BENGAL ENGINEERING AND SCIENCE UNIVERSITY, SHIBPUR

B.E. 6th Semester (AE) Final Examination, April 2013

Theory of Propulsion (AE-603)

Full Marks: 70 **Time: 3 hrs**

i) Answer questions 1 and 2 (20 marks) and question 3 (30 marks).

ii) Notations used carry their conventional senses.

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1. For an ideal ramjet cycle is flying at $M_\infty = 4.0, p_\infty = 0.8bar, T_\infty = 260K$. Further data given are: $(c_p T_\infty)/\Delta H_p = 0.0061$, fuel-air mass ratio $f = f_{stoich} = 0.05$.

(a) Draw the characteristic points schematically in a (T, s) chart;

(b) Obtain the (stagnation, static) states (temperature, pressure) at the characteristic points in (T,s) chart;

(c) Compute flow velocities at inlet and nozzle exhaust;

(d) Compute specific thrust;

(e) Compute specific heat addition, heat rejection and work done;

(f) Compute η_{th}, η_p and overall efficiency.

2. Let's consider the following specification of the Canadian straight jet engine from United Aircrafts Canadian Ltd. (UACL), model no. JT115D-4, mass flow rate = 34.1 kg/s, overall compression ratio = 10.0, turbine inlet temperature = 960°C. Consider running the engine near the sea level with ambient pressure = 1.0 bar, ambient temperature = 298K, approaching flow velocity = 250 m/s. Compute

(a) the gas state (temperature, pressure) at the characteristic points of the engine for an ideal cycle analysis;

(b) the thrust, specific thrust;

(c) heat added, heat rejected and work output;

(d) thermodynamic and propulsive efficiency and overall efficiency; and

(e) draw the cycle in a (T,s) chart.

3. Consider the flow process in a single stage axial compressor. Let air at pressure $p_1 = 1bar$, temperature $T_1 = 288K$, and relative velocity $w_1 = 130m/s$ enter the rotor with entry angle $\beta_1 = 30^o$. Let azimuthal speed $u = u_1 = u_2 = 250m/s$. Also, let $c_{1m} = c_{2m} = c_1$ and $c_2 = w_1$. Compute $c_{1m} = c_{2m}, c_{1u}, c_{2u}, w_{1u}, w_{2u,}, w_1, w_2, H, \beta_2$ and degree of reaction $\hat{r}$. Draw the blades schematically. With efficiency = 1, compute the pressure and temperature at the end of rotor and stator.