UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 8 Examination in Engineering: December 2015

Module Number: ME8324 **Module Name: Industrial Fluid Dynamics**

[Three Hours]

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

Q1 a) Explain the terms; Major Energy Losses and Minor Energy Losses in pipes.

[3 Marks]

b) What is the difference between K-factor and 2-K methods used for calculation of minor energy losses in pipes?

[3 Marks]

c) Two reservoirs with a surface level difference of 20 m are to be connected by 1 m diameter pipe 6 km long.

(i) What will be the discharge when a cast iron pipe of roughness k=0.3 mm is used?

(ii) What will be the percentage increase in the discharge, if the cast iron pipe is replaced by a steel pipe of roughness k=0.1 mm?

Note: Neglect all local losses and use the following equation to calculate the friction factor

$$\frac{1}{\sqrt{f}} = 2log_{10}(R_0/k) + 1.74$$

Where R_0 = Radius of the pipe

k = Roughness of the internal pipe surface

f = Friction factor

[6 Marks]

Q2 a) What type of flow structures can the separated flow model be applied to predict the two-phase frictional pressure drop?

[2 Marks]

b) Explain the separated flow model to predict two-phase frictional pressure drop in pipe lines.

[2 Marks]

c) Petroleum Co-operation wants to transport petrol (Gasoline) through a pipe line of 15 km long. A smooth pipe with 15 cm in diameter is selected for this purpose. Petrol in certain conditions is assumed to be flowed through the pipe as a two-phase mixture with mass quality 0.05 and mass flux 520 kg/m^{2}s. If the physical properties of two-phases are petrol density $\rho_L = 732$ kg/m^3, gas phase density $\rho_G = 1.2$ kg/m^3, petrol viscosity $\mu_L = 6.0 \times 10^{-4}$ Pa.s and gas phase viscosity $\mu_G = 1.2 \times 10^{-5}$ Pa.s, determine

(i) The single phase pressure gradients.

(ii) The Lockhart and Martinelli parameter (X).

(iii) The two-phase pressure drop across the pipe line using Chisholm C Coefficient method.

(iv) The percentage of pressure drop increment due to the consideration of two-phase mixture flow.

[8 Marks]

Q3 a) Define cavitation in a centrifugal pump. What are the effects of cavitation? Give necessary precaution against cavitation.

[3 Marks]

b) A centrifugal pump discharges 0.15 m^3/s of water against a head of 12.5 m. The pump is driven by a constant speed electric motor of 600 rpm. The outer and inner diameters of impeller are 500 mm and 250 mm, respectively. The vanes are bent back at 35° to the tangent at exit. If the area of the flow remains 0.07 m^2 from inlet to outlet, calculate,

(i) Manometric efficiency of the pump.

(ii) Vane angle at inlet.

(iii) Loss of head at inlet of the impeller when the discharge is reduced by 40% without changing the rotation speed of the impeller.

[9 Marks]

Q4 a) To investigate performance of geometrically similar pumps following parameters are important,

(i) The Specific speed

(ii) The Head Coefficient

(iii) The Flow Coefficient

(iv) The Power Coefficient.

Write down equations for above four parameters.

[4 Marks]

b) A one-fifth scale model of a centrifugal pump was tested in a laboratory at 100 rpm. The head developed and the power input at the best efficiency point were found to be 8 m and 30 kW, respectively. If the prototype pump has to work against a head of 30 m, determine,

(i) The working speed of the prototype.

(ii) The power required to drive the prototype.

(iii) The ratio of flow rates handled by the pumps.

(iv) The specific speed of the pumps, if the model pump flow rate is 0.015 m^3/s.

[8 Marks]

Q5 a) What are the commonly used duct design methods? Explain one of them.

[2 Marks]

b) Figure Q5 (b1) shows the schematic of a typical supply air duct layout for a government office. The air flow rate requirements for each office room and the length of main and branches of the duct system are also shown in the figure. The duct material is galvanized steel and the cross section is in rectangular shape with aspect ratio 3:1. Use equal-friction method to design the duct system and determine,

(i) Total frictional losses in ducts.

(ii) Total local or dynamic losses in fittings.

(iii) Fan Total Pressure (FTP).

(iv) Power required to supply air.

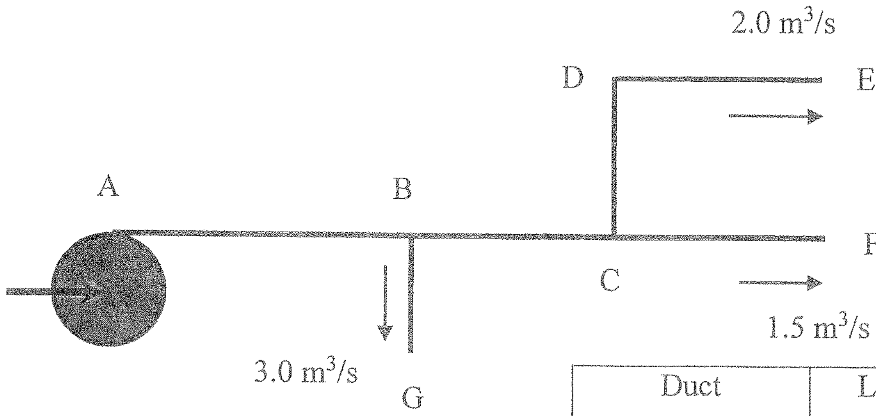
(v) Dimension of the main branch duct by using the chart in Fig. Q5 (b2).

Note: Take the velocity of air in the main duct AB as 7 m/s, a dynamic loss coefficient of 0.3 for upstream to downstream and 0.8 for upstream to branches and for elbows. The dynamic loss coefficient for the out let may be taken as 1.0. Use the following equation to calculate frictional pressure gradient of the ducts,

$$\frac{\Delta p_f}{L} = \frac{0.022243Q^{1.852}}{D_{eq}^{4.973}}$$

Symbols of the equation show usual notation.

[10 Marks]



Duct	Length (m)
AB	10
BC	10
CD	10
DE	5
CF	5
BG	5

Figure Q5 (b1)

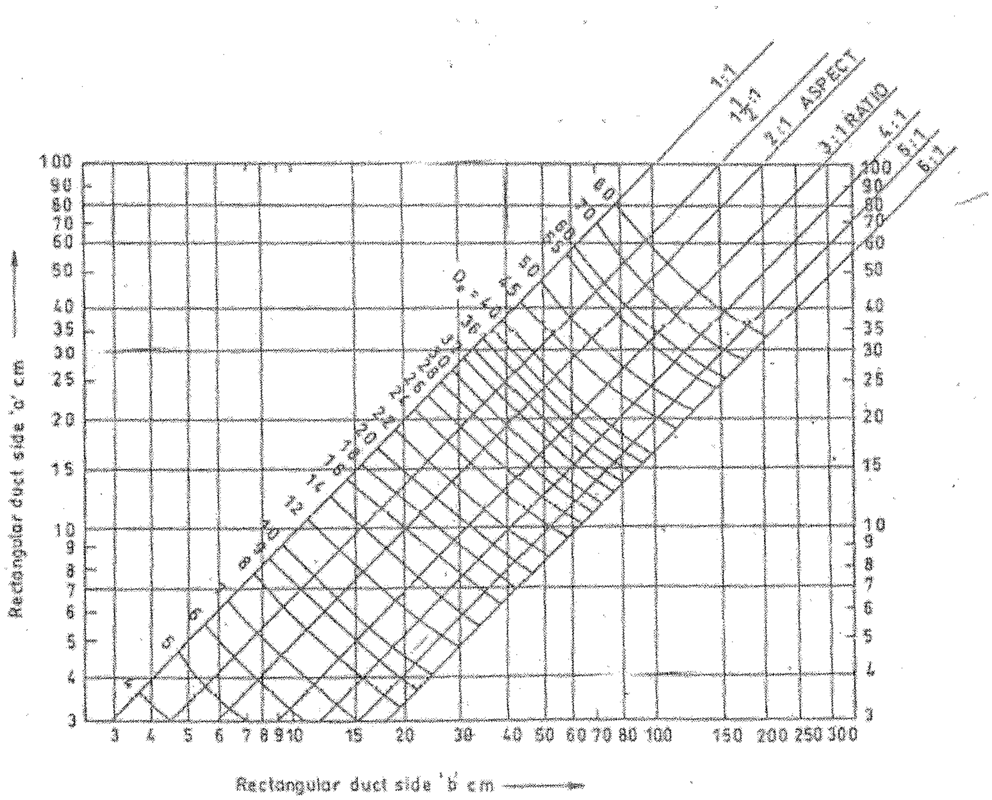


Figure Q5 (b2)