies. It can be applied mechanically, electrically, or hydraulically.

Gearbox: Gears connect the low-speed shaft to the high-speed shaft and increase the turbine speed from 30 to 60 rpm to the 1200 to 1800 rpm required by most generators to produce electricity in an efficient manner. Because the gearbox is a costly and heavy part, design engineers are exploring slow speed, direct-drive generators that need no gearbox.

Generator: It is usually an off-the-shelf induction generator that produces 50- or 60-Hz AC power.

Nacelle: The rotor attaches to the nacelle, which sits atop the tower and includes a gearbox, low- and high-speed shafts, generator, controller, and a brake. A cover protects the components inside the nacelle. Some nacelles are large enough for technicians to stand inside while working.

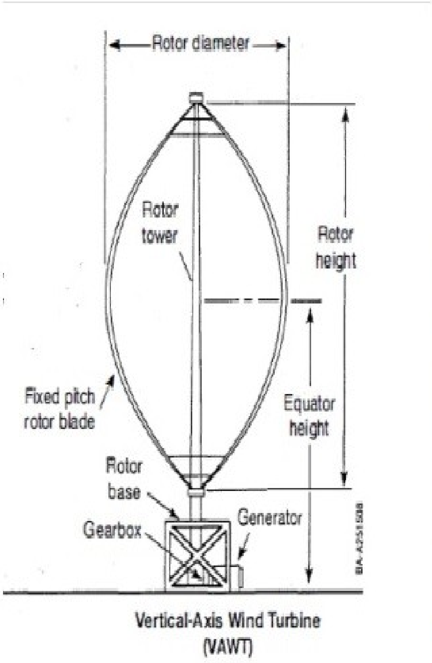
3. Explain in detail about different Types of Wind Turbines

- The wind turbine captures the wind's kinetic energy in a rotor consisting of two or more blades mechanically coupled to an electrical generator. The turbine is mounted on a tall tower to enhance the energy capture. Numerous wind turbines are installed at one site to build a wind farm of the desired power generation capacity.
- Obviously, sites with steady high wind produce more energy over the year. Two distinctly different configurations are available for turbine design, the horizontal axis configuration and the vertical-axis configuration.

Vertical-axis wind turbines

Vertical-axis wind turbines (VAWTs) are a type of wind turbine where the main rotor shaft is set transverse to the wind (but not necessarily vertically) while the main components are located at the base of the turbine. This arrangement allows the generator and gearbox to be located close to the ground, facilitating service and repair. VAWTs do not need to be pointed into the wind which removes the need for wind-sensing and orientation mechanisms.

A VAWT tipped sideways, with the axis perpendicular to the wind streamlines, functions similarly. A more general term that includes this option is "transverse axis wind turbine" or "cross-flow wind turbine



Advantages

- They are omni-directional and do not need to track the wind. This means they don't require a complex mechanism and motors to yaw the rotor and pitch the blades.
- Ability to take advantage of turbulent and gusty winds. Such winds are not harvested by HAWTs, and in fact cause accelerated fatigue for HAWTs.
- Wings of the Darrieus type have a constant chord and so are easier to manufacture than the blades of a HAWT, which have a much more complex shape and structure.
- Can be grouped more closely in wind farms, increasing the generated power per unit of land area.
- Can be installed on a wind farm below the existing HAWTs; this will improve the efficiency (power output) of the existing farm.

Disadvantages

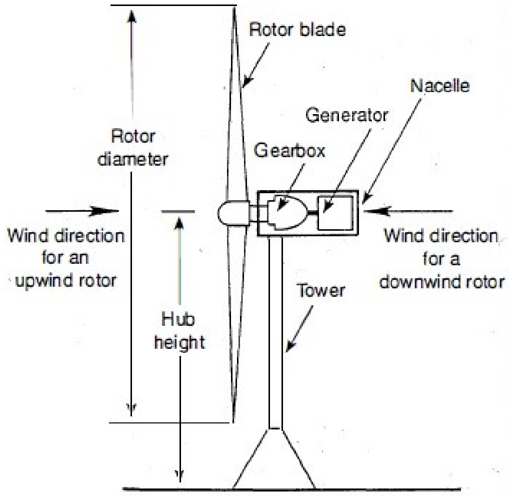
One of the major outstanding challenges facing vertical axis wind turbine technology is dynamic stall of the blades as the angle of attack varies rapidly.

Horizontal-axis wind turbines

Horizontal-axis wind turbines (HAWT) have the main rotor shaft and electrical generator at the top of a tower, and must be pointed into the wind. Small turbines are pointed by a simple wind vane, while large turbines generally use a wind sensor coupled with a servomotor.

Most have a gearbox, which turns the slow rotation of the blades into a quicker rotation that is more suitable to drive an electrical generator. Any solid object produces a wake behind it, leading to fatigue failures, so the turbine is usually positioned upwind of its supporting tower.
Downwind machines have been built, because they don't need an additional mechanism for keeping them in line with the wind. In high winds, the blades can also be allowed to bend which reduces their swept area and thus their wind resistance.

In upwind designs, turbine blades must be made stiff to prevent the blades from being pushed into the tower by high winds. Additionally, the blades are placed a considerable distance in front of the tower and are sometimes tilted forward into the wind a small amount.



Horizontal-Axis Wind Turbine
(HAWT)

Advantages

- Variable blade pitch, which gives the turbine blades the optimum angle of attack. Allowing the angle of attack to be remotely adjusted gives greater control, so the turbine collects the maximum amount of wind energy for the time of day and season.
- The tall tower base allows access to stronger wind in sites with wind shear. In some wind shear sites, every ten meters up, the wind speed can increase by 20% and the power output by 34%.

Disadvantages

- Taller masts and blades are more difficult to transport and install. Transportation and installation can now cost 20% of equipment costs.
- Stronger tower construction is required to support the heavy blades, gearbox, and generator.
- Reflections from tall HAWTs may affect side lobes of radar installations creating signal clutter, although filtering can suppress it.
- Mast height can make them obtrusively visible across large areas, disrupting the appearance of the landscape and sometimes creating local opposition.

4. Difference between horizontal axis machine and vertical axis machine

In the horizontal-axis Danish machine, considered to be classical, the axis of blade rotation is horizontal with respect to the ground and parallel to the wind stream. Most wind turbines are built today with the horizontal-axis design, which offers a cost-effective turbine construction, installation, and control by varying the blade pitch.

The vertical-axis Darrieus machine has different advantages. First of all, it is Omni directional and requires no yaw mechanism to continuously orient itself toward the wind direction. Secondly, its vertical drive shaft simplifies the installation of the gearbox and the electrical generator on the ground, making the structure much simpler. On the negative side, it normally requires guy wires attached to the top for support.

This could limit its applications, particularly at offshore sites. Overall, the vertical-axis machine has not been widely used, primarily because its output power cannot be easily controlled in high winds simply by changing the blade pitch. With modern low-cost variable-speed power electronics emerging in the wind power industry, the Darrieus configuration may revive, particularly for large-capacity applications.

The Darrieus has structural advantages compared to a horizontal-axis turbine because it is balanced. The blades only “see” the maximum lift torque twice per revolution. Seeing maximum torque on one blade once per revolution excites many natural frequencies, causing excessive vibrations. Also a vertical-axis wind turbine configuration is set on the ground. Therefore, it is unable to effectively use higher wind speeds using a higher tower, as there is no tower here.

5. Speed Control - Wind Turbines

The rotor speed must be controlled for three reasons:

- To capture more energy, as seen before.

• To protect the rotor, generator, and power electronic equipment from overloading during high-gust winds.

• When the generator is disconnected from the electrical load, accidentally or for a scheduled event. Under this condition, the rotor speed may run away, destroying it mechanically, if it is not controlled.

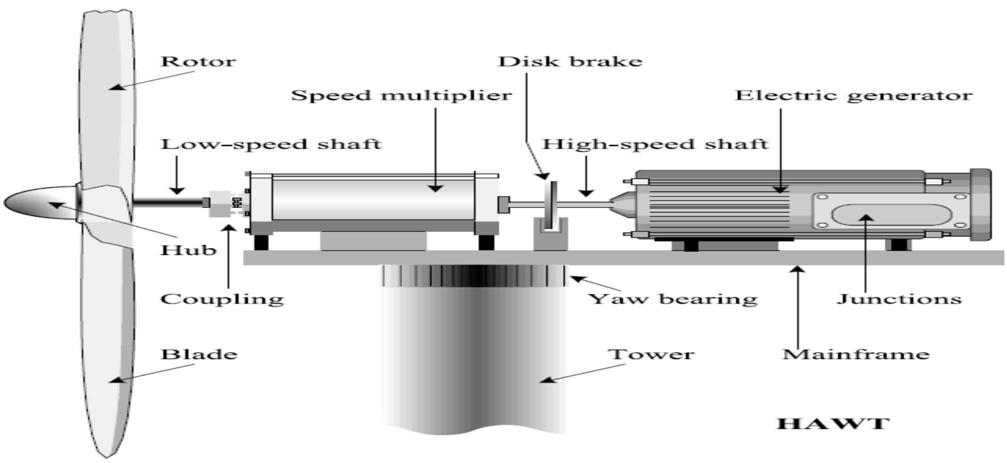
The speed control requirement of the rotor has five separate regions:

1. The cut-in speed at which the turbine starts producing power. Below this speed, it is not worthwhile, nor efficient, to turn the turbine on.
2. The constant maximum Cp region where the rotor speed varies with the wind speed variation to operate at the constant TSR corresponding to the maximum Cp value.
3. During high winds, the rotor speed is limited to an upper constant limit based on the design limit of the system components. In the constant-speed region, the Cp is lower than the maximum Cp, and the power increases at a lower rate than that in the first region.
4. At still higher wind speeds, such as during a gust, the machine is operated at a controlled constant power to protect the generator and power electronics from overloading. This can be achieved by lowering the rotor speed. If the speed is decreased by increasing the electrical load, then the generator will be overloaded, defeating the purpose. To avoid generator overloading, some sort of a brake (eddy current or another type) must be installed on the rotor.
5. The cut out speed, at which the rotor is shut off to protect the blades, the electrical generator, and other components of the system beyond a certain wind speed.

6. Explain wind energy conversion system with neat schematic diagram.

A WECS is a structure that transforms the kinetic energy of the incoming air stream into electrical energy. This conversion takes place in two steps, as follows. The extraction device, named *wind turbine rotor* turns under the wind stream action, thus harvesting a mechanical power. The rotor drives a rotating electrical machine, the generator, which outputs electrical power.

Several wind turbine concepts have been proposed over the years. A historical survey of wind turbine technology is beyond the scope here, but someone interested can find that in Ackermann (2005). There are two basic configurations, namely *vertical axis wind turbines* (VAWT) and, *horizontal axis wind turbines* (HAWT). Today, the vast majority of manufactured wind turbines are horizontal axis, with either two or three blades. HAWT is comprised of the tower and the nacelle, mounted on the top of the tower (Figure). Except for the energy conversion chain elements, the nacelle contains some control subsystems and some auxiliary elements (*e.g.*, cooling and braking systems, *etc.*).



HAWT

The energy conversion chain is organised into four subsystems:

- aerodynamic subsystem, consisting mainly of the turbine rotor, which is composed of blades, and turbine hub, which is the support for blades;

- drive train, generally composed of: low-speed shaft – coupled with the turbine
- hub, speed multiplier and high-speed shaft – driving the electrical generator;
- electromagnetic subsystem, consisting mainly of the electric generator;
- Electric subsystem, including the elements for grid connection and local grid.

All wind turbines have a mechanism that moves the nacelle such that the blades mare perpendicular to the wind direction. This mechanism could be a tail vane (small wind turbines) or an electric yaw device (medium and large wind turbines). Concerning the power conversion chain, it involves naturally some loss of power. Because of the nonzero wind velocity behind the wind turbine rotor one can easily understand that its efficiency is less than unity. Also, depending on the operating regime, both the motion transmission and the electrical power generation involve losses by friction and by Joule effect respectively. Being directly coupled one with the other, the energy conversion chain elements dynamically interact, mutually influencing their operation.

7. Derive the expression for the Forces acting on the blades and thrust on turbines

There are two types of forces which are acting on the blades. They are, circumferential force acting in the direction of wheel rotation that provides the torque and axial force acting in the direction of the wind stream that provides an axial thrust that must be counteracted by proper mechanical design.

$$T = \frac{P}{\omega} = \frac{P}{\pi DN}$$

Where T – Torque (Nm)
ω– Angular Velocity of turbine wheel (m/s)
D – Diameter of turbine wheel (m)

$$D = \sqrt{\frac{4}{\pi} A}$$

N-Wheel of revolution per unit time (S^-1)

$$P = \eta \times P_{total}$$

$$F_{x\max} = \frac{\pi}{9g_c} \rho D^2 V_i^2$$

8. Performance of wind machines

The overall conversion efficiency η_0 = (Useful output power)/(Wind power output) = $\eta_A * \eta_G * \eta_C * \eta_{Gen}$

Where

η_A=Efficiency of the aero turbine
η_G=Efficiency of gearing
η_C=Efficiency of the mechanical coupling
η_{Gen}=Efficiency of the generator
η_A=(Useful shaft power output)/(Wind power input)=C_P=Coefficient of performance

9. Speed and power relation – Wind

The kinetic energy in air of mass m moving with speed V is given by the following in joules:

$$\text{kinetic energy} = \frac{1}{2} mV^2$$

The power in moving air is the flow rate of kinetic energy per second in watts:

$$\text{power} = \frac{1}{2} (\text{mass flow per second}) V^2$$

If
P= mechanical power in the moving air (watts),
ρ = air density (kg/m3),
A= area swept by the rotor blades (m2), and
V= velocity of the air (m/sec),

Then the volumetric flow rate is AV, the mass flow rate of the air in kilograms per second is ρAV, and the mechanical power coming in the upstream wind is given by the following in watts:

$$P = \frac{1}{2}(\rho AV)V^2 = \frac{1}{2}\rho AV^3$$

Two potential wind sites are compared in terms of the specific wind power expressed in watts per square meter of area swept by the rotating blades. It is also referred to as the power density of the site, and is given by the following expression in watts per square meter of the rotor-swept area:

$$\text{specific power of the site} = \frac{1}{2}\rho V^3$$

This is the power in the upstream wind. It varies linearly with the density of the air sweeping the blades and with the cube of the wind speed. The blades cannot extract all of the upstream wind power, as some power is left in the downstream air that continues to move with reduced speed.

POWER EXTRACTED FROM THE WIND

The actual power extracted by the rotor blades is the difference between the upstream and downstream wind powers. Using Equation 3.2, this is given by the following equation in units of watts:

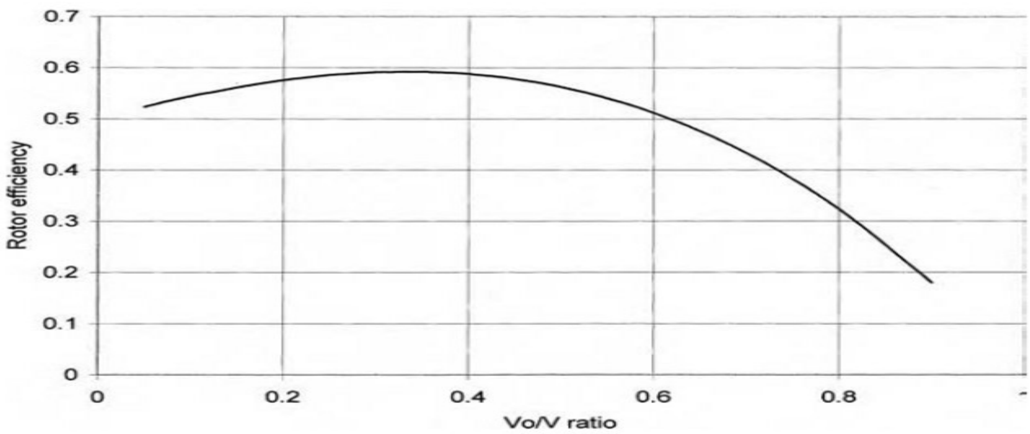
$$P_o = \frac{1}{2}(\text{mass flow per second})\left\{V^2 - V_o^2\right\}$$

where

Po= mechanical power extracted by the rotor, i.e., the turbine output power,
V= upstream wind velocity at the entrance of the rotor blades, and
Vo= downstream wind velocity at the exit of the rotor blades.

$$\text{mass flow rate} = \rho A \frac{V + V_o}{2}$$

The mechanical power extracted by the rotor, which drives the electrical generator, is therefore:



Rotor efficiency vs. V_o/V ratio has a single maximum.

$$P_o = \frac{1}{2}\left[\rho A \frac{(V + V_o)}{2}\right](V^2 - V_o^2)$$

The preceding expression is algebraically rearranged in the following form:

$$P_o = \frac{1}{2}\rho A V^3 \frac{\left(1+\frac{V_o}{V}\right)\left[1-\left(\frac{V_o}{V}\right)^2\right]}{2}$$

The power extracted by the blades is customarily expressed as a fraction of the upstream wind power in watts as follows:

$$P_o = \frac{1}{2}\rho A V^3 C_p$$

Where

$$C_p = \frac{\left(1+\frac{V_o}{V}\right)\left[1-\left(\frac{V_o}{V}\right)^2\right]}{2}$$

Comparing Equations, we can say that Cp is the fraction of the upstream wind power that is extracted by the rotor blades and fed to the electrical generator. The remaining power is dissipated in the downstream wind. The factor Cp is called the power coefficient of the rotor or the rotor efficiency.

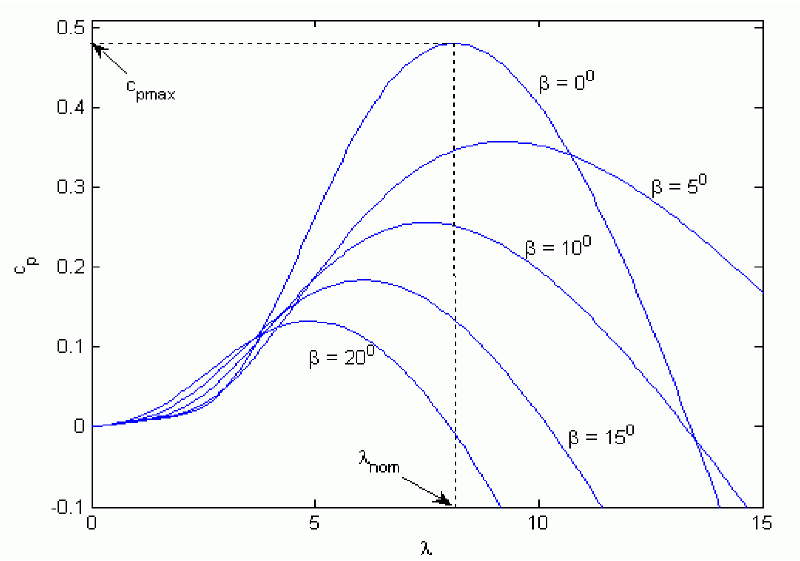


Figure: typical characteristics of wind energy conversion system

Advantages of Wind Energy

- It is a free source of energy

- Produces no water or air pollution
- Wind farms are relatively inexpensive to build
- Land around wind farms can have other uses

Disadvantages of Wind Energy

- Requires constant and significant amounts of wind
- Wind farms require significant amounts of land
- Can have a significant visual impact on landscapes