



SUMMER- 14 EXAMINATION

Subject Code: **12244**

Model Answer

Important Instructions to examiners:

- 1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
- 2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
- 3) The language errors such as grammatical, spelling errors should not be given more Importance (Not applicable for subject English and Communication Skills).
- 4) While assessing figures, examiner may give credit for principal components indicated in the figure. The figures drawn by candidate and model answer may vary. The examiner may give credit for any equivalent figure drawn.
- 5) Credits may be given step wise for numerical problems. In some cases, the assumed constant values may vary and there may be some difference in the candidate's answers and model answer.
- 6) In case of some questions credit may be given by judgement on part of examiner of relevant answer based on candidate's understanding.
- 7) For programming language papers, credit may be given to any other program based on equivalent concept.

Q. No 1 A) (04 marks for suitable answer)

a) Need to switch over alternate energy sources because of the following reasons

1. The supply of crude oil will fail to meet increasing demand.
2. Demand for energy is continuously growing. To meet this alternate energy source is essential
3. Coal reservoirs are unable to fulfill the energy demand
4. Nuclear energy, hydroelectric energy, wind energy, solar energy sources are utilized but they are also unable to meet energy demand.

Thus there is need to switch over alternate energy sources like Municipal and industrial wastes Biomass, Biogas plants, improved wood stoves, solar water heaters, solar cookers, solar lanterns can be used at large.

b)

Renewable energy sources available in India(**any four, 02 marks**)

1. Wind power
2. Biomass
3. Solar applications of energy
4. Hydraulic power
5. Fuel cells
6. Bio fuels



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Non Renewable energy sources available in India: (**any four, 02 marks**)

1. Coal
2. Oil
3. Natural gas
4. Nuclear
5. Propane

c) Advantages of Nuclear energy(**any two, 02 marks**)

1. No emission of pollutant gases (CO_2 and others) that would be generated by burning of fossil fuels.
2. The amount of fuel needed is very small as compared to fossil fuels. This saves on raw materials and also in transport & handling.
3. Production of electric energy is continuous.
4. As an alternative to fossil fuels need not consume as much of carbon fuels like oil, so therefore the problem of global warming is reduced.

Disadvantages of nuclear energy(**any two, 02 marks**)

1. A major drawback is the generation of nuclear waste and the difficulty to manage and it takes many years to lose its radioactivity and danger.
2. Nuclear reactors, once constructed, have an expiration date. After this date, they must be dismantled
3. Nuclear plants have a limited life afterwards disposal is very tedious.
4. Current nuclear reactors work by fission nuclear reactions. These chain reactions occur so that if the control systems should fail every time more and more reactions would occur to cause a radioactive explosion that would be virtually impossible to control.
5. Shortage of trained technical manpower.
6. High capital cost.

d) Factors deciding final cost of electricity purchased by customer.(**any four, one mark each**)

1. Capital cost of power plant including cost of land, buildings & equipments
2. Operating cost of the plant including fuel, water expenses, salaries of staff etc
3. Maintenance cost of the plant & equipment
4. Transmission cost



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5. Distribution cost

6. Cost due to losses in transmission & distribution

Q. No 1 B) (two marks for each definition)

- a) i) Declination angle (δ) : It is the angle between a line extending from the centre of the sun to the centre of the earth and the projection of this line upon the earth's equatorial plane.
- ii) Azimuth angle(γ) : it is the angle of deviation of the normal to the surface from the local meridian, the zero point being south, east positive and west negative.
- iii) Incident angle (θ) : it is the angle being measured between the beam of rays and normal to the plane.

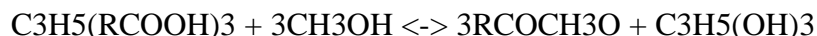
b) Biodiesel Transesterification(06 marks for suitable answer)

Biodiesel Transesterification: Biodiesel is an alternative diesel fuel. Vegetable oil is too thick to flow through modern diesel engines without causing damage, so we can lower its viscosity through a process called Transesterification.

Transesterification is the chemical process which replaces one type of alcohol for another in an ester. An ester is made by combining an alcohol with an acid.

Vegetable oil is an ester of glycerol with long chain fatty acids. The formula for vegetable oil is $C_3H_5(RCOOH)_3$, with the fatty acids represented by RCOOH attached to a glycerol ($C_3H_5(OH)_3$) molecule. Examples of fatty acids are Stearic acid, Palmitic acid, Linoelic acid, and Oleic acid. Methanol (CH_3OH) is used to replace glycerol ($C_3H_5(OH)_3$). A strong alkali is used as a catalyst to break apart the fatty acids from the glycerol. In commercial production we typically see Sodium Methylate (CH_3NaO) dissolved in methanol used as the catalyst.

The chemical formula for biodiesel transesterification is:



The biodiesel transesterification process is slightly reversible making it difficult to get 100% conversion. To push the reaction to its most complete status we use LeChetlier's Principle and offset the reactants to drive the reaction in a more favorable direction.

Q. No 2 a)Energy Audit: An energy Audit is the first step in energy management programme. It shows how efficiently energy is being used and highlights opportunities for energy cost savings. It also shows ways to improve productivity.(**02 marks**)

Types of energy audit: There are two types of Energy Audit



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- 1) Preliminary Audit
- 2) Detailed Audit .(**02 marks**)

b)Principle of wind energy conversion: (04 marks for suitable answer)

Atmospheric winds are formed due to uneven solar heating and the rotation of the earth which accelerates the air. Winds transfer atmospheric energy to offset uneven solar heating. Breezes are the effect of quick heating of land than sea water. Wind energy is the kinetic energy associated with the movement of atmospheric air. The kinetic energy of the wind is transferred through blades of wind generator into mechanical energy and drives the shaft of generator which generates electricity. The energy depends on wind speed, density of the air which is the effect of temperature, barometric pressure and altitude.

c) Advantages of Solar energy(any two, 02 marks)

1. Solar energy is freely available.
2. Solar energy does not cause pollution
3. Solar energy can be used in remote areas where it is too expensive to extend the electricity power grid.
4. Many everyday items such as calculators and other low power consuming devices can be powered by solar energy effectively.
5. It is estimated that the worlds oil reserves will last for 30 to 40 years. On the other hand, solar energy is infinite (forever).
6. It is renewable and does not require fuel.

Disadvantages of Solar energy (any two, 02 marks)

1. Solar energy can only be harnessed when it is daytime and sunny.
2. Solar collectors, panels and cells are relatively expensive to manufacture although prices are falling rapidly.
3. Solar power stations can be built but they do not match the power output of similar sized conventional power stations. They are also very expensive.
4. Large areas of land are required to capture the suns energy. Collectors are usually arranged together especially when electricity is to be produced and used in the same location.
5. Solar power is used to charge batteries so that solar powered devices can be used at night. However, the batteries are large and heavy and need storage space. They also need replacing from time to time.

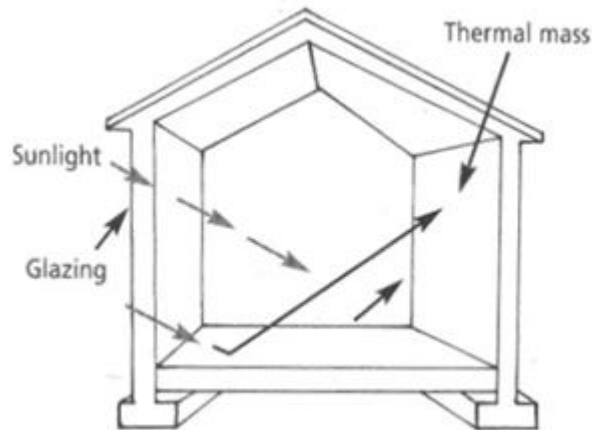
d) Space heating by passive method.(02 marks for sketch, 02 marks for explanation)

Space heating: A solar space heating can consist of a passive system, an active system or combination of both. Passive systems are typically less costly and less complex than active system. Passive solar space heating takes advantage of warmth from the sun through design features such as large south facing windows and materials in the floors or walls that absorb warmth during the day. A sunspace or greenhouse is a good example of passive system for solar space heating



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e) Instruments required for energy Audit are (any four, 01 mark each)

- i) Electrical measuring instruments
- ii) Combustion analyzer
- iii) Thermometer
- iv) Infrared thermometer
- v) Flow meter
- vi) Leak detector
- vii) Lux meter

f) **Heat pipe : .(02 marks for sketch, 02 marks for explanation)**

Heat pipe is tube containing vapour with the condensate recycled by a wick and offers an effective conductivity much greater than that of copper. Usually heat pipe is a means for transporting heat efficiently from a source to a cooler receiver by utilizing the latent heat of vaporization of a liquid. A heat pipe is a closed space containing a suitable working liquid and its vapor. One part of the space is in contact with the heat source and with the cooler material to which the heat is to be transported. The interior wall of the space is lined with a porous material called a wick.

In the hotter part of the heat pipe, the working fluid is vaporized thereby taking up the latent heat of vapourisation. The vapour diffused towards the cooler region because the pressure is lower there & condensed to liquid. In doing so it deposits the heat of vaporization taken up from the source. The liquid is returned to the heat source region by capillary action of the wick. There is thus a continuous movement of vapour from the heat source to the receiver and of condensed liquid back to the source, accompanied by the transfer of heat.



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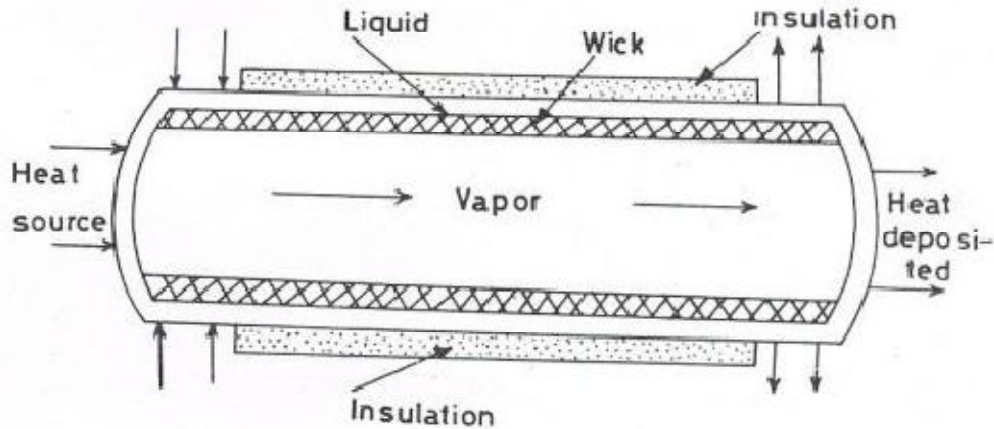


Fig. 1. Simple heat pipe.

Q.No.3 a.

(i) Power in Wind

Wind has a motion and by virtue of motion it possesses energy. The energy possessed by wind is Kinetic energy. When flowing wind is slowed down by creating an obstruction like wind turbine, then this kinetic energy in the wind is converted into mechanical energy or mechanical power in the form of rotation of shaft of turbine. As shaft is rotated mechanical power is obtained from turbine. The shaft of turbine is connected to shaft of alternator, which also gets rotated and mechanical power is converted into electrical energy output. So wind has power which can be expressed by following formulae,

$$P = \frac{1}{2} * \rho * V^3 * A$$

Where P = Power in wind (Watts)

ρ = Density of air (Kg/m^3)

V = Velocity of air (m/s)

(Correct Formulae – 01 Marks, Appropriate short Description- 01Marks)

(ii) Maximum Power

When flowing wind is slowed down by creating an obstruction like wind turbine, then this kinetic energy in the wind is converted into mechanical energy or mechanical power in the form of rotation of shaft of turbine. As shaft is rotated mechanical power is obtained from turbine. A wind turbine slows down wind and thereby extracts power by converting kinetic energy. A wind



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turbine cannot extract 100% of air's kinetic energy i.e. air cannot stop completely, otherwise it gets piled up behind turbine. Albert Betz deducted that maximum power or energy which can be captured or obtained from wind is about 59.5 %.

Hence maximum power which can be extracted from wind can be written as,

$$P_{\max} = 0.595 * P$$

Where P_{\max} = Maximum Power in wind (Watts)

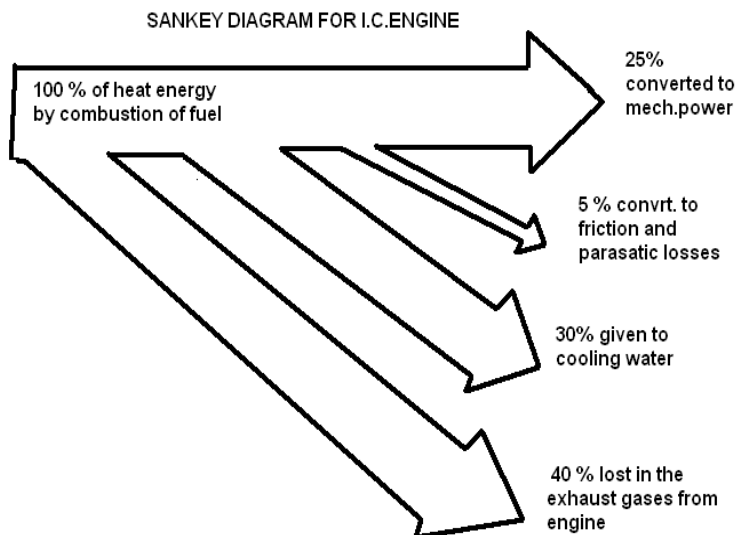
P = Power in wind (Watts)

(Correct Formulae – 01 Marks, Appropriate short Description- 01 Marks)

Q.No.3 b. Sankey Diagram for I.C.Engine

(Correct Description – 02 Marks, Appropriate Figure- 02 Marks)

Sankey diagrams are specific types of flow diagrams used to represent flow of quantities like energy, fluid flow, mass flow , material flow etc. Sankey diagrams are represented by arrows with varying widths. Width of arrows are proportional to flow quantity. Sankey diagrams are used to visualize flow of energy or mass in a process. They are helpful in locating a dominant flow quantity in a process. In an Internal combustion engine, heat energy is supplied by burning fuel in engine and part of heat is converted into mechanical energy, part is given to exhaust gases , part of heat is given to cooling water and part of heat is lost in friction. This is shown by Sankey Diagram as under,



Q.No.3 c.

Consideration for site selection for wind mills

- Availability of higher and constant wind speed with 7 to 8 m/sec



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- Availability of wind throughout the year.
- Proper altitude of site.
- Availability of sufficient land for installing wind mills.
- Connectivity to electric grid.
- Connectivity of site by road and other modes of transport.
- Easy and proper access to locality.
- Ecology considerations

(Any four considerations – 04 Marks)

Q.No.3 d.

Applications of Biodiesel

- Biodiesel is used as fuel in diesel engine driven automobile vehicles like cars , trucks and buses. It is mixed in petroleum diesel in suitable proportion like B10 or B20 and used in engine.
- Biodiesel is used as fuel in Diesel railway engines. It is mixed in petroleum diesel in suitable proportion like B5 or B10 and used in engine.
- Biodiesel is used as an alternative fuel in oil fired boilers where conventionally furnace oil or diesel are used.
- Biodiesel is used as an alternative fuel in diesel engine pump sets used in farms.
- Biodiesel is used as an alternative fuel in diesel engine Generator sets used for electricity generation.
- Biodiesel is used as an alternative fuel in farm tractors used in farms.

(Correct Any four applications – 04 Marks)

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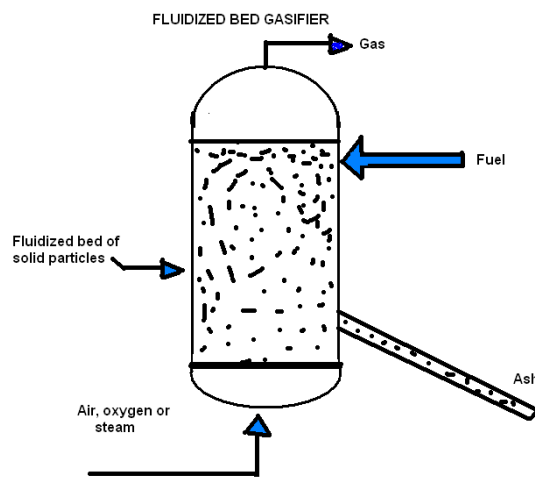
Model Answer

Fluidized Bed Gasifier

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Q.No.3 e.

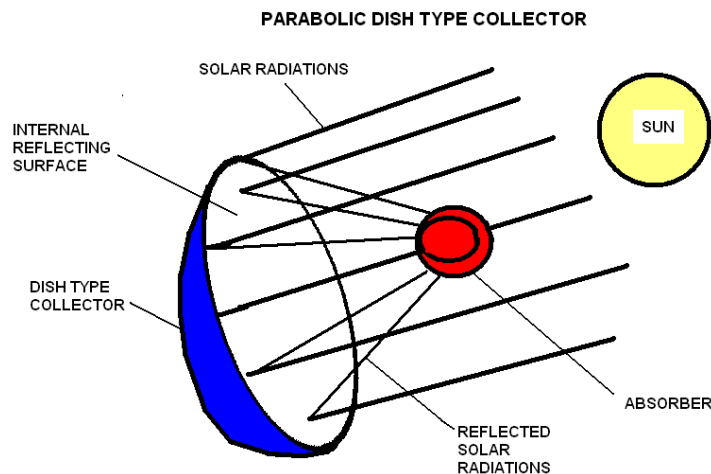
A fluidized bed gasifier use a fluidized bed consisting of hot solid particles suspended in a high pressure air flow. Air is blown through bed of heated solid particles at sufficient velocity due to which particles gets suspended in flow of air. Fuel particles are introduced at bottom of reactor gets mixed up and heated. Pyrolysis of fuel takes place quickly resulting in large amount of gases. System is provided with cyclone separator to separate char blow out. Feedstock flexibility is main advantage of this gasifier. Better control on reaction is also possible.



(Correct Description – 02 Marks, Appropriate Figure- 02 Marks)

Q.No.4 A.-a)

Parabolic Dish Collector





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System contains a large reflective parabolic dish similar in shape as that of satellite television dish. Solar radiation falls on internal reflecting parabolic surface and gets concentrated at absorber area/volume placed at focal point. All the heat is absorbed by absorber and a fluid is heated. This system is used in Dish –Sterling engine arrangement. Very high amount of heat is concentrated at a point and high temperatures can be obtained at focal point. A contentious solar tracking system is essential to absorb maximum heat in solar energy.

(Correct Figure – 02Marks, Appropriate Description- 02 Marks)

Q.No.4 A- b. Advantages and Disadvantages of Renewable Energy

Advantages:

1. These are renewable in nature and non exhaustible.
2. Clean and non polluting sources of energy.
3. Requires less maintenance for operation of equipments

(Appropriate two advantages – 02 marks)

Disadvantages:

1. Cost of equipment required to obtain energy is high.
2. Energy available is not continuous form.
3. Large amount of electricity cannot be generated.
4. Reliability of supply of energy is not guaranteed.

(Appropriate two disadvantages – 02 marks)

Q.No.4 A- c. Advantages and Disadvantages of Geothermal Energy

Advantages:

1. These are renewable in nature and non exhaustible.
2. Clean and non polluting sources of energy, does not produce greenhouse gases.
3. Requires less maintenance for operation of equipments

(Appropriate two advantages – 02 marks)



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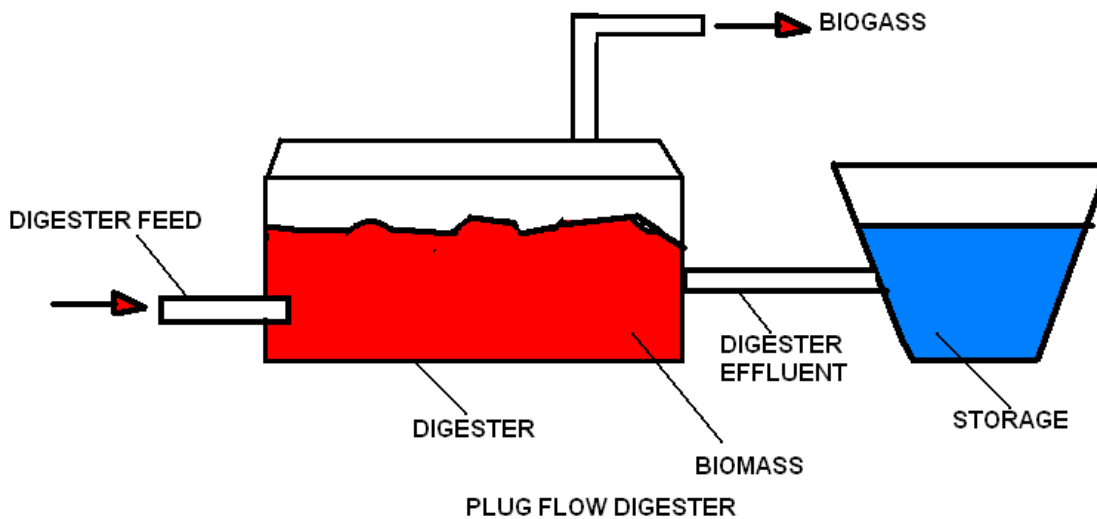
Disadvantages:

1. Cost of equipment required to obtain energy is high.
2. Energy available is not continuous form.
3. Large amount of electricity cannot be generated.
4. Reliability of supply of energy is not guaranteed.
5. Available in selected areas only.
6. Harmful gases sometimes may get evolved.

(Appropriate two disadvantages – 02 marks)

Q.No.4 A- d.

Plug Flow Digester



Plug Flow digesters are suitable for ruminant animal manure which has a solid concentration of 11 % to 13 %. Water is mixed in biomass and it is sent to digester. The digester is a long rectangular container usually built below grade with an airtight expandable cover. New material added to one end pushes the older material to opposite end. Coarse solids in animal manure forms viscous material as they are digested. As a result the material flows through the tank in the form of a “PLUG”. The average retention time of plug in digester i.e. the time for which material plug remains in digester is from 20 to 30 days. Anaerobic digestion of manure slurry releases biogas as material flows through the digester.

(Correct Figure – 02 Marks, Appropriate Description- 02 Marks)



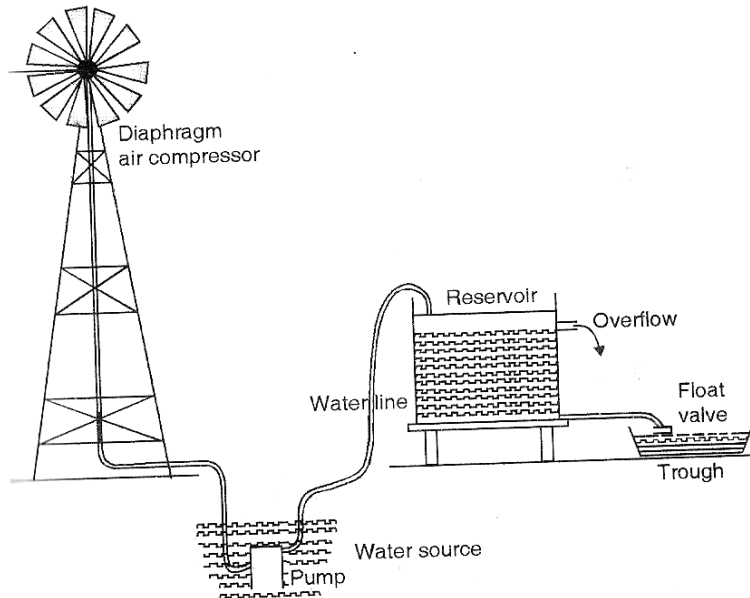
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Q.No.4 B- a.

Air activated Reciprocating wind pump



Wind powered (air-activated) pump layout

Here the wind mill operates a diaphragm type air compressor mounted on its shaft. The compressed air produced from air compressor operates the water pump which sucks the water from well and delivers to the reservoir. From reservoir the water is supplied. Since wind is a variable energy source, this pumping system requires sufficient water reservoir to maintain constant supply of water .

(Correct Figure – 03 Marks, Appropriate Description- 03 Marks)

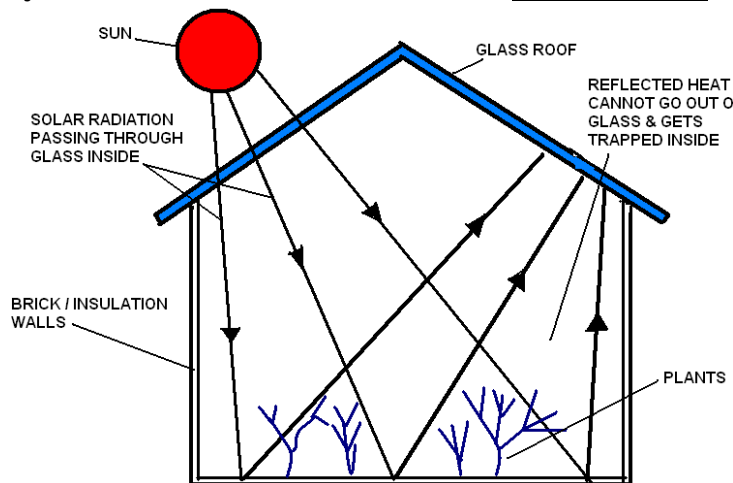
Q.No.4 B- b.

Solar green House

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Model Answer



Green house is the chamber where the plants can be grown throughout the year. These are effective solar collectors. It provides crop cultivation in controlled environment. It has a brick or wooden walls with transparent roof of glass and arrangement for ventilation and temperature control for plant environment including soil temperature, air humidity, soil moisture, light, air composition etc.

As shown in figure solar radiations enter in green house and gets absorbed inside. Heating of inside surface results in emission of heat which has long wave length and cannot pass through glass and gets trapped inside the green house.

(Correct Figure – 03 Marks, Appropriate Description- 03 Marks)

Q.5 a) OPEC is an Organization of the Petroleum Exploring Countries . It was founded in 1960.

- OPEC is an international organization whose mission is to co-ordinate the policies of oil producing countries. The goal is to secure a steady income to member states and to secure supply of oil to customers.
- The head quarter was in Geneva , Switzerland, before moving to Vienna, Austria.

(02 marks)

Name of countries: (02 marks)

Algeria, Angola, Equador, Iran , Iraq, Kuwait, Libiya, Nigeria, Qatar, Saudi Arabia, UAE, and venezuala.

Q. 5 b) Power co-efficient :

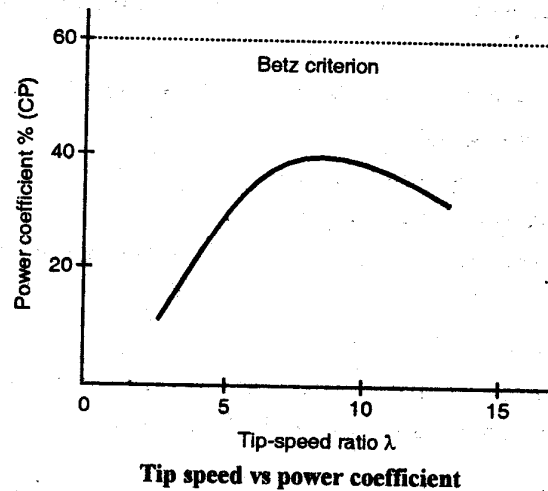
Power co-efficient is defined as ratio of Electricity produced by wind turbine to total energy available in the wind.

Power co-efficient tells us the efficiency of turbine to convert the energy in the wind to electricity. (02 marks)



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Betz Limit :

Albert Betz has first delivered that no wind turbine could convert more than 59.5% of kinetic energy of the wind into mechanical energy turning a rotor.

$P_{max} = 0.595 P_{total}$ (02 marks)

c) Energy Management :

- It is defined as judicious use of energy to maximize profits, minimize costs, and enhance competitive positions.
- Management activity that judiciously uses energy comes under it.
- Waste disposal may create opportunities for efficient use of energy.

This will maximize profit and minimize cost. (02 marks)

Objectives :

- To Reduce cost
- To develop and maintain effective monitoring and strategies for efficient energy usage.
- To determine new and better ways to increase return from energy investments through research and developments.

To develop interest in and dedication to energy management Program for all employees.
(02 marks)

d) Species used as bio mass:

Any organic matter formed directly or indirectly by virtue of photosynthesis is called as bio mass.

- Crop residues
- Forest residues



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- Agro industrial residues
 - Animal waste
 - Aquatic plants
 - Purpose grown trees
commonly used species are
 - Willows
 - Poplars
 - Hempt
 - Miscanthus
 - Maize
 - Sorghums(grass like grain crop produces sugar)
 - Oil bearing plants
 - Other municipal solid waste and synthetic organics
- (any four of above species, 04 marks)**

e) Solar Pump : Solar pumping consists of power generated by solar energy for water pumping useful for irrigation.

Features of solar pumping :

- i. Greatest need of pumping occurs in summer months when solar radiation is greatest.
- ii. Pumping can be intermittent to an extent.
- iii. During periods of low radiations, evaporation losses from crops are also low.

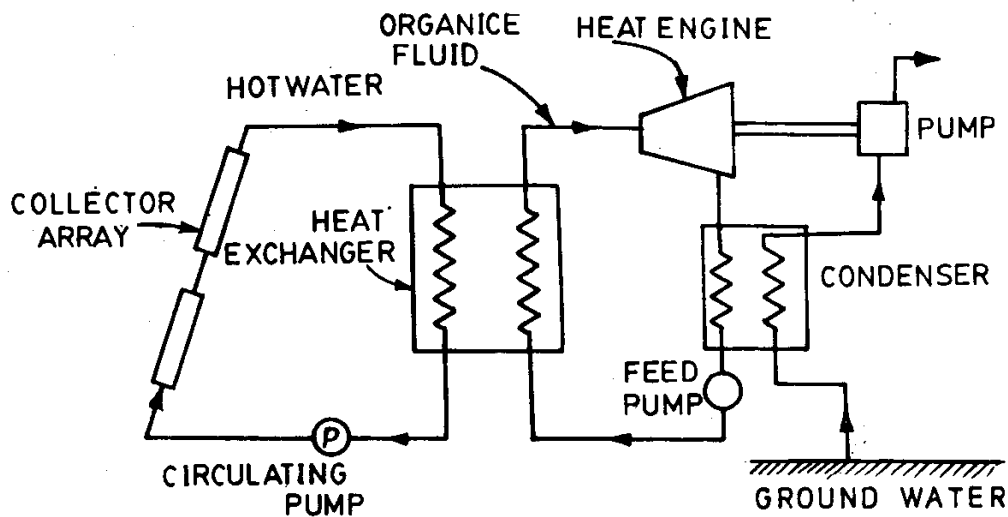
The basic system consists of following components :

1. Solar collectors may be Flat plate or suntracking concentrators
2. The heat transport system
3. Boiler or heat exchangers
4. Heat Engine : Rankine/ stirling hot gas, rotary piston
5. Condenser
6. Pump may be Reciprocating, centrifugal, diaphragm

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Schematic of a solar pump.

Working: Solar pump is similar to solar heat engine working in low temperature cycle. The source of heat is solar collector and sink is the water to be pumped.

The primary components of the system are

- i) Array of flat plate collectors
- ii) Rankine engine with an organic fluid as the working substance

During operation, heat transfer fluid flows through the collector arrays. Depending on the collector configuration, solar flux and the operating conditions of the engine, the fluid will be heated in the collector to higher temperature.

Solar energy is thus converted to thermal energy.

Now, fluid flows into heat exchanger (boiler) due to temp. gradient and comes back to the collector.

This water yields its heat to an intermediate fluid in the boiler. This fluid evaporates and expands in the engine before reaching the condenser, where it condenses at low pressure.

Condenser is cooled by the water to be pumped.

The fluid is then reinjected in boiler to close the cycle.

The rankine engine is coupled to the electric generator.

(Note: solar pump operated by solar cells should also be considered)

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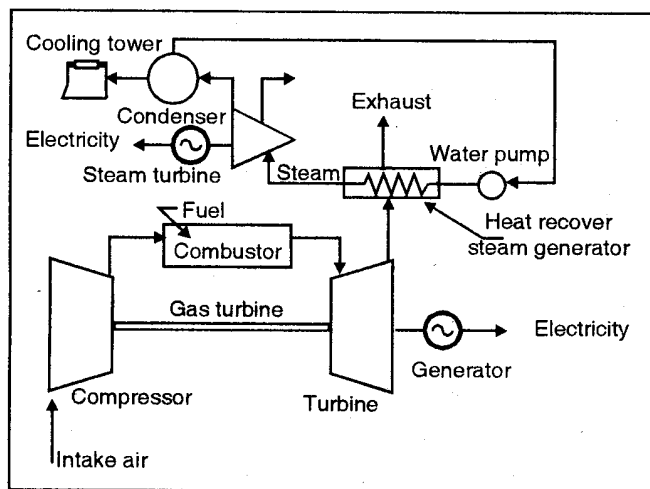
(02 marks for sketch, 02 marks for suitable description)

f) combined cycle cogeneration system :

(02 marks for any one sketch, 02 marks for suitable description)

combined cycle means two thermodynamic cycles connected to each other via working fluid and operating at different temperatures.

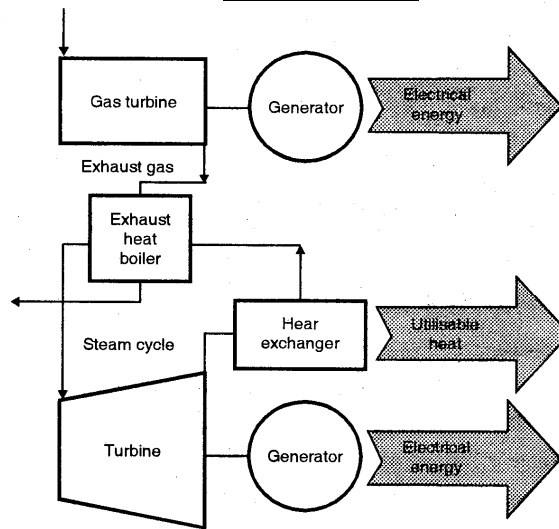
High temperature cycle(topping) rejects heat which is recovered and used by low temperature cycle(bottoming)for additional electric or Mechanical power generation thus increasing efficiency.Most commonly used combined cycle system use a gas/steam turbine combination.



Combined cycle system

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Combined cycle system with steam and heat flow

Q. 6 a) Principle of energy conservation : (04 marks for suitable answer)

Energy conservation : It means reduction in energy consumption without making any sacrifice of quality and quantity of production or for same energy consumption getting higher production.

It may be achieved through efficient energy use.

It may result in increase of financial capital, security, and human comfort.

Individuals and organizations that are direct consumers of energy may want to conserve energy in order to reduce cost and promote economic security.

Principle: There are two principles governing energy conservation policies

- i) Maximum thermodynamic efficiency
- ii) Maximum cost effectiveness in energy use.

The first and second laws of thermodynamics measure the efficiency of energy use and allocation of available production factors determine the cost effectiveness of conservation.

Maximum thermodynamic efficiency in energy use is defined as maximum work done or production by using a given amount of primary energy input.

Maximum work = Energy input – Energy loss in transfer – Energy discharge

Hence energy conservation is energy demand management that aim at increasing the efficiency of use.



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Q. 6 b) Purpose of insulation :

- To reduce overall energy consumption
- Offers better process control by maintaining process temperature
- Prevents corrosion by keeping exposed surface of refrigerated system above dew point.
- Provides fire protection
- Absorbs vibrations(**02 marks**)

Critical Thickness:

Since heat loss through insulation is a conductive heat transfer , there are instances when adding insulation actually increases heat loss.

- Critical Thickness is the thickness at which insulation begins to decrease heat loss. (**02 marks**)

Q. 6 c) Return on Investment(ROI) : (04 marks for suitable answer)

ROI is rate of profit or just return. It is ratio of money gained or lost on an investment relative to the amount of money invested.

ROI is usually expressed as percentage.

$ROI = (\text{annual net cash flow}) * 100 / \text{capital cost}$

ROI is used to compare return on investment where money gained or lost or money invested are not easily compared using monetary values.

d) Working procedure for Energy Management Cell: (04 marks for suitable answer)

- All Energy intensive industries should have a dedicated Energy Management Cell
- The cell should provide necessary structure and formalize the process of energy conservation thereby enhancing its efficiency.
- The cell should interact with Manufacturing & other divisions in different disciplines.
- This will help in carrying out its activities like planned internal & external energy audits, implementation of projects etc.
- This cell will become a focal point for effective energy management in the plant.

This cell will

- Carry out management studies, analysis etc.
- Accelerate energy management activities in plant.
- Conduct regular maintenance from an energy perspective
- Conduct an energy audit.



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Q. 6 e) Working of regenerator : (**02 marks for sketch, 02 marks for description**)

- Regenerator is useful for large capacities of plant size, widely used in glass and steel melting furnaces.
- Long periods means higher thermal storages and hence higher costs.
- Accumulation of dust or slagging on surface reduce efficiency and heat transfer.
- Heat losses from the walls of the regenerator and air in leaks during the gas period and out leak during air period also reduces heat transfer.

