



UNIVERSITY OF RUHUNA

Faculty of Engineering

End - Semester 8 Examination in Engineering: September 2023

Module Number: ME 8211

Module Name: Energy Management

[Three Hours]

[Answer all questions, each question carries Ten marks]

Note: Clearly state any assumptions you made in answering the questions.

- Q1. (a) Briefly explain what is defined by an **Energy Audit**. [1 Mark]
- (b) List out five (05) basic energy management measures that an organization should have. [2.5 Marks]
- (c) Name the three (03) levels of Energy Audits. What are the expected results of these three levels? [1.5 Marks]
- (d) Describe the "**Ten Step Method**" of detailed energy audit by providing "**Plan of Action**" and "**Purpose / Results**". [5 Marks]
- Q2. Lighting for an office is provided by 20 incandescent lamps, each consuming 100W of electricity. The lights remain switched on for 12 hours a day for a period of 300 days per year. The management of the company proposes to replace the incandescent lamps with 20W Compact Fluorescent Lights (CFL). As the Energy Manager of the company, you are requested to evaluate the following based on the data provided at the end of the question.
- (a) Annual energy cost of lighting for the office, if incandescent lamps are continued to be used. [2 Marks]
- (b) Annual energy cost of lighting for the office, if the incandescent lamps are replaced with an equal number of CFL bulbs. [2 Marks]
- (c) Annual savings in Rupees due to the replacement of incandescent lamps with CFL bulbs. [2 Marks]
- (d) Assuming the purchase cost of CFL bulbs to be the major investment cost, calculate the simple payback period for the replacement of incandescent lamps with CFL bulbs. [2 Marks]
- (e) Would you recommend or reject the proposal? (Provide the basis for your answer). [2 Marks]

DATA:

- Unit cost of electricity = Rs. 12 per kWh
- Retail price of an incandescent lamp (100 W) = Rs. 30
- Retail price of a CFL bulb (20 W) = Rs. 450
- Life of a CFL bulb is approximately 10,000 hours.
- The life of an incandescent bulb is approximately 1,000 hours.

Q3. (a) State the objectives of hiring an Energy Manager in an industry.

[2.5 Marks]

(b) List out the five (05) Primary Functions of an Energy Manager.

[2.5 Marks]

(c) "The key to a successful energy management program is the dedication and commitment from top management". Discuss the significance of this statement and state three methods that you will use to get the attention and support of the Top Management.

[5.0 Marks]

Q4. In a given manufacturing plant, a diesel-fired steam boiler operates to deliver steam to its production processes. Table Q4 summarises data extracted from a proposal to replace the current diesel-fired boiler with a biomass-fired boiler having the same capacity to be operated in the same duty cycle. Answer the following questions.

Table Q4

Capacity of the diesel-fired boiler	10 ton/hr
Typical operation time of the boiler per day	6 hrs
No. of working days per month	20
Enthalpy of the feed water at the boiler (55 °C , 12 barg)	231 kJ/kg
Enthalpy of the saturated steam to be generated by the boiler (188 °C , 12 barg)	2784 kJ/kg
Thermal 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. 340/l
Efficiency of the proposed biomass-fired boiler	55%
Calorific value of biomass to be used (firewood)	18 MJ/kg
Unit cost of firewood	Rs. 25/kg
Total investment to be made if the current diesel-fired boiler to be replaced with the biomass-fired boiler	Rs. 100 million

(a) Calculate the Net Hourly Rate of heat required to generate steam for the plant.

[1 Mark]

(b) Calculate the Daily Fuel Cost for the diesel-fired boiler.

[2 Marks]

(c) Calculate the Predicted Daily Fuel Cost for the biomass-fired boiler.

[2 Marks]

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

[2 Marks]

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

[3 Marks]

- Q5. (a)** In an Energy Audit of a Coal-fired Industrial Boiler producing superheated steam, following data have been recorded. Calculate the boiler efficiency using the **Direct Method**.

Quantity of steam generated = 12 ton/hr

Pressure of superheated steam = 15 barg

Temperature of superheated steam = 230 °C

Temperature of feed water = 60 °C

Enthalpy of feed water at 60 °C and 15 barg = 253.5 kJ/kg

Enthalpy of superheated steam at 15 barg and 230 °C = 2875.5 kJ/kg

Rate of coal consumption = 2.5 ton/hr

Gross calorific value of coal = 20 MJ/kg

[2.0 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 key methods of waste heat recovery related to a boiler.

[3.0 Marks]

- (d)** Briefly discuss the ways of improving energy efficiency in steam distribution systems.

[3.0 Marks]