Minoufiya University
Faculty of Engineering
Mechanical Power Eng. Dept
Academic Year: *2013-2014*
Date: 20/1/2014

Minufiya University

Subject: *Gas Turbines*
Code: *MPE 519*
Academic level: Diploma.
Time allowed: *3 hours*
Total degree : *100 marks*

Answer all the following questions: *Resources: Steam Tables and Chart*

Question-1 [45 marks]

a) Explain using diagrammatic sketches the schemes for the cycles of gas-steam turbines. Compare between the efficiencies of both steam and combined gas-steam turbines. Discus also the conditions occurs to obtain the equilibrium of plants performance between steam and gas-steam plants. [10 marks]

b) In a gas turbine generating station. The overall compression ratio is 12/1, performed in three stages with pressure ratios of 2.5/1; 2.4/1; and 2/1 respectively. The air inlet temperature to the plant is 25 °C and intercooling between stages reduces the temperature to 40 °C. The H. P. turbine drives the high pressure and intermediate-pressure compressor stages; the L. P. turbine derives the low-pressure compressor and alternator. The gases leaving the L. P. turbine are passed through a heat exchanger which heats the air leaving the high-pressure compressor. The temperature at inlet to the H. P. turbine is 650 °C, and reheating between turbine stages raises the temperature to 650 °C. The gases leave the heat exchanger at a temperature of 200 °C. The isentropic efficiency of each compressor stage is 0.83, and the isentropic efficiencies of the H. P. and the L. P. turbines are 0.85 and 0.88 respectively. Take the mechanical efficiency of each shaft as 98%. The air mass flow rate is 140 kg/s. *Calculate* the power output in kilowatts, the thermal efficiency, and the flow of cooling water required for the intercoolers when the rise in water temperature must not exceed 30 K. Neglect pressure losses and changes in kinetic energy and take the specific heat of water as 4.19 kJ/kg.K. *Calculate* also the heat exchanger thermal ratio. [35 marks]

Question-2 [35 marks]

a- Draw the velocity triangles for an axial flow compressor stage and prove that energy transferred by the compressor blades is given by the following relation:

$$E = U\, C_a\, (\tan\beta_1 - \tan\beta_2)/g$$ [10 marks]

b- Air at 0.1 MPa pressure and 25 °C temperature is compressed inside the stage of axial compressor. If the air inlet to the stage with the stagnation enthalpy equals 344.5 kJ/kg and the inlet flow angle is 16°. The compressed air leaves the stage at the following conditions: the flow exit angle is 25° and the air temperature at exit is 57 °C (exit temperature). The compressor shaft velocity is 2500 rpm. The mean diameter of the stage is 1.8 m. The degree of reaction of this stage is 0.75.

Draw the velocity triangles of the stage and find out the following:

i- Rotor blade angles.

ii- the compressor work done.

iii- the pressure ratio of the stage.

iv- The work done factor. [25 marks]

Question-3 [20 marks]

a- What are the specification must be considered during residual oils burning in gas turbine in order to achieve successful combustion.

b- Show thermodynamically the flow characteristics on the Mollier chart of axial compressor stage.

c - Mention the factors affecting gas turbine performance and some modification to decrease the effect of these factors.

d- Air temperature and site elevation have direct effect on the gas turbine performance. Discuss the reasons for this tendency and show the effect of ambient temperature on both heat rate and output power.

With best wishes
Prof. Nabil Hanfy and Dr. Ashraf Amin