# UNIVERSITY OF RUHUNA

## Faculty of Engineering

End - Semester 8 Examination in Engineering: December 2015

**Module Number: ME 8335**          **Module Name: Energy Management**

**[Three Hours]**

**[Answer all questions, each question carries ten marks]**

**[Steam tables are provided]**

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

[1 Mark]

b) List out five basic energy management measures that an organization should have.

[2.5 Marks]

c) Name the three 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 hrs. 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:

(i) Annual energy cost of lighting for the office, if incandescent lamps are continued to be used. [2 Marks]

(ii) Annual energy cost of lighting for the office, if the incandescent lamps are replaced with an equal number of CFL bulbs. [2 Marks]

(iii) Annual savings due to the replacement of incandescent lamps with CFL bulbs.

[2 Marks]

(iv) 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]

(v) 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 (100W) = Rs. 30
- Retail price of a CFL bulb (20 W) = Rs. 450
- Life of a CFL bulb is approximately 10,000 hrs.
- Life of an incandescent bulb is approximately 1,000 hrs.

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

      Quantity of steam generated = 10 ton/hour

      Steam pressure = 10 bar

      Temperature of steam = 200 °C

      Feed water temperature = 70 °C

      Coal consumption = 2.2 ton/hour

      Gross calorific value of coal = 20,000 kJ/kg

**[5 Marks]**

**b)** Comment on the limitations of using the direct method to calculate the efficiency of a boiler compared with the indirect method.

**[2 Marks]**

**c)** State different measurements and related measuring equipment that can be applicable for collection of data to calculate the efficiency of a boiler using the **indirect method**.

**[3 Marks]**

**Q4.** **a)** Write short notes on the below.

    **(i)** Static head and friction head of a pumping network.

    **(ii)** Pump characteristic curve.

**[2 Marks]**

**b)** There are different measures to improve energy efficiency in both pumps and pumping networks. State **three** of such methods for pumps and three **other** methods for pumping networks.

**[3 Marks]**

**c)** A water pump is used for an industrial application where a constant supply of water at 1.1 m³/min has to be pumped to a tank, which is 20 m above the water intake. The length of the pipe network is about 100 m and a 15 cm diameter. A galvanized pipe has been used for the pipe network. The pipe network also consists of five 90⁰ elbows, and **two** fully-open gate valves. By using the data given in **Table Q4.1, Table Q4.2, Figure Q4.1** and **Figure Q4.2**, do the relevant calculations and select the appropriate pump and the electric drive motor for the pump. You may take the temperature of water as 20°C, where its density is 1000 kg m⁻³ and viscosity is 0.001 N s m⁻².

**[5 Marks]**

**Q5.** **a)** Comment on below points related with steam distribution networks.

    **(i)** Superheated steam is preferred than saturated steam within a steam distribution network.

    **(ii)** Steam distribution pipes are installed not horizontally, but with some inclination.

    **(iii)** Importance of installing strainers in a steam distribution network.

    **(iv)** Importance of installing air vents in a steam distribution network.

**[4 Marks]**

**b)** Sketch and briefly describe the operation of three types of steam traps used in a steam distribution network.

**[3 Marks]**

**c)** State **six** different energy recovery options applicable for steam distribution networks.

**[3 Marks]**

## Table Q 4.1. Relative roughness factors for pipes

| Material | Roughness factor ($\varepsilon$) |
|---|---|
| Riveted steel | 0.001 - 0.01 |
| Concrete | 0.0003 - 0.003 |
| Wood staves | 0.0002 - 0.003 |
| Cast iron | 0.0003 |

| Material | Roughness factor ($\varepsilon$) |
|---|---|
| Galvanized iron | 0.0002 |
| Asphalted cast iron | 0.001 |
| Commercial steel | 0.00005 |
| Drawn tubing | Smooth |

## Table Q 4.2. Friction loss factors in fittings

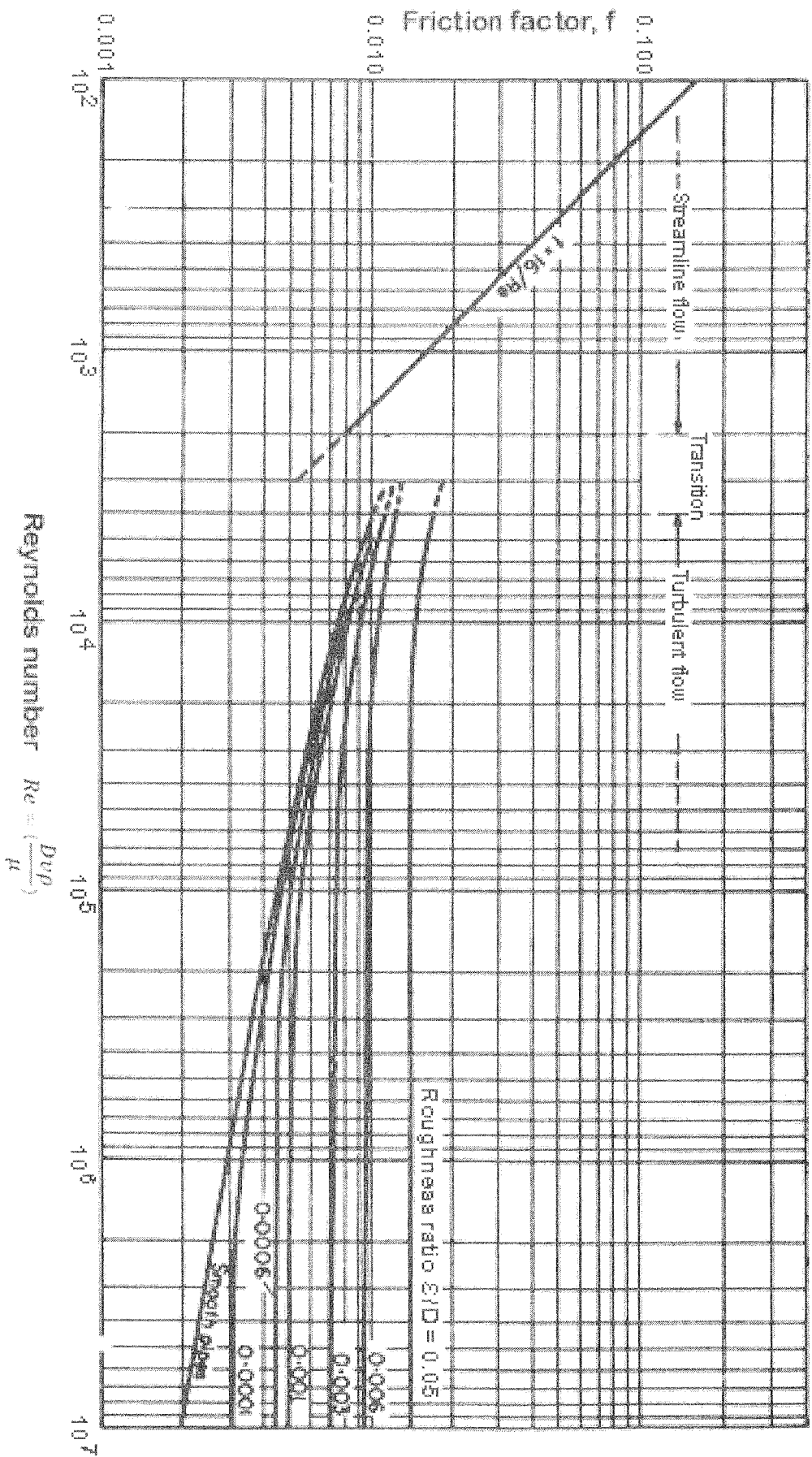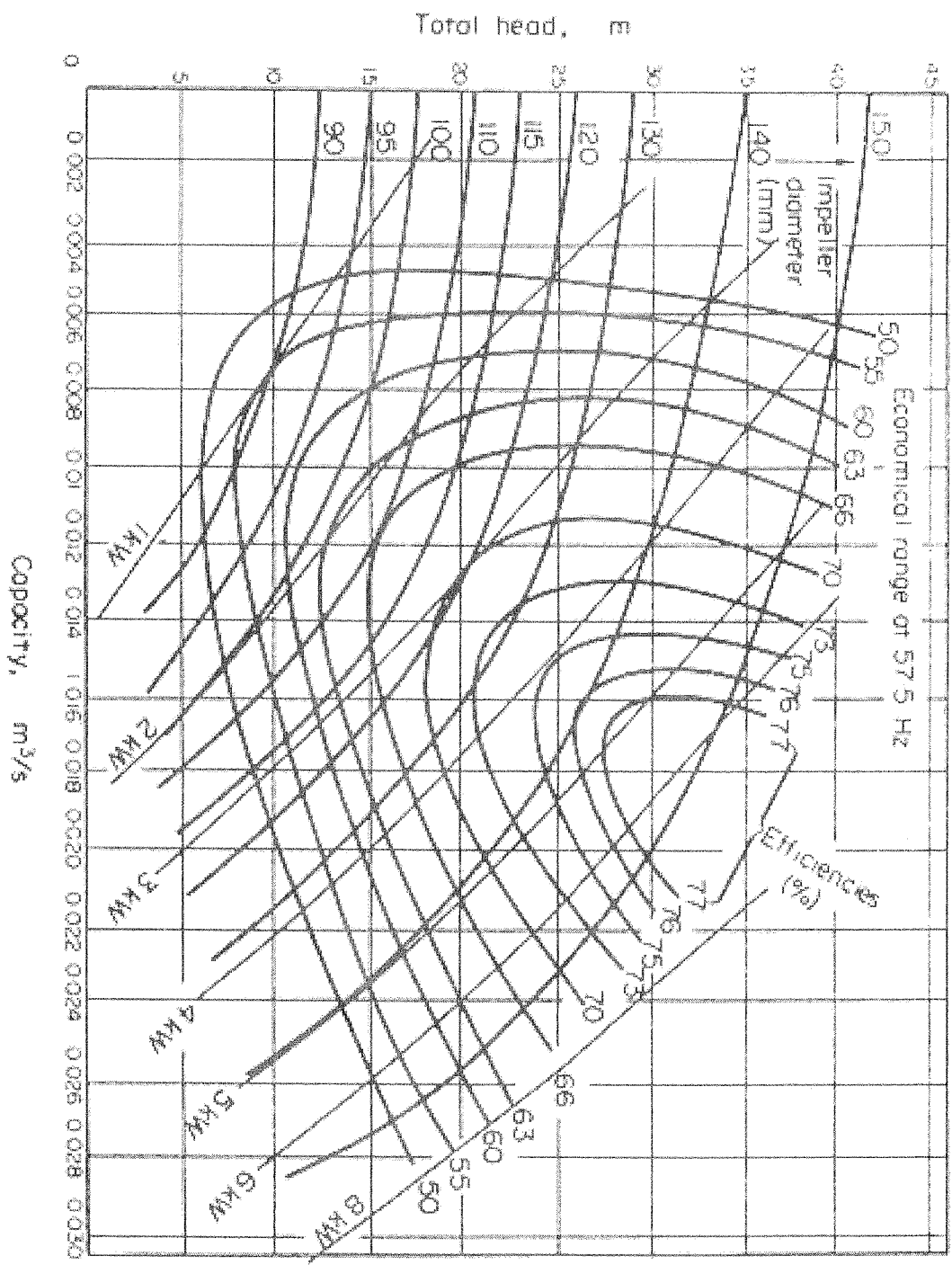| | $k$ |
|---|---|
| Valves, fully open: | |
| gate | 0.13 |
| globe | 6.0 |
| angle | 3.0 |
| Elbows: | |
| 90° standard | 0.74 |
| medium sweep | 0.5 |
| long radius | 0.25 |
| square | 1.5 |
| Tee, used as elbow | 1.5 |
| Tee, straight through | 0.5 |
| Entrance, large tank to pipe: | |
| sharp | 0.5 |
| rounded | 0.05 |

Figure Q 4.1. Friction factors in pipe

Figure Q 4.2. Characteristic curves for centrifugal pumps