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Improvement Test

Sub:	**RENEWABLE ENERGY SOURCES**							Code:	10EE836
Date:	21/5/18	Duration:	90 mins	Max Marks:	50	Sem:	8	Branch:	EEE

Answer Any FIVE FULL Questions

		Marks	OBE	
			CO	RBT
1.	Explain the main considerations in selection of a site for wind energy conversion system	[10]	CO4	L1
2	Derive an expression for the maximum power output of a horizontal axis wind turbine with usual notations.	[10]	CO4	L1
3	Explain the working of a fuel cell.	[10]	CO5	L5
4	Describe how wave energy originate? Discuss the advantages and disadvantages of small hydro resources.	[10]	CO5	L2

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5	With a neat sketch explain Janata model digester plant	[10]	CO4	L2
6	Summarize the factors affecting biogas generation?	[10]	CO5	L2
7	Analyze the environmental advantages and disadvantages related to biomass Energy.	[10]	CO5	L4
8	A propeller type wind turbine has the following data : Speed of free wind at a height of 10 m = 12 m/s, Air density = 1.226 kg/m3, $\alpha = 0.14$, height of tower = 100m, diameter of rotor = 80m, Generator efficiency = 85%, Wind velocity at the turbine reduces by 20%. V = 0.8 Vz. Calculate (a) total power available in the wind (b)power extracted by the turbine (c) electrical power generated (d)axial thrust on the turbine (e)maximum axial thrust on the turbine.	[10]	CO4	L3

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1. Selection of site for a wind energy conversion system

- High annual wind speed.
- No tall obstructions for a radius of 3 Km.
- Open plain or open shore
- Top of a smooth, well rounded hill with gentle slopes
- Mountain gap which produces wind funneling
- Site for the wind plant should be nearer to the consumers of the generated electrical energy.
- It must be convenient for transportation facility.
- Plant should be erected in the place, where winds are strong and persistence.
- Plant must be installed at higher attitudes, where the motion of wind energy is available with higher velocity.
- The land cost should be low.
- It is better to choose the site nearer to the sea coast, mountains, etc. for the wind.
- Energy conversion plant.

----------(10 Marks)

2. Power Equations

Conservation of mass :

$m = \rho A_1 V_1 = \rho A_2 V_2 = \rho A V_t$ = constant

$F = ma = m(dv/dt) = \rho A V_t (V_2 - V_1)$

Power and Work

Let work done = $dE = Fdx$

P = Power = $(dE/dt) = F(dx/dt) = FV$

$P = \rho A V_2 (V_1 - V_2)$

Using Kinetic energy $P = (½)\ \rho A V(V_1^2 - V_2^2)$

Combining the previous equations,

$\rho A V^2 (V_1 - V_2) = (½)\ \rho A V(V_1^2 - V_2^2)$

$V(V_1 - V_2) = ½\ (V_1 + V_2)(V_1 - V_2)$

$V = V_1 + V_2/2$

$P = ½\ \rho A 1/2(V_1 + V_2)(V_1^2 - V_2^2)$

$P = 1/4 \rho A(V_1 + V_2)(V_1^2 - V_2^2)$

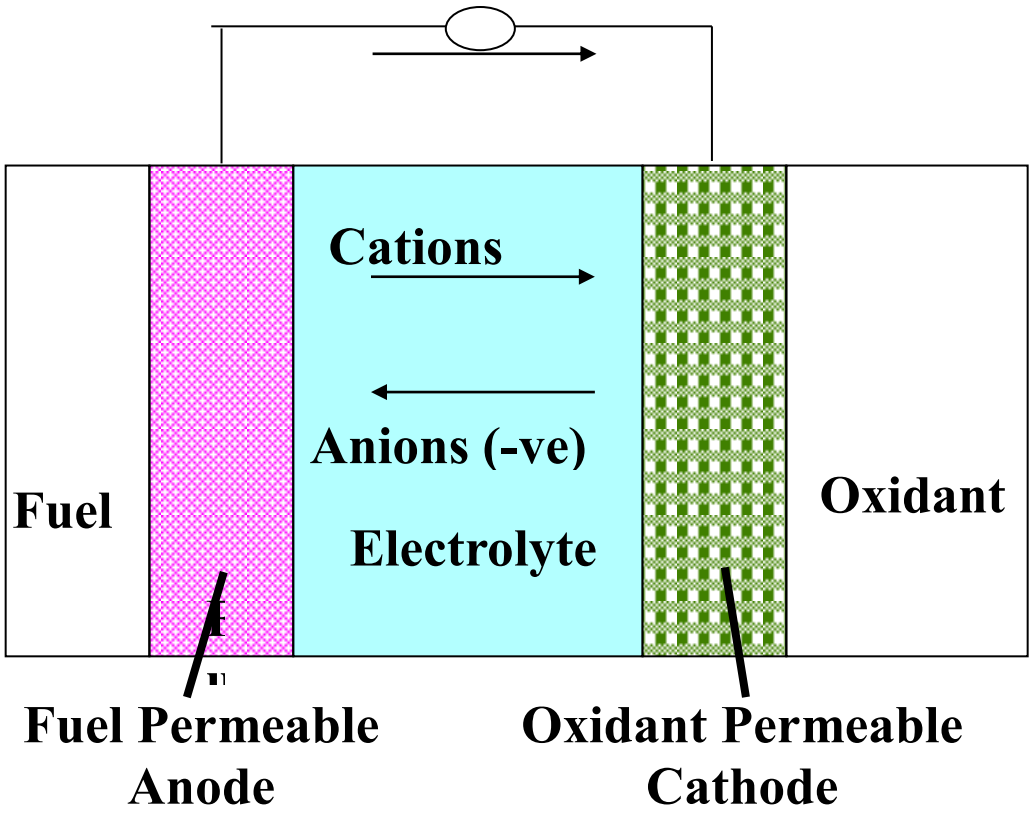
For maximum power $dP/dV2 = 0$

Differentiating we get $V_2 = (1/3)\ V_1$

$P_{max} = (8/27)\rho A V_1^{\,3}$ - (10 Marks)

3. Working of a Fuel cell

A Fuel cell is a electrochemical device that converts chemical energy into electrical energy. Every fuel cell has two electrodes, one positive and one negative, called, respectively, the cathode and anode. The reactions that produce electricity take place at the electrodes. In all types of fuel cell, hydrogen is used as fuel and can be obtained from any source of hydrocarbon.



The fuel cell transform hydrogen and oxygen into electric power, emitting water as their only waste product. Every fuel cell also has an electrolyte, which carries electrically charged particles from one electrode to the other, and a catalyst, which speeds the reactions at the electrodes. A single fuel cell generates a tiny amount of direct current (DC) electricity. A converter is used to

produce AC current. In practice, many fuel cells are usually assembled into a stack. Cell or stack, the principles are the same. A fuel cell consists of two electrodes namely an anode and a cathode and sandwiched around an electrolyte. An electrolyte is a substance, solid or liquid, capable of conducting owing ions from one electrode to other. The Fuel gas (hydrogen rich) is passed towards the anode where the following oxidation reaction occurs:

$H2\ (g) = 2H+ + 2e-$

The liberated electrons from hydrogen in anode side do not migrate through electrolyte. Therefore, they passes through the external circuit where work is performed, then finally goes into the cathode. On the other hand, the positive hydrogen ions (H+) migrate across the electrolyte towards the cathode.

- Explanation -7 Marks, Diagram – 3 Marks

4. **Wave energy** : Differential warming of the earth causes pressure differences in

the atmosphere, which generate winds As winds move across the surface of open bodies of water, they transfer some of their energy to the water and create waves. The amount of energy transferred and the size of the resulting blows, the distance over which the wind blows, or fetch. Therefore, coasts that have exposure to the prevailing wind direction and that face long expanses of open ocean have the greatest wave energy levels. Waves retain energy differently depending on water depth Lose energy slowly in deep water. Lose energy quickly as water becomes shallower because of friction between the moving water particles and the sea bed. Wave energy conversion devices are designed for optimal operation at a particular depth range. – 5 Marks

Advantages of Hydro resources

- 75% of costs are site specific
- High initial costs
- But civil works and equipment can last >50 years
- Very low operating and maintenance costs
- One part-time operator is usually sufficient
- Periodic maintenance of major equipment requires outside contractor
- High head developments tend to be less costly
- Typical range: $1,200 to $6,000 per installed kW

Disadvantages

- Environmental Consequences.
- Expensive
- Droughts
- Limited Reservoirs.

----------(5 Marks)

5. Fixed Dome type – Janata Model Biogas Plant Construction

Biogas can be a great alternative of fossil fuels. It is already in use in many rural areas. Biogasplants use animal waste, plant waste and human waste. All this wastes have great combustible property. Biogas is an excellent renewable energy source. It is produced by the digestion of waste materials by the means of anaerobic reaction. Anaerobic means the absence of Oxygen. In most of the rural areas cow and buffalo dungs is used as biomass fuel for producing gas. The typical composition of biogas is

Methane - CH_4 (55 - 65 %)
Carbon dioxide CO_2 (30-40%)
H_2 , H_2S , N_2 (< 10%)

Biogas Technology involves the bacterial breakdown of the waste materials to produce Methane,Carbon Dioxide and Water . The process involves the following three steps -

Hydrolysis
Organics materials contains mainly carbohydrate mainly in the form of cellulose, hemicellulose and lignin. These have very complex structure which is not suitable for absorption. So these matters are converted into simple soluble materials by the action of celluolytic or hydrolytic bacteria. Concentration of bacteria in the organic materials, temperature and pH controls the rate of hydrolysis. pH between 6 to 7 and temperature between 30-40 degree Celsius is good for bacteria to work.

Acid Formation
Simple organic materials are turned into acid by acetogenic bacteria.

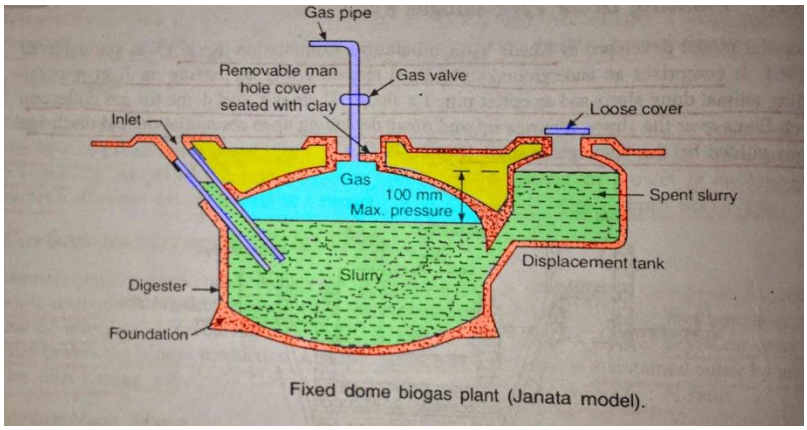
Methane Formation
Methanogenic bacteria turns the acid into methane, carbon dioxide, hydrogen, nitrogen and oxygen. The methane content is 60%. It has high calorific value. Very good for combustion and producing energy.

Biogas plants
Biogas plant converts the organic wastes like dung, human waste and plant wastes into a inflammable and it also produces a high quality organic manure as a by product. Most popular two designs of biogas plant is

1. Fixed Dome Type Biogas plant (Janata Model) (Operates in constant volume)
2. Floating Drum type Biogas plant. (Operates in constant pressure)

In this article I will discuss about the first one - The Fixed Dome type or Janata Model biogasplant.

Fixed Dome Type Biogas Plant - Janata Model



Fixed dome biogas plant (Janata model).

This type of biogas plant is very economical is design. It works with the constant volume principle. The main structure is made up of brick and cement masonry. This type of plant doesn't have any moving parts so it is safe from wear and tear. The operating pressure varies from 0 to 100 cm of water column. It is also known as Janata model.

----------(10 Marks)

6. **Factors affecting Biogas generation**
   - pH or the hydrogen ion concentration(6.5-7.5)
   - Temperature (33-35˚C)
   - Total solid content of the feed material
   - Loading rate
   - Seeding
   - Uniform feeding
   - Diameter to depth ratio
   - Carbon to nitrogen ratio
   - Nutrients
   - Mixing or stirring or agitation of the digester
   - Retention time or rate of feeding
   - Type of feed stocks
   - Toxicity due end product
   - Pressure
   - Acid accumulation inside the digester

Acid formers and methane fomenters must remain in a state of dynamic equilibrium, which can be achieved by proper design of digester. Anaerobic fermentation of raw cow dung can takes place at any temperature between 8 and 55°C. The value of 35°C is taken as optimum. The rate of biogas formation is very slow at 8°C. For anaerobic digestion, temperature variation should not be more than 2 to 3°C. Methane bacteria work best in the temperature range of 35 and 38°C. A pH value between 6.8 and 7.8 must be maintained for best fermentation and normal gas production. The pH above 8.5 should not be used as it is difficult for the bacteria to survive above this pH. The biogas so obtained is a mixture of methane (CH_4):55-65% and Carbon dioxide (CO_2): 30-40%. The biogas contains traces of H_2, H_2S and N_2.

----------(10 Marks)

7. **Environmental advantages and disadvantages related to biomass energy**

   Advantages

- Renewable resource
- Reduces landfills
- Protects clean water supplies
- Reduces acid rain and smog
- Reduces greenhouse gases – carbon dioxide, methane

Disadvantages

- Biomass has a smaller energy content for its bulk than fossil fuels
- Costs of labor, transportation, and storage would then be higher
- It will intensify air pollution.
- It may cause saltilization and decrease to total size of the arable land.
- Crop and forest residues often contain high concentrations of important nutrients.
- If the residue is harvested as energy, the nutrients can be lost to the surrounding environment.
- Other synthetic chemical nutrients or fertilizers can later be added.
- More plants and trees must be planted, because they will be used in a higher quantity.

----------(10 Marks)

8. (a) $P_{av} = (\pi/8)\ \rho\ D^2\ V_1^{\ 3}$

$V_1 = V_H\ (Z/H)^{\alpha} = 12\ (100/10)^{0.14} = 16.56$ m/s

$V_1 = 16.56$ m/s

$V = 0.8\ V_1 = 13.25$ m/s

$P_{av} = (\pi/8) \times 1.226 \times (80)^2 \times (16.56)^3 = 13.99$ MW

$P_{av} = 13.99$ MW

(b) Pmax = Power extracted by the turbine $= (8/27)\ \rho\ A\ V_1^{\ 3}$

$= (8/27) \times 1.226 \times \pi(80^{\ 2}/4) \times (16.56)^{\ 3}$

$= 8.29$ MW

$Cp = 4a(1 - a)^2$

Here $a = (V_1 - V)/ V_1 = (16.56 - 13.25)/ 16.56 = 0.1998$

$Cp = 4(0.1998)(1 - 0.1998)^2 = 0.512$

$P_T = C_P\ P_{av} = 0.512 \times 13.99$ MW $= 7.15$ MW

Efficiency, $\eta = (P_o/P_{in})$

(c) $P_{out} = \eta \times P_{in} = 0.5 \times P_T = 0.85 \times 7.15 = 6.085$ MW

(d) $F_A = (1/8)\ \rho\ \pi\ D^2\ (V_1^{\ 2} - V_2^{\ 2})$

Here $a = (V_1 - V_2) / 2\ V_1$

$V_2 = V_1 - 2a\ V_1 = V_1(1 - 2a) = 16.56\ (1 - 2(0.2)) = 9.936$ m/s

$F_A = (1/8) \times 1.226 \times \pi \times 80^{\ 2}\ (16.56^{\ 2} - 9.936^{\ 2})$

$= 5.4 \times 10^{\ 5}$ N

(e) Maximum axial thrust , $F_{max} = (\pi/9)\ \rho\ D^2\ V_1^{\ 2}$

$= (\pi/9) \times 1.226 \times 80^{\ 2} \times 16.56^{\ 2}$

$= 7.51 \times 10^{\ 5}$ W

----------(10 Marks)