UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 8 Examination in Engineering: December 2018

Module Number: ME8312 **Module Name: Energy Management**

[Three Hours]

[Answer **all questions**, each question carries **10** marks]
Clearly state any assumptions made in answering the questions.

Q1. a) Briefly explain what is an Energy Audit.

[1.0 Mark]

b) State five basic energy management measures an organisation should have.

[2.5 Marks]

c) State the **three levels** of energy audits. What would be the expected results of these three levels?

[1.5 Marks]

d) Describe the "**Ten Step Method**" of a detailed energy audit by stating "**Plan of Action**" and "**Purpose / Results**" for each step.

[5.0 Marks]

Q2. In a given manufacturing plant, a diesel-fired steam boiler operates to deliver steam to its production processes. **Table Q2** summarises data extracted from a proposal to replace the current diesel-fired boiler with a biomass-fired boiler having the same capacity and to be operated in the same duty cycle. Answer the following questions.

Table Q2

Capacity of the diesel-fired boiler	5 ton/hr
Typical operation time of the boiler per day	12 hrs
No. of working days per month	20
Enthalpy of the feed water available for the boiler (50 °C , 0 barg)	210 kJ/kg
Enthalpy of the steam to be generated by the boiler (185 °C , 10 barg)	2780 kJ/kg
Efficiency of the diesel-fired boiler	75%
Calorific value of diesel	45 MJ/kg
Density of diesel	850 kg/m^3
Unit cost of diesel	Rs. 110/l
Efficiency of the proposed biomass-fired boiler	60%
Calorific value of biomass to be used (firewood)	18 MJ/kg
Unit cost of firewood	20 Rs/kg
Total investment to be made if the current diesel-fired boiler to be replaced with the biomass-fired boiler	Rs. 50 million

a) Net hourly rate of heat required to generate steam for the plant.

[1.0 Mark]

b) Daily fuel cost for the diesel-fired boiler.

[2.0 Marks]

c) Predicted daily fuel cost for the biomass-fired boiler.

[2.0 Marks]

d) Calculate the simple payback period and state whether the boiler replacement can be recommended or not.

[2.0 Marks]

e) Provide any additional safety, health and environmental aspects to be taken in to consideration if the biomass-fired boiler is to be used in the manufacturing plant for steam generation.

[3.0 Marks]

Q3. a) In an energy audit of a coal-fired industrial boiler, below data have been recorded. Calculate the boiler efficiency using the **direct method**.

Quantity of steam generated = 10.0 ton/hr
Pressure of steam = 12.0 barg
Temperature of steam = 220.0 °C
Temperature of feed water = 65.0 °C
Enthalpy of feed water at 65.0 °C = 272.1 kJ/kg
Enthalpy of superheated steam at 12.0 barg and 220.0 °C = 2860.6 kJ/kg
Rate of coal consumption = 2 ton/hr
Gross calorific value of coal = 20 MJ/kg

[5.0 Marks]

b) Discuss the benefits of performing a boiler efficiency calculation.

[2.0 Marks]

c) Waste heat recovery is a common approach for improving energy efficiency. Briefly describe the key methods of waste heat recovery related to a boiler and the steam distribution system.

[3.0 Marks]

Q4. a) Assume that a client has requested you to choose a boiler for his manufacturing plant. State the key aspects you will consider in taking your decision.

[2.5 Marks]

b) Furthermore, the client has requested you to design the steam distribution system. State the key aspects you will consider in designing the system.

[2.5 Marks]

c) In a manufacturing plant, a boiler feeds 12 barg steam to the main steam line, which provides steam for the use of the whole plant. One particular heating oven operates at 5 barg, using the steam obtained from a branch line connected to the main steam line. In the heating oven, steam flows in side of a heating element composed of a copper coil. The condensate produced at the coil is directed to a condensate recovery pipe line. Considering this setup, draw a schematic diagram of the steam distribution network. In the diagram, make sure to include any essential standard steam circuit components, in addition to the ones mentioned above. Name all the components in the sketch clearly.

[5.0 Marks]

Q5. a) The heat flow capacities, initial temperatures and final temperatures of five streams are shown in the **Table Q5**.

Table Q5

Stream No.	Type	Thermal capacity rate (kW/K)	Initial Temperature (°C)	Final Temperature (°C)
1	Hot	3.0	350	120
2	Hot	1.5	250	80
3	Hot	9.0	150	90
4	Cold	12.0	100	200
5	Cold	5.0	50	140

i) Determine the Hot and Cold Pinch temperatures using "Tabular Method". Take the minimum allowable temperature difference between the streams as 20 K.

ii) Calculate the minimum external heating and cooling requirements.

iii) Draw the heat exchanger network indicating the minimum external energy requirements of hot and cold streams.

[9.0 Marks]

b) Briefly explain the effect of the **minimum temperature difference between streams** on the amount of heat exchange between the streams and the external energy requirements.

[1.0 Mark]