(*University of Choice*)

MASINDE MULIRO UNIVERSITY OF SCIENCE AND TECHNOLOGY (MMUST)

MAIN CAMPUS

UNIVERSITY EXAMINATIONS

2021/2022 ACADEMIC YEAR

FIFTH/FOURTH YEAR SPECIAL/SUPPLIMENTARY EXAMINATIONS

FOR THE DEGREE OF

BACHELOR OF SCIENCE IN MECHANICAL AND INDUSTRIAL ENGINEERING

BACHELOR OF SCIENCE IN RENEWABLE ENERGY AND BIOFUELS TECHNOLOGY

COURSE CODE: MIE 571/RET 471

COURSE TITLE: POWER PLANT ENGINEERING

DATE: 3 – 10 - 2022 **TIME: 3:00 PM – 5:00 PM**

Instructions to Candidates

1. Answer **Question 1 (compulsory)** and any other **TWO** Questions
2. All symbols have their usual meaning
3. Steam tables are provided

DURATION: 2 Hours

QUESTION ONE (Compulsory) – 30 Marks

a) The annual peak load on a 30MW power plant is 25MW. The power station supplies load having maximum demands of 10MW, 8.5MW, 5MW and 4.5 MW. The annual load factor is 40%.
Determine the following:

(i) Average load

(2 Marks)

(ii) Demand factor

(2 Marks)

b) Give four safety measures that are usually provided for the safe and controlled operation of a hydro-electric plant

(4 Marks)

c) List four advantages of geothermal energy over other forms of energy

(4 Marks)

d) Explain briefly the two effects of using impure feed-water in a boiler plant.

(4 Marks)

e) What are the functions of the following in a boiler plant?

(i) Economisers

(2 Marks)

(ii) Superheaters

(2 Marks)

f) Briefly explain two reasons for the use of waste heat recovery technology

(4 Marks)

g) State four categories of geothermal resources

(2 Marks)

h) Give four advantages of using Fluidized-Bed Combustion Boilers.

(4 Marks)

QUESTION TWO – 20 Marks

Determine the percentage change in efficiency of a Diesel power plant having a compression ratio of 18 and cut-off taking place at 6% of the stroke, when the specific heat at constant volume increases by 2%. Take:

$$c_v = 0.717\ kJ/kgK, R = 0.287\ kJ/kgK, and\ \eta = 1 - \frac{(\beta^\gamma - 1)}{\gamma(\beta - 1)r_v^{\gamma-1}}$$

(20 Marks)

QUESTION THREE – 20 Marks

A combined cycle plant has a gas turbine unit and a steam turbine unit. The exhaust from thegas turbine is supplied to the steam turbine to generate electricity. For the gas turbine; thepressure ratio is 8, the temperature of air to the inlet of the compressor is 17^0C, and the maximum cycle temperature is 900^0C. For the steam turbine; steam conditions at entry toturbine are 2MN/m^2 and 400^0C, condenser pressure is 5000N/m^2, and the temperature of gasesleaving the steam generator is 180^0C. Total power output of the plant is 60MW. Isentropic efficiencies of the air compressor, the gas turbine, and the steam turbine are 79%, 83%, and 80% respectively. For combustion gases; C_p = 1.11kJ/kgK, and γ = 1.33, while for air; C_p = 1.005kJ/kgK, and γ = 1.4. Assume that the mass flow rate of fuel, feed pump work, and all pressure losses are negligible.

a) Draw and label a schematic diagram of the plant

(3 Marks)

b) Calculate the cycle efficiency of the gas turbine

(6 Marks)

c) If the heat supplied to the steam generator were by an external source, determine the efficiency of the steam cycle

(6 Marks)

d) Calculate the mass flow rate of air to the gas turbine, and the mass flow rate of steam to the steam turbine

(3 Marks)

e) Determine the overall efficiency of the combined cycle

(2 Marks)

QUESTION FOUR – 20 Marks

A steam power plant has the following data:

- Installed capacity = 120MW
- Capital cost of the plant = Kshs 3500 per kW
- Interest and depreciation = 15%
- Fuel consumption = 1kg/kWh
- Fuel cost = Kshs 50 per 1000kg
- Peak load = 100MW
- Load factor = 60%
- Salaries, wages, repairs and other operating costs per year = Kshs 10 million

Determine the generation cost per unit of energy for the steam plant.

(20 Marks)