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

SET 2102/316: THERMODYNAMICS

DATE: 1/8/2016 **TIME: 8:30 – 10:30 AM**

INSTRUCTIONS:

Attempt all theFOUR questions.

QUESTION ONE

A 4-cylinder, 4-stroke petrol engine has a bore of 57mm, a stroke of 90mm and its rated speed is 2800 rev/min. It is tested at this speed against a brake which has a torque arm of 0.356m.The net brake load is 155N and the fuel consumption is 6.74 L/hr.The specific gravity of fuel is 0.735 and a lower calorific value of 44200Kj/kg. Morse test is carried out and the cylinders are "cut-out" with corresponding brake loads of 111N,106.5N,104.2N and 111N, determine the;

(a) Brake mean effective pressure (5 marks)

(b) Brake thermal efficiency (7 marks)

(c) Specific fuel consumption on a brake power basis(2 marks)

(d) Mechanical efficiency(4 marks)

(e) Indicated mean effective pressure (2 marks)

QUESTION TWO

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/kgK and γ =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 THREE

(a) From basic principles, show that for a counter-flow recuperative heat exchanger, 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 $\Theta_1$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 leaves at100°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/kgK and 4.19kj/kgK respectively, determine the length of the tube required. (5 marks)

QUESTION FOUR

(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 300rev/min, calculate;

i. The indicated power.

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