THE PAPUA NEW GUINEA UNIVERSITY OF TECHNOLOGY
DEPARTMENT OF ELECTRICAL AND COMMUNICATION ENGINEERING

SECOND SEMESTER EXAMINATION (2022)

EE425 – RENEWABLE ENERGY SYSTEMS

ELECTRICAL ENGINEERING - YEAR 4 (POWER)

TIME ALLOWED: 3 HOURS

INFORMATION FOR STUDENTS

1. You have **TEN (10)** minutes to read the paper.
   You must **NOT** begin writing during this time.

2. All answers must be written in the **ANSWER BOOK** supplied.
   COMPLETE THE DETAILS REQUIRED ON THE FRONT COVER OF YOUR ANSWER BOOK - DO THIS NOW.

3. Drawing instruments and calculators are permitted.

4. Mobile phones and head phones are **NOT** permitted

5. Answer **ALL FIVE (5)** questions. Total of 50 marks.

6. Marks are shown for each part of each question.

7. If you are found cheating in the Examination, the penalties specified by the University shall apply.

Question One **Biomass Energy.**

Biomass is produced by green plants that use the energy of sunlight to convert carbon dioxide and water into simple sugar and oxygen.

(a) Fast pyrolysis is characterized by high heating rate and short vapour residence times as shown in Fig. 1.0. Describe the process of the bio-oil and the essential features of a fast pyrolysis system. ***(5)***

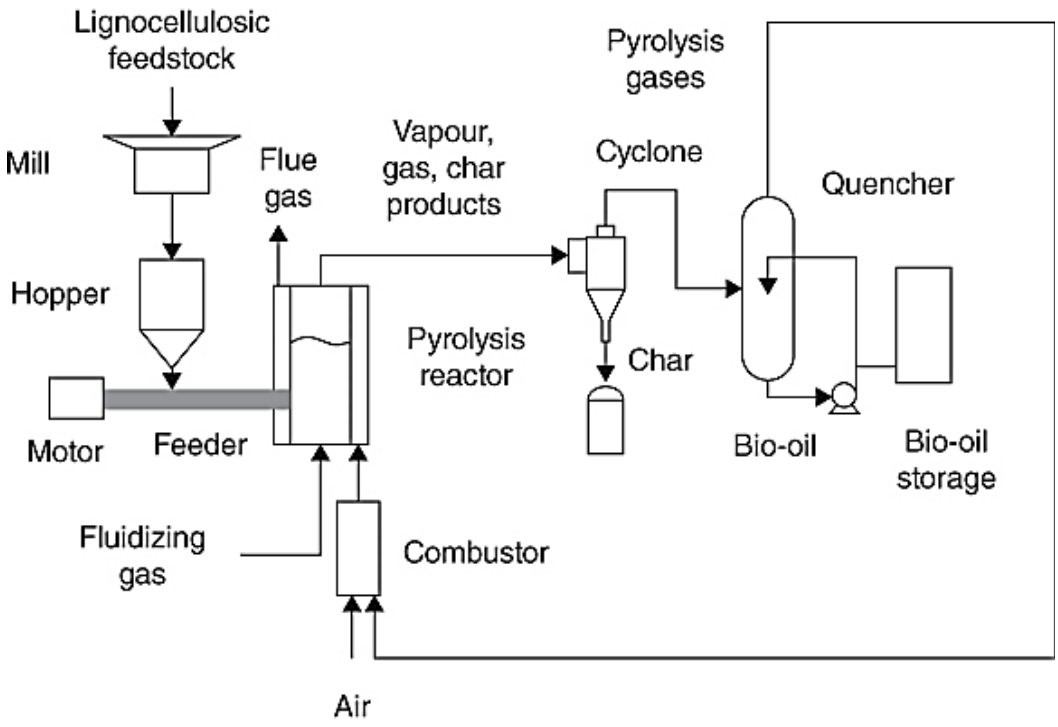

Fig. 1.0 Fast pyrolysis system

(b) Fermentation is a chemical process where glucose breaks down to form ethanol and CO_2. With the aid of a diagram (fermentation process flowchart) describe the three processes used in fermentation of biomass to produce 100% pure ethanol. ***(5)***

Question Two **Hydropower Energy.**

The most useful source of electrical energy generation in the world is hydroelectric plant, in which the movement of water results in power production by driving a hydro turbine.

(a) Assume a Pelton turbine with a mean runner diameter of 1.5 m and a net head of 400 m. The runner is spinning at N=1500 rpm. Considering the side clearance of 15° and discharge of 0.1 m^3/s, obtain the power available at the nozzle and calculate the hydraulic efficiency of the turbine.

(5)

(b) Consider a reaction turbine running at 700 rpm, which has an external diameter and a width of 700 mm and 400 mm, respectively. The absolute velocity of water at inlet is equal to 50 m/s and the guide vanes are at 25° to the wheel tangent. The parameters of the reaction turbines are shown in Fig. 2.0. Calculate the discharge through the turbine and the inlet vane angle.

(5)

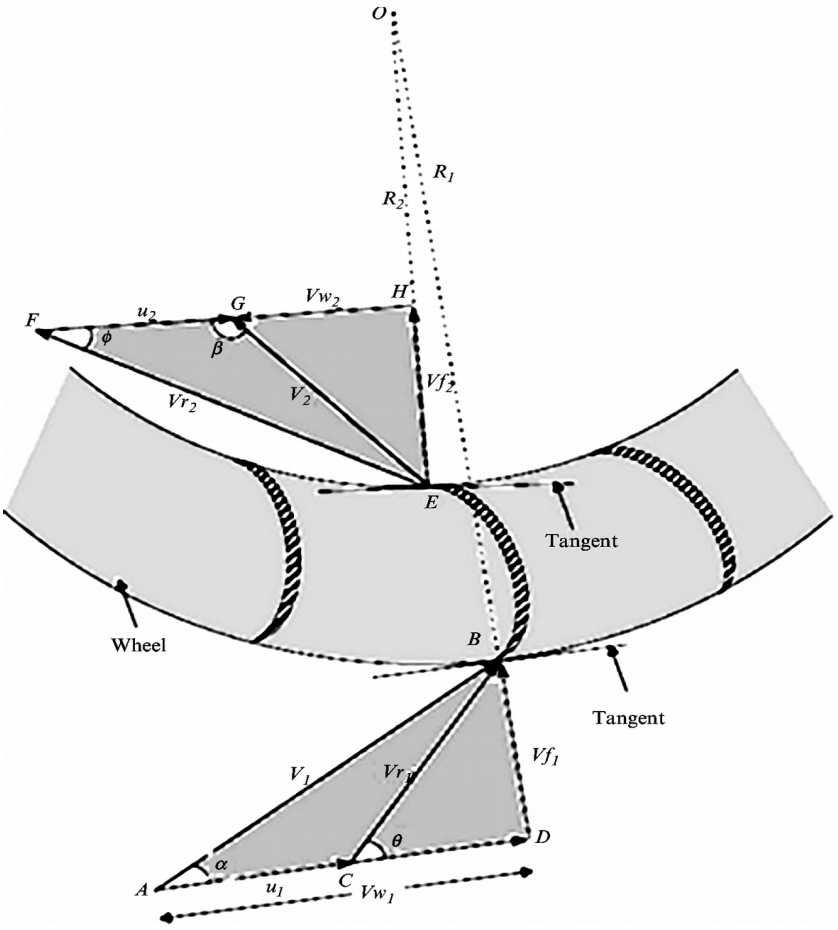

Fig. 2.0 Parameter of the reaction turbines

Question Three **Wave Energy.**

The energy from ocean waves come in irregular and oscillating form at all times of the day and night and can be harnessed to provide electricity supply.

(a) What are the advantages and disadvantages of wave power? ***(2)***

(b) What are the four devices and their operations in converting wave energy to electricity? ***(2)***

(c) What are the key issues affecting wave power devices? ***(2)***

(d) Discuss the limitations of ocean wave energy ***(2)***

(e) State the main criteria for deciding the location of ocean wave plants ***(2)***

Question Four **Tidal Energy.**

Tides are periodic rises and falls of large bodies of water in the ocean. Gravity is one major force that creates tides and hence tidal energy on the oceans of the earth.

(a) For a typical tidal power plant shown in Fig. 4.0, the basin area is 30 × 110 m^2. The tide has a range of 12 m. However, turbine stops working when the head on it falls below 3 m. Assume that density of seawater is 1,025 kg/m^2, acceleration due to gravity is 9.81 m/s^2, combined efficiency of turbine and generator is 80%, and period of energy generation is 6 hours and 12 minutes.

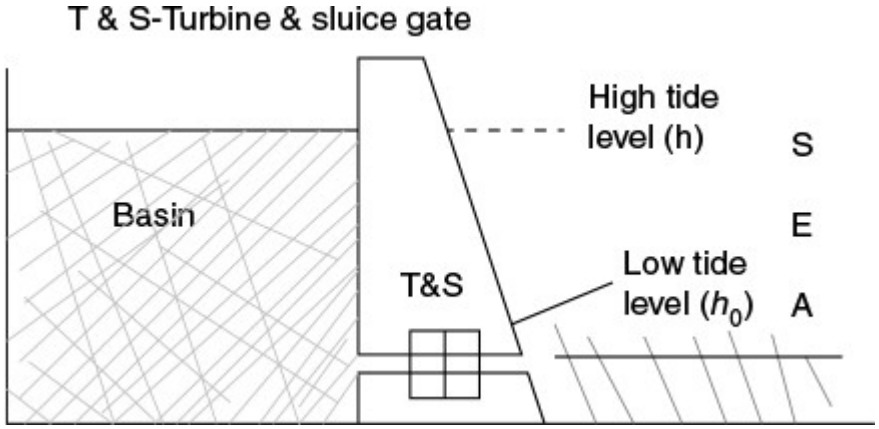

Fig. 4.0 Single-basin tidal plant

Calculate:

(i) Work done in filling or emptying the basin. ***(2)***
(ii) The average power ***(2)***
(iii) The energy generated in one filling process. ***(2)***

(b) An improvement over the single-basin system is the two-basin system. Draw the two-basin system and describe its operation and regulation of power output of individual tide. ***(4)***

<u>Question Five</u> **Geothermal Energy.**

Geothermal energy is basically thermal energy stored in the Earth's crust and has the potential to provide long-term, secure base-load energy and greenhouse gas (GHG) emission reductions.

(a) The most important methods used in geophysical exploration of geothermal fields are thermal, electrical and magnetic measurements. There are three (3) different methods of electrical measurements and setups used in the surface exploration of geothermal energy. Name the three methods and briefly describe each of them. ***(3)***

(b) Direct use of geothermal resources is primarily for direct heating and cooling. Explain the use of geothermal resource in direct heating. ***(3)***

(c) A geothermal reservoir shown in Fig. 5.0 shows the hard dry rock resource with a thermal gradient of 36^{o} C/km. The minimum useful temperature is 150^{o} C above the surface temperature. Determine the heat content per square kilometer of the hard dry rock to a depth of 10 km, assuming density = 2700kg/m^{3} and specific heat of 800 J/kg/degree. ***(4)***

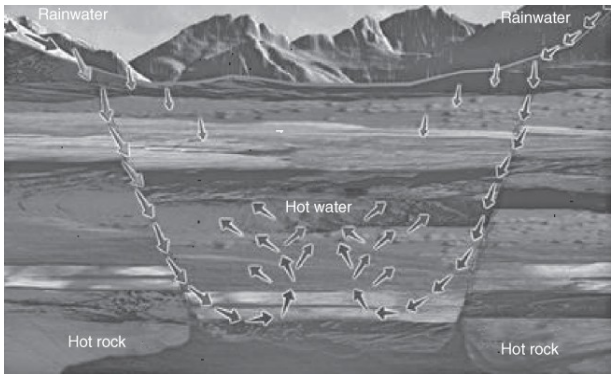

Fig. 5.0 A geothermal reservoir