MACHAKOS UNIVERSITY COLLEGE

(A Constituent College of Kenyatta University)
University Examinations for 2015/2016

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF MECHANICAL AND MANUFACTURING ENGINEERING

SECOND SEMESTER EXAMINATION FOR DIPLOMA IN MECHANICAL ENGINEERING

MED – PR 309: THERMODYNAMICS III

DATE: 2/8/2016 **TIME: 8:30 – 10:30 AM**

INSTRUCTIONS:

-Section A is compulsory

-Attempt any TWO other questions from section B

SECTION A (COMPULSORY)

QUESTION ONE

a) State and give expressions for Newton's and Fourier's laws ofheat transfer. (4 marks)

b) Name and briefly explain the principles of operation of three classes of heat exchangers. (6 marks)

c) Briefly discuss the importance ofthe following modifications on the basicGas Turbine unit usingboth plant and T-S diagrams.

i. With intercooling between stages

ii. With reheat system

iii. With regenerative system (9 marks)

d) The velocity of steam leaving the nozzles of an impulse turbine is 900m/s and the nozzle angle is 20°.The blade velocity is 300m/s and the blade velocity coefficient is 0.7.The blades are symmetrical, for a mass flow of 1kg/s calculate the;

i. Blade inlet angle.
ii. Driving force on the wheel.
iii. Axial thrust.
iv. Diagram power.
v. Diagram efficiency. (11 marks)

SECTION B: (ATTEMPT ANY TWO QUESTIONS IN THIS SECTION)

QUESTION TWO

A steel pipe of 100mm bore and 7mm wall thickness carrying steam at 260^0C is insulated with an inner layer of diatomaceous earth, 40mm thick and an outer layer of magnesia, 60mm thick. If the atmospheric temperature is 15^0C and the heat transfer coefficients for the inside and outside surfaces are 550 and 15w/m^2k respectively, and the thermal conductivities of steel, diatomaceous earth and magnesia are 50, 0.09 and 0.07W/mK respectively.

(a) Derive from basic principles an expression for the heat transfer through the System and calculate the; (10 marks)

(b) Rate of heat flow per unit length of the pipe. (6 marks)

(c) Outside surface, interface and inside surface temperatures of the pipe. (4 marks)

QUESTION THREE

A 5MW gas turbine set operates with two compressor stages and an overall pressure ratio of 9/1. A high pressure turbine is used to drive the compressors, and a L.P.T drives the generator. Temperature at entry to H.P.T is 650^0C and reheating to 650^0C after expansion in H.P.T stage takes place while the isentropic efficiency of turbines is 0.85.The exhaust from L.P.T is passed through a heat exchanger whose thermal ratio is 0.75 to heat the air leaving the H.P.C stage. The compressor have equal pressure ratio and intercooling is complete between stages. The air inlet temperature is 15^0C, compressor isentropic efficiency is 0.8 and a mechanical efficiency of 98% can be assumed for the power- shaft and compressor-turbine shaft. For air intake `c_p =1.005kj/kgK and γ =1.4, and for the gases in the combustion chamber, turbine and regenerator take c_p=1.15kj/kgKandγ=1.333. Determine;

(a) The thermal efficiency of the plant. (16 marks)

(b) The work ratio. (2 marks)

(c) The mass flow in kg/s. (2 marks)

QUESTION FOUR

(a) From basic principles, show that for a counter-flow recuperative heatexchanger, the Logarithmic mean temperature deference Θ_m, is given by the expression;

$$\Theta_m = \frac{\Theta_1 - \Theta_2}{ln\frac{\Theta_1}{\Theta_2}}$$

Where Θ_1 and Θ_2 are temperature difference at sections. (15 marks)

(b) Oil enters the tube of a double pipe heat exchanger at 350°C and leavesat 100°C and water enters at 10°C. The oil is cooled by water and the counter current flow rates are 200kg/h and 1400kg/h respectively. The overall heat transfer coefficient is 0.25kW/m^2 and the tube has a mean diameter of 75mm.Taking the specific heat capacities of oil and water as1.13kj/kgKand 4.19kj/kgK respectively, determine the length of the tube required. (5 marks)

QUESTION FIVE

(a) show that for a single-stage reciprocating air compressor, the volumetric efficiency, η_v is given by;

$$\eta_v = 1 - \frac{v_c}{v_s}\left\{\left(\frac{p_2}{p_1}\right)^{1/n} - 1\right\}$$

Where v_s=swept volume, v_c=clearance volume, p_1=intake pressure

p_2=delivery pressure, n =index of expansion and compression. (5 marks)

(b) Air at a pressure of 1.013 bars and temperature of 15°C is compressed through a pressure ratio of 9/1 in a single acting, two stage reciprocating air compressor. Both stages have the same pressure ratio, and the compression and expansion index is 1.3. Intercooling is complete and the air mass flow rate is 4.5kg/min.If the clearance volumes of both stages are 5% of their respective swept volumes and the compressor runs at 300r.p.m, calculate;

i. The indicated power.

ii. The swept volume of cylinders. (15 marks)