Minoufia University Faculty of Engineering Shebin El-Kom 2nd Semester Exam. Academic Year: *2014-2015* Max. Marks. 100	Minufiya University	Year: Post Grad. (PhD. Prep.) Dept.: Mechanical Power Eng. Subject: *Turomachine* Code: *MPE 713* Time allowed: *3 hours* Date: 08/06/2015

Please do not use a pencil to write. (Note: Numbers of Exam. Papers are 2 pages.)

Assume any missing data from your point of view in the limits of what you studied.

Answer all the following questions:

Question-1 **[35 marks]**

a) Explain the difference between the compressor and turbine cascade performance.

b) A single-stage gas turbine operates at its design condition with an axial absolute flow at entry and exit from the stage. The absolute flow angle at nozzle exit is 70 deg. At stage entry the total pressure and temperature are 311 kPa and 850°C respectively. The exhaust static pressure is 100 kPa, the total-to-static efficiency is 0.87 and the mean blade speed is 500 m/s. Assuming constant axial velocity through the stage, determine

(i) The specific work done;
(ii) The Mach number leaving the nozzle;
(iii) The axial velocity;
(iv) The total-to-total efficiency;
(v) The stage reaction.
Take (Cp = 1.148 kJ/kg°C and γ = 1.33 for the gas).

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Question-2 **[30 marks]**

a) Explain the physics of stall and surge phenomena in compressors.

b) A multistage axial compressor is required for compressing air at 293 K, through a pressure ratio of 5 to 1. Each stage is to be 50% reaction and the mean blade speed 275 m/s, flow coefficient 0.5, and stage loading factor 0.3, are taken, for simplicity, as constant for all stages. Determine the flow angles and, the number of stages required if the stage efficiency is 88.8%. Take Cp = 1.005 kJ/(kg°C) and γ =1.4 for air.

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Question-3 **[35 marks]**

a) *Explain with drawing the turbine flow characteristics.*

b) *Combustion gases enter the first stage of a gas turbine at a stagnation*

temperature and pressure of 1200K and 4.0 bar. The rotor blade tip diameter is 0.75 m, the blade height is 0.12m and the shaft speed is 10500 rev/min. At the mean radius the stage operates with a reaction of 50 per cent, a flow coefficient of 0.7 and a stage loading coefficient of 2.5. Take(Cp = 1.160 kJ/kg°C and $\gamma = 1.33$)

Determine:

(1) The relative and absolute flow angles for the stage;

(2) The velocity at nozzle exit;

(3) The static temperature and pressure at nozzle exit assuming a nozzle efficiency of 0.96 and the mass flow;

(4) The rotor blade root stress assuming the blade is tapered with a stress taper factor K of 2/3 and the blade material density is 8000 kg/m^3;

(5) The approximate mean blade temperature;

[Use; $\sigma_c = 0.5K\rho_m U_t^2[1-(r_h/r_t)^2]$, $T_b=T_2+0.85w_2^2/(2C_p)$, $C_{P(\text{combustion gas})}=1160$ J/Kg. K]

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With my best wishes. Prof.dr. Taher Sabry & Prof.dr. Mostafa Nasr