KENYATTA UNIVERSITY

UNIVERSITY EXAMINATIONS 2011/2012

SECOND SEMESTER EXAMINATION FOR THE DEGREE OF BACHELOR OF SCIENCE (MECHANICAL AND MANUFACTURING ENGINEERING)

EMM 404: THERMODYNAMICS III

DATE: **Wednesday 11th April 2012** **TIME:** **11.00.a.m – 1.00p.m**

INSTRUCTIONS

This paper contains 5 questions

All questions carry 20 marks each

Steam Tables, with Mollier Diagram in S.I units are provided

Question 1

a) Explain why the Rankime cycle instead of the Carnot cycle is used as the standard of reference of performance of steam engines. [3marks]

b) A Steam Power Plant operates between a boiler pressure of 40 bars and condenser pressure of 0.050 bars on a Rankime cycle, with dry saturated steam at entry to the turbine.

Calculate the:

i) Cycle Efficiency [3marks]

ii) Work Ratio [4marks]

iii) specific steam consumption in Kg/KWHr. [4marks]

c) Using a clearly labelled line diagram, explain how a steam plant with a super heater works. [6marks]

[Total 20 marks]

Question 2

a) Discuss any five uses of compressed air. [5marks]

b) Show that for a single-acting, single-cylinder, two-stage reciprocating compressor,

$P_i = \sqrt{P_1 P_2}$

$where\ P_1 = admission\ pressue$

P_i = *ideal intermediate pressure*

P_2 = *final delivery presue*

[8marks]

c) In a single-acting, single-cylinder two-stage reciprocating air compressor, 4.65 Kg of air are compressed from 1 bar and 15.5°C through a pressure ratio of 8.5:1. Both stages have the same pressure ratio each, and expansion/compression if both stages is governed by relation $PV^{1.3}$ = constant.

Assume that inter-cooling is complete.

Calculate the indicated power if the compressor is running at *300rpm* [7marks

[Total 20 marks]

Question 3

a) Show that when a compressible fluid under a pressure of P_1 (N/m^2) flows adiabatically from a container through an orifice, for maximum flow rate,

$\frac{P_1}{P_2} = 0.5283$

Where P_2 = external pressure immediately in front of the orifice and $\gamma = 1.4$.

b) Air at 8.7 bars and 195°C expands at the rate of 5Kg/s through a convergent-divergent nozzle into atmosphere at 1 bar under maximum flow conditions.

Calculate the throat and exit cross-sectional areas of the nozzle

Assume the initial velocity is zero [12marks]

[Total 20 marks]

Question 4

a) i) Define the terms

i) Volumetric efficiency with respect to internal combustion engines

[2marks]

ii) Mean Effective Pressure [2marks]

iii) Discuss any three typical features of positive displacement machines.

[3marks]

b) A four cylinder petrol engine has a bore of 57 mm and a stoke of 90mm. Its rated speed is 280r*pm*. The stoichiometric air fuel ratio of the engine is 14.5:1, and fuel consumption is 6.741 litres per hour.

An analysis of the dry products of combustion do not reveal any traces of oxygen and carbon monoxide. The specific gravity of petrol used = 0.735.

The engine was tested at a pressure of 1.013 bar under a temperature of 15°C
Calculate the volumetric efficiency of the engine. [7marks]

c) A 4-stroke single cylinder gas engine has a bore of 146mm and a stroke of 290mm. At *475rpm*, the net load on the friction brake is 435N and the torque arm is 0.45m. The indicator diagram has a net area of 550mm^2 and a length of 70mm with a spring rating of 0.815 bar per mm. Calculate:

i) Indicated Power [2marks]

ii) Brake Power [2marks]

iii) Mechanical Efficiency [2marks]

[Total 20 marks]

Question 5

a) A working from first principles and explaining the meaning of symbols used and stating the assumptions made derive an expression for the mean effective pressure, in terms of the steam supply pressure, the condenser pressure and the expansion ratio for a steam engine. Assume that there is no clearance volume and that the expansion is hyperbolic. [6marks]

b) Sketch the operations of a steam engine on a *P.V.* diagram assuming that there is no clearance volume. [4marks]

c) The following readings were taken during a test on a steam engine

Engine stroke	-	0.4m
Piston diameter	-	0.25m
Mean speed	-	1.30rpm
Area of indicator diagram	-	580mm^2
Length of the indicator diagram	-	65mm
Strength of the indication spring	-	8.35MN/mm^2/m

Load on brake $F_1 = 450N$

Spring balance reading $F_2 = 50N$

Radius of brake wheel = 0.5m

Calculate

i) Indicated Power. [4marks]

ii) Brake Power. [4marks]

iii) Mechanical Efficiency [4marks]

[Total 20 marks]