00136

The Open University of Sri Lanka
Faculty of Engineering Technology
Department of Mechanical Engineering

Study Programme	:	Bachelor of Technology Honours in Engineering
Name of the Examination	:	Final Examination
Course Code and Title	:	**DMX7305 /DMX6536 Renewable Sources of Energy**
Academic Year	:	2020/2021
Date	:	25.02.2022
Time	:	0930-1230 hrs
Duration	:	3 hours

General instructions

1. Read all instructions carefully before answering the questions.
2. This question paper consists of 07 questions and 06 pages.
3. **Answer any 05 questions only.** All questions carry equal marks.
4. Answer for each question should commence from a new page
5. **Relevant charts/ equations are provided.**
6. **This is a Closed Book Test (CBT).**
7. Answers should be in clear handwriting.
8. Do not use red colour pen.

Q1 (a) Discuss the opportunities and limitations in the use of renewable energy sources for power generation in Sri Lanka, considering different renewable energy options.

(b) Do you think that Sri Lanka can achieve 100% renewable energy status in the next 10- 20 years' time? Give reasons for your answer.

(c) Define the term "sustainability with reference to energy".

(d) Demand for energy is ever increasing. At the same time when you increase the capacity by introducing new energy projects it adversely affects the environment. How can you address the issue with reference to sustainability?

(e) Name five (05) human effects on environment.

[*20 Marks*]

Q2. (a) From Geothermal point of view the earth surface can be classified into three areas. Name these areas and describe them in brief.

(b) What do you mean by geothermal exploration?

(c) What are the objectives of Geothermal exploration?

(d) Describe in brief geo-pressurized fields.

(e) What are the two basic types of drilling techniques? Describe one of them.

(f) List the main components of a Geothermal power plant and describe in brief function of each component.

(g) What are the problems associated with the use of Geothermal fluids?

[20 Marks]

Q3. (a) Name few industrial applications of Gasifiers in Sri Lanka?

(b) Explain in brief the complete process of gasification.

(c) Distinguish pyrolysis from gasification.

(d) Municipal Solid Waste management is a very big issue in the urban areas of Sri Lanka. Explain in brief how can you apply pyrolysis technology to address this issue.

(e) A Gasifier with 60% efficiency is used to run a Gas turbine with 90% efficiency in a biomass powered electricity generation plant. It produces electricity to supply 5MW uninterrupted power to the main grid. First the moist wood is supplied by a supplier. Hence a dryer is used before fuel wood is fed into the gasifier to reduce the moisture in wood. Find the:

(i) water content of the moist wood entering the dryer.

(ii) water content of the moist wood leaving the dryer.

(iii) Lower Heating Value (LHV) of the moist wood entering the gasifier.

(iv) amount of wood required per day to run the power plant.

(v) Gas flow rate of the Gasifier outlet.

[20 Marks]

Following data and empirical formulas are provided:
Wood consist with 47% wt Carbon, 7% wt Hydrogen, 46% wt Oxygen
Moisture content of the wood before dryer 30%
Moisture content of the wood after the dryer 10%
Gasifier efficiency 60%, LHV Gas =4.6MJ/m^3
Gasifier efficiency is given by the equation below.

$$\eta CG = \frac{LHV_{gas} \times \dot{V}_{gas}}{LHV_{moist} \times \dot{m}_{fuel}} x100\%$$

$$LHV_{dry} = 0.35\ X_C + 0.939\ X_H - 0.108\ X_O \ MJ/kg$$

$$LHV_{moist} = LHV_{dry}\ (1-w) - h_{fg}\ w \ MJ/kg$$

enthalpy of evaporation of water h_{fg} = 2256kJ/kg

w = water content

X_C, X_H and X_O are the wt % of Carbon, Hydrogen and Oxygen respectively.

Q4. (a) What are the main reasons for employing regulating devices in wind turbines?

(b) The power of a wind turbine is dependent mainly on three factors. What are they?

(c) What are the major and essential components of a wind turbine?

(d) What are the advantages and disadvantages of wind turbines?

(e) Wind turbines can be classified mainly into two types. What are they? Describe clearly how you distinguish these two.

(f). In a small town, there are 2400 families use electricity for their energy requirement. Average electricity consumption for a family is 10 kWh a day. It has been decided to introduce a wind turbine project to cater this demand. It is proposed to install wind turbines with total capacity of 1 MW with operating efficiency of 50% for each turbine.

(i) How many wind turbines are required to install to cater the full demand?

(ii) If the hub hight of the wind turbine from its ground level is 100m and the blade length is 50 m, what is the wind speed at hub height?

(iii) If they install the same wind turbine at a higher elevation of 100 m above the previous location, what should be the wind speed at new location?

(iv) What is the power output of the turbine if it is installed at higher elevation?

[*20 Marks*]

Wind Power (P) = 1/2 ρ A V^3 η where ρ is the density of the air (1.225 kg/m^3) , A is the swept area of the wind, and V is the wind speed. η is the efficiency of the wind turbine.

The wind velocity variation with hub height is given as below.

$$v_2 / v_1 = [h_2 / h_1]^p$$

Where v_1 – velocity of wind in (m/s) at hub height of h_1 in (m)

v_2– velocity of wind in (m/s) at hub height of h_2 in (m)

p – wind shear exponent and for urban areas p can be taken as p= 0.15

Q5. Write short notes on the following.

(i) Production of Bio diesel
(ii) How Gasification can be used to solve the burning issue of shortage of LP Gas in Sri Lanka?
(iii) How biogas can be utilised as a cooking fuel?
(iv) Application of reaction turbines in hydropower systems.
(v) Solar thermal applications in electrical power generation.

[*20 Marks*]

Q6. a) Describe the following

(i) Extra-terrestrial radiation
(ii) Irradiation
(iii) Diffuse radiation
(iv) Solar declination angle
(v) Solar hour angle

b) At 40 ^{0}N latitude (φ)

Determine

(i) Direct normal extra-terrestrial irradiance (I_0) at equinox
(ii) Solar declination angle (δ) at equinox
(iii) Sunrise time, sun set time and day length at
(a) Equinox
(b) Summer Solstice
(c) Winter Solstice

[*20 Marks*]

Following equations are given with their usual notations.

$I_0 = I_{SC}$ [1 + 0.034 cos (360N/365)] where I_{SC} =1353w/m^2 ,

δ = 23.45 sin [360 (284+N)/365] where N is the day number from January 01

$w_{SS} = \cos^{-1}$ [-tan φ tan δ]

Sun rise time (T_{sr}) = 12 -w_{ss} x1/15) hrs

Sun set time (T_{ss}) = 12+w_{ss} x1/15) hrs

Day length (T_d) = w_{ss} x 2/15 hrs

Q7. a) What are the three types of conventional Hydropower plants? Describe in brief all three.

b) What is the total capacity of Hydropower in Sri Lanka? Name few projects which contributes most with their capacities.

c) Assume that the total capacity of Hydro power is already achieved in Sri Lanka. But using the stored water in the main reservoir there is still have a possibility to increase the capacity. Explain how you achieve it and the method you applied to increase the capacity.

d) Give examples for impulse and reaction types of turbines. Why are reaction turbines preferred most in pump storage hydropower systems?

e) What are the advantages of Hydropower projects other than power generation?

f) What is the objective of having wicket gate in a hydropower system?

g) What is the purpose of having trash rack and surge tank in a hydroelectric system?

h) Alqueva hydro power system in Moura, Portugal provides 520 MW power to the main grid. Dam height is 96 m, length of the dam is 458 m and width of the dam is 7 m. This power plant consists with 4 turbines of 130 MW capacity.

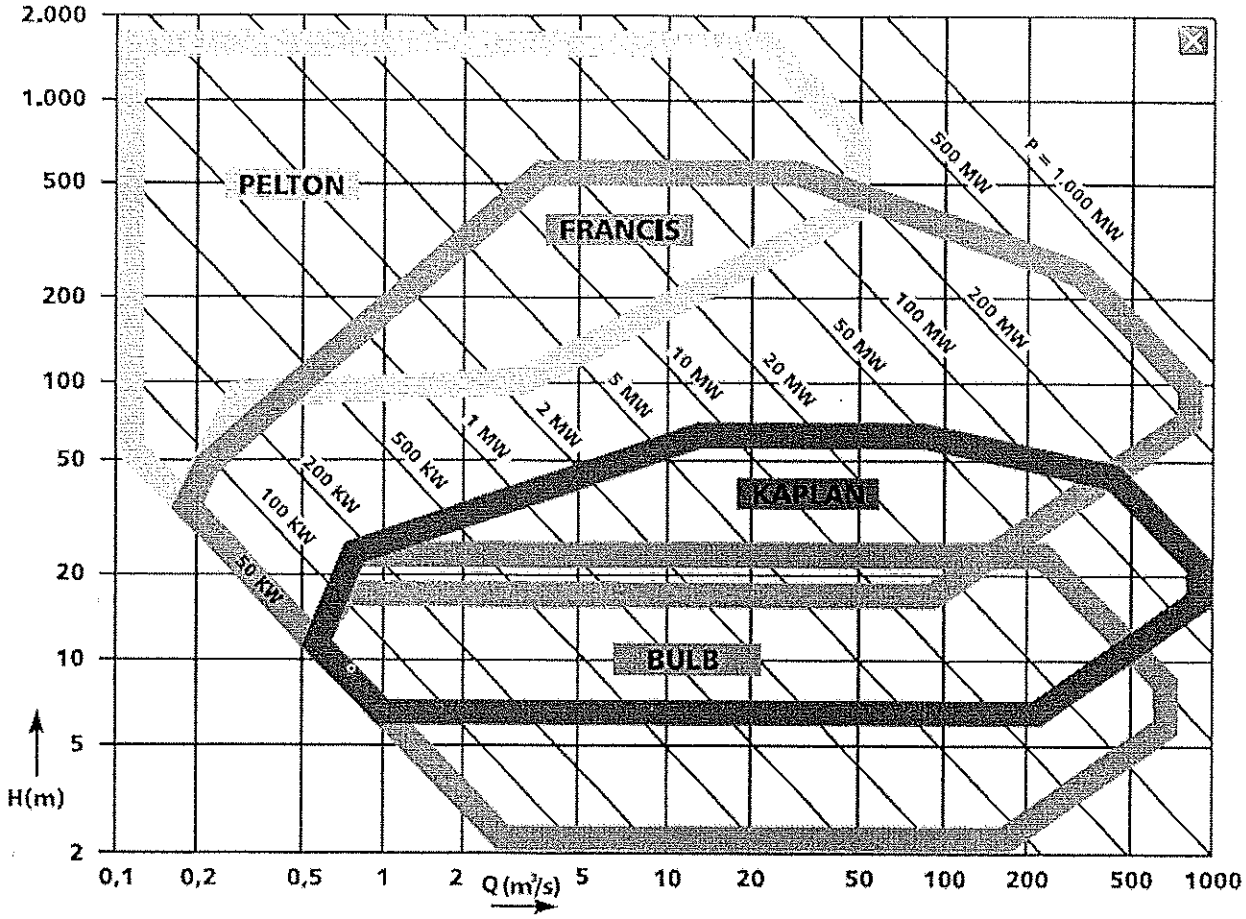
i) What is the type of this Dam?

ii) What type of a hydropower plant is this?

iii) Find the flow rate entering the turbine? If the turbine efficiency is 95%. Assume density of water as 1000 kg/m^3 and g=9.8ms^{-2}

i) Select the best suitable turbine for this hydropower plant considering the height of the dam, power output and the water discharge rate. **[turbine selection chart is provided in page 6]**

[*20 Marks*]



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