TECHNICAL UNIVERSITY OF MOMBASA

Faculty of Engineering and Technology
Department of Mechanical & Automotive Engineering
UNIVERSITY EXAMINATION FOR:
Diploma in Marine Engineering (Y3S1)
EMR 2305 : Thermo-Fluids II (Paper 2)
SPECIAL/SUPPLEMENTARY EXAMINATION
SERIES: SEPTEMBER 2018
TIME: 2 HOURS
DATE: Sep 2018

Instruction to Candidates:

You should have the following for this examination

- *Examination Pass & Student ID Card*
- *Answer booklet*
- *Non-Programmable scientific calculator*

This paper consists of **FIVE** questions. Attempt any **THREE** questions.
Maximum marks for each part of a question are as shown.
Do not write on the question paper.

Question ONE

a) The pressure P, developed in a jet pump is found to depend on the jet diameter d, diffuser diameter D, the velocity u of the jet, the volume flow Q and the density and viscosity of the fluid. Using dimensional analysis, prove that the functional relationship between the variables can be given by: **(12 marks)**

$$\frac{P}{\rho u^2} = f\left[\frac{Q}{ud^2}, \frac{\mu}{\rho u D}, \frac{d}{D}\right]$$

b) Oil flows over a submerged body horizontally at a velocity 15 m/s. The property values for oil are: kinematic viscosity = 3.45×10^{-5} m^2/s, density = 833 kg/m^3. An enlarged model is used with 8:1 scale in a water towing tank. Determine:

i. The velocity of the model to achieve dynamic similarity.
ii. If drag force on the model is 3.5 N, predict the drag force on the prototype.

Take: *Kinematic viscosity* of water = 1.14×10^{-6} m^2/s.

(8 marks)

Question TWO

a) With reference to viscous flow through a circular pipe, prove that the velocity distribution u can be given by:

$$u = -\frac{1}{4\mu}\frac{\partial p}{\partial x}[R^2 - r^2]$$

Where: R is the radius of the pipe and the other symbols retain their usual meaning.

(12 marks)

b) A fluid of viscosity 10 poise and specific gravity 0.90 is flowing through a circular pipe of diameter 110 mm. the velocity at the center of the pipe is 2 m/s. Determine:

i. Pressure gradient
ii. The shear stress at the pipe wall
iii. The Reynolds number (Re) of the flow
iv. The velocity at a distance of 30 mm from the wall.

(8 marks)

Question THREE

a) Prove that the Manometric head H_{mano} of a centrifugal pump can be given by:

$$H_{mano} = H_e + h_f$$

Where: H_e is the effective head and h_f is head loss in the system.

(8 marks)

b) The inlet and outlet diameters of a centrifugal impeller are 0.2 m and 0.4 m respectively. The vane angle at outlet is 45°. The pump speed is 1000 rpm. The flow velocity is constant at 3 m/s. The entry of the water is at radial direction. Determine:

i. The vane angle at inlet,
ii. The work done for 1 kg,
iii. The absolute velocity at outlet and its direction α_2

(12 marks)

Question FOUR

a) With reference to internal combustion engines, briefly explain the following terms:

i. Brake power,
ii. Indicated power,
iii. Brake specific fuel consumption,
iv. Indicated mean effective pressure,
v. Mechanical efficiency.
vi. Brake thermal efficiency

(6 marks)

b) A four stroke engine has single cylinder with bore of 18 cm and stroke of 34 cm. The Engine has an indicated mean effective pressure of 555 kPa at 390 rpm. At this the brake load is 510 N at a brake radius of 56.5 cm.

Cooling water is flowing at a rate of 270 kg/hr with its inlet and exit temperatures being 18°C and 58°C respectively. The fuel has a calorific value of 43000 kJ/kg and is supplied at 3.6 kg/hr. The exhaust gases carry away 38% of fuel energy. Determine:

i. Mechanical efficiency
ii. Brake thermal efficiency and
iii. Also prepare a heat balance sheet on per second basis.

(14 marks)

Question FIVE

a) Prove that for a two-stage reciprocating air compressor, the intermediate pressure P'_2 for minimum work done assuming perfect intercooling will be given by:

$$P'_2 = \sqrt{P_1 P_2}$$

Where: p_1 and p_2 are the suction and delivery pressure respectively.

(10 marks)

b) A two-stage reciprocating air compressor delivers 4.2 kg of free air per min at 1.01325 bar and 15 °C. The suction conditions are 0.95 bar, 22 °C. The compressor delivers air at 13 bar. Compression occurs throughout following $PV^{1.25} = C$. There is optimum and perfect intercooling between the two stages and Mechanical efficiency is 0.75. Neglecting clearance volume determine:

i. The heat transfer in intercooler per second.
ii. The capacity of electric motor.
iii. The % saving in work if two stage intercooling is compared with single stage compressor between same limits.

(10 marks)