Mansoura University
Faculty of Engineering
Mech. Power Eng. Dept.
Fourth Year

Final Semester Exam
Steam and Gas Turbines-MPE4421
January 5, 2013 Time: 3 hours
Full Mark: 100

Answer the following questions. Use of steam and gas tables and charts is allowed. Assume any necessary assumptions.

Mark

**Steam Turbines**

1. a) How are steam turbines classified? Give a list of the types of steam turbines. [10]

b) What are the advantages and disadvantages of the combined cycle? [5]

c) A steam turbine plant employing regenerative feed heating has the following data: [15]

Steam conditions at inlet p=85 bar, t=520 °C

Condenser pressure= 0.042 bar

Bleed points are at pressures 15,10.5 and 0.8 bar. The efficiencies of expansions between various pressures are 85%, 80% , 79% and 70% respectively. Draw a schematic of the plant and the T-S diagram of the cycle, and determine:

i) the final state of steam after expansion,
ii) mass of steam raised in the boiler per kg of steam condensed in the condenser,
iii) improvement in the thermal efficiency and heat rates due to feed heating, and

d) A combined gas and steam plant develops 10 MW at a gas turbine shaft with an efficiency of $\eta_{gt}$= 22%. A steam turbine power plant ($\eta_{st}$=33%)is operated through the WHRB which receives the turbine exhaust , calculate: [10]

i) The output of steam turbine plant,
ii) The thermal efficiency of the combined cycle plant,
iii) The overall heat rate.

2. The initial pressure and temperature of steam entering a single stage impulse turbine ($d=1m$, $N=3000$ rpm and $\eta_{st}=85\%$ ) are 100 bar and 550 $^{o}C$ respectively. The steam flow rate is 100 kg/s and exit angle of the nozzle blades is $70^{o}$. Assuming maximum utilization factor, determine the rotor blade angles, blade height, power developed and the final state of steam after expansion. [10]

**Gas Turbines**

3. Classify briefly types of turbomachines. [10]
4. For a simple gas turbine cycle, calculate the optimum pressure ratio for maximum specific work using the following data; [20]
   Compressor inlet temperature = 300K,
   Turbine inlet temperature = 1500K,
   Compressor polytropic efficiency = 90%,
   Turbine polytropic efficiency = 92%,
   $\sum(\Delta p_o/p_o) = 3\%$ , $(R/\overline{C_p},c) = 0.26$, $(R/\overline{C_p},e) = 0.24$ and $[m_e\overline{C_p},e/m_c\overline{C_p},c] = 1.1$.
5. A turbojet engine is operating under the following conditions: Altitude = 12 km. Mach number = 1.2. Pressure ratio across the compressor = 18. Temperature at turbine inlet = 1300 K. The diffuser pressure recovery ratio = 80% and the efficiencies of the compressor, the turbine and the nozzle are; 88%, 90% and 95%, respectively. Air enters the compressor at a rate of 40 kg/s, and the jet fuel has low heating value = 44 MJ/kg. Draw carefully the temperature-entropy chart and for average specific heats calculate each of; [20]
   a) The thrust developed.
   b) The propulsive efficiency.
   c) The rate of fuel consumption.
   d) The thrust specific fuel consumption

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Good luck, Dr. A. Abd Elsalam