TECHNICAL UNIVERSITY OF MOMBASA

Faculty of Engineering & Technology

DEPARTMENT OF MECHANICAL & AUTOMOTIVE ENGINEERING

UNIVERSITY EXAMINATIONS FOR
THE DEGREE OF BACHELOR OF SCIENCE IN MECHANICAL ENGINEERING

(Y5 S1)

EMG 2501 POWER PLANTS

END OF SEMESTER EXAMINATIONS
SERIES: DECEMBER 2016
TIME: 2 HOURS

INSTRUCTIONS TO CANDIDATES:

This paper contains **FIVE** questions. Answer **ANY THREE** questions

Supplied: *Thermophysical and Transport Properties of Fluids (SI Edition)*, by Y.R. Mayhew and G.F.C. Rogers

Question 1

An ideal Rankine cycle with reheat uses water as the working fluid. Superheated steam vapour enters the turbine at 8 MPa, 480^{o}C. Steam expands through the first-stage turbine at 0.7 MPa and reheated to 480^{o}C. The condenser pressure is 8 kPa. The net power output of the cycle is 100 MW.

(a) Draw a schematic of the entire process and sketch the process on a *T*-*s* diagram.

Calculate;

(b) The rate of heat transfer to the working fluid passing through the steam generator, in MW.

(c) The thermal efficiency.

(d) The rate of heat transfer to cooling water passing through the condenser, in MW.

Given that the cooling water enters the condenser at 15^{o}C and exits at 35^{o}C with negligible pressure change. **(20 marks)**

Question 2

A power plant operates on a regenerative vapour power cycle with one open feedwater heater. Steam enters the first turbine stage at 12 MPa, 520^{o}C and expands to 1 MPa, where some of the steam is extracted and diverted to the open feedwater heater operating at 1 MPa. The remaining steam expands through the second turbine stage to the condenser pressure of 6 kPa. Saturated liquid exits the open feedwater heater at 1 MPa. Assume isentropic isentropic efficiencies in the turbines and pumps to be 100%.

(a) Draw a schematic diagram for the cycle and sketch the process on a *T*-*s* diagram.

Calculate for the cycle;

(b) The thermal efficiency and

(c) The mass flow rate into the first turbine stage, in kg/h, for a net power output of 330 MW.

(20 marks)

Question 3

A cogeneration system operating as illustrated in Figure Q3. The steam generator provides a 10^6 kg/h of steam at 8 MPa, 480^{o}C of which 4 *x* 10^5 kg/h is extracted between the first and second turbine stages at 1 MPa and diverted to a process heating load. Condensate return from the process heating load at 0.95 MPa, 120^{o}C and is mixed with liquid exiting the lower-pressure pump at 0.95 MPa. The entire flow is then pumped to the steam generator pressure. Saturated liquid at 8 kPa leaves the condenser. The turbine stages and the pumps operate with isentropic efficiencies of 86 and 80%, respectively.

(a) Sketch the process on a *T*-*s* diagram.

Calculate;

(b) The heating load, in kJ/h.

(c) The power developed by the turbine, in MW.

(d) The rate of heat transfer to the working fluid passing through the steam generator, in kJ/h.

(20 marks)

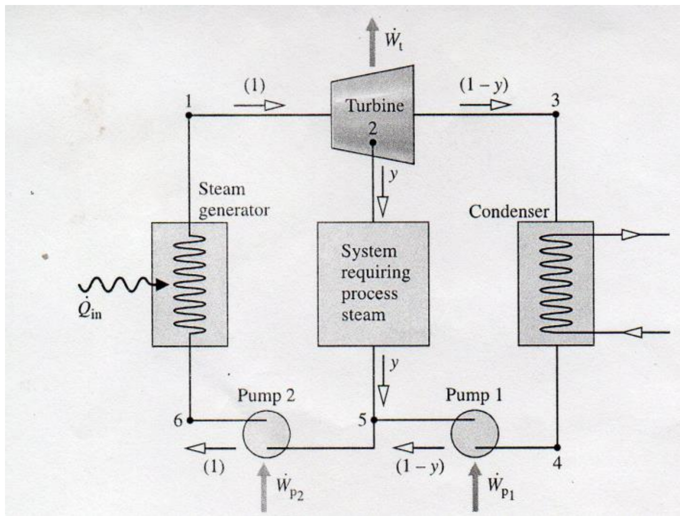


Figure Q3. Schematic of a cogeneration system in which process steam is bled from the turbine

Question 4

A regenerative gas turbine power plant is as shown in Figure Q4. Air enters the compressor at 100 kPa, 300 K. The air is compressed in two stages to 900 kPa, with intercooling to 300 K between the stages at a pressure of 300 kPa. The turbine inlet temperature is 1480 K and the expansion occurs in two stages, with reheat to 1420 K between the stages at a pressure of 300 kPa. The isentropic efficiency of each compressor and turbine stage is 84 and 82%, respectively. The regenerator effectiveness is 75% and the net power developed is 1.8 MW.

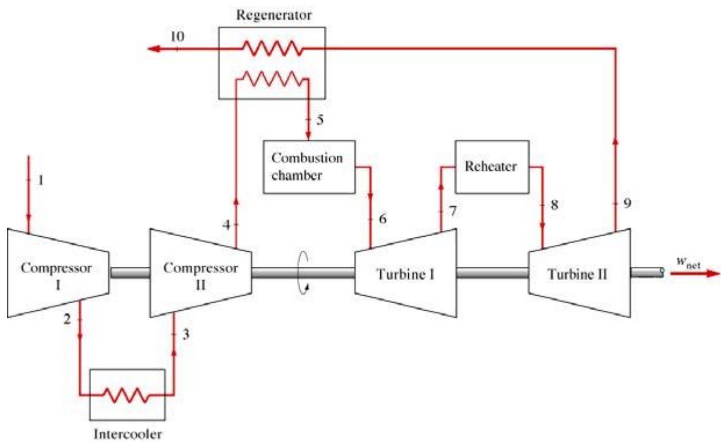
(a) Sketch the process on a *T-s* diagram.

Calculate;

(b) The volumetric flow rate, in m^3/s, at the inlet of each compressor stage.

(c) The thermal efficiency of the cycle.

(d) The back work ratio. **(20 marks)**



Q4. A regenerative gas turbine plant

Question 5

The conditions at the beginning of compression in an air-standard Diesel cycle are fixed by p_1 = 200 kPa and T_1 = 380 K. The compression ratio is 20 and the heat addition per unit mass is 900 kJ/kg.

(a) Sketch the 2 ocess on p-V 3 and T-s diagrams.

Calculate:

(b) The maximum temperature in the cycle.

(c) The cut-off ratio.

(d) The net work output per unit mass of air, in kJ/kg.

(e) The thermal efficiency.

(f) The mean effective pressure, in kPa

(g) The net power output

(h) Discuss the various limiting factors experienced in operation of diesel powered plants.

(20 marks)