TECHNICAL UNIVERSITY OF MOMBASA

Faculty of Engineering and Technology

DEPARTMENT OF MECHANICAL AND AUTOMOTIVE ENGINEERING

DIPLOMA IN MARINE ENGINEERING (DMAE VI)

EMR 2315
THERMO-FLUIDS

END OF SEMESTER EXAMINATIONS

YEAR 3 SEMESTER 2

SERIES: DECEMBER, 2013

TIME: 2 HOURS

INSTRUCTIONS TO CANDIDATES:

1. You should have the following for this examination:
   - Answer Booklet
   - Drawing Instruments
   - Scientific Calculator

2. This paper consists of **FIVE** Questions.
3. Answer **ANY THREE** Questions.
4. All Questions carry equal marks.
4. **This paper consists of *FOUR* printed pages.**

Question ONE

(a) Define the following:

(i) Cavitations
(ii) Net Positive Suction Head (NPSH)
(iii) Rotary Pump
(iv) Reciprocating Pump
(v) Pump

(10 marks)

(b) (i) State and explain **TWO** types of bubbles that form inside a liquid. **(5 marks)**

(ii) Draw typical characteristic curves for a centrifugal pump, showing head, efficiency, power input, NPSH(R), flow rate (Q) and read (ΔH) on a single graph.
(3 marks)

(iii) State **TWO** basic requirements for trouble free operation and longer service life of centrifugal pumps. **(2 marks)**

Question TWO

(a) (i) Differentiate between:
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(I) Parallel flow and counter flow in heat exchangers
(II) Double-pipe heat exchanger and compact heat exchangers
(III) Shell and tube heat exchanger and plate and frame heat exchanger

(8 marks)

(ii) Hot oil is to be cooled in a double-tube counter flow heat exchanger. The copper inner tubes have a diameter of 2cm and negligible thickness. The inner diameter of the outer tube (the shell) is 3cm. Water flows through the tube at a rate of 0.5kg/s and oil through the shell at a rate of 0.8kg/s. Taking the average temperatures of the water and the oil to be 45ºC & 80ºC, respectively, determine the overall heat transfer coefficient of this heat exchanger.

The properties of water at 45ºC are:

$\rho = 990kg/m^3$, $\Pr = 3.91$, $k = 0.637W/m°C$, $V = u/\rho = 0.602\times10^{-6}m^2/s$

The properties of oil at 80ºC are:

$\rho = 852kg/m^3$; $\Pr = 490$, $k = 0.138W/m.c$, $V = 37.5\times10^{-6}m^2/s$ *and* $Nu = 5.45$.

(12 marks)

Question THREE

(a) Explain the principle of operation of the two types regenerative heat exchangers.**(10 marks)**

(b) Show that the effectiveness of a parallel flow heat exchanger is given by:

$$E = \frac{1 - e^{-NTU(HR)}}{1 + R}$$

Where: R - Ratio of the minimum to maximum thermal capacities
NTU - Number of transfer Units

(20 marks)

Question FOUR

In an open gas turbine unit, the air from the compressor passes through a heat exchanger where it is heated by the gases from the L.P turbine. The H.P. turbine drives the compressor only. The exhaust gases from the H.P turbine pass through the low pressure combustion chamber, then into the L.P turbine which drives the external load. Given the following information:

Overall pressure ratio	9:1
Compressor isentropic efficiency	0.88
H.P turbine isentropic efficiency	0.86
L.P Turbine Isentrop efficiency	0.9
Heat exchanger effectiveness	0.75
Temperature of gasses entering the H.P turbine	700^{o}C
Temperature of gas entering the L.P turbine	650^{o}C
Atmospheric pressure	1.01325 bar
Atmospheric temperature	25^{o}C

Taking Cp for air and gases as 1.005kJ/kgk and adiabatic index γ as 1.4:

(a) Sketch the plant layout and T-S diagrams. **(5 marks)**

(b) Determine:

(i) Pressure of gas entering the L.P turbine
(ii) Overall thermal efficiency

(15 marks)

Question FIVE

(a) Define the term diagram efficiency and show that the diagram efficiency can be expressed as:

$$\eta_{diag} = \frac{4b}{ai}\left[\cos\alpha i - \frac{b}{ai}\right]$$

where:

αi = Nozzle angle

ai and b are the absolute inlet velocity and the blade velocity respectively.

(10 marks)

(b) A single wheel impulse steam turbine of blade wheel diameter 1.2m discharges 650kg of the steam per hour at 450m/s to the plane of the wheel. If the blade inlet and outlet singles are 45^{o} and 40^{o} respectively, and the blade wheel rotates at 280rpm, determine the following for a 15% loss of relative velocity due to friction in the blade when the absolute velocity at exit is radial.

(i) The nozzle angle
(ii) Power developed by the turbine
(iii) The diagram efficiency

(10 marks)