Name: __________
Roll No.: __________

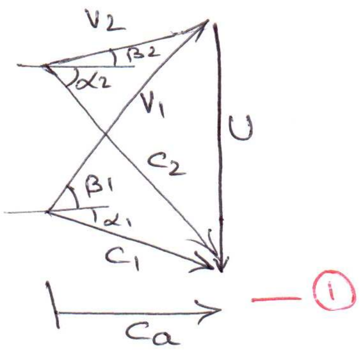
AE 651: Aerodynamics of Compressors and Turbines

Quiz No. 1
Maximum marks: 10

18^{th} August 2015 **Time: 20 minutes**

Note: Suitably assume missing data if any and clearly mention the same.

1. Air at 3 kg/s and a stagnation temperature of 290 K, enters a 10 stage axial flow compressor when operating with a mean blade speed of 180 m/s. The compressor operates with a pressure ratio of 6.5 and has an isentropic efficiency of 90 %. The axial velocity is 150 m/s and is constant across the stages. If the compressor stages have symmetrical velocity triangles, determine the power required to drive the compressor and the blade angles at the entry and exit of the rotor.



— (1)

$T_{02s} = 290 \times 6.5^{\frac{1.4-1}{1.4}}$

$= 495.33\ K$ — (1)

$\eta_c = 0.90 = \dfrac{T_{02s} - T_{01}}{T_{02} - T_{01}}$

$\therefore T_{02} = 518.14\ K$ — (1)

$\therefore$ Power required to drive the compressor

$= \dot{m} C_p \Delta T_0 = 3 \times 1005\,(518.14 - 290)$

$= \underline{687.84\ kW}$ — (2)

Temperature rise per stage, $\Delta T_0/\text{stage} = \dfrac{518.14 - 290}{10}$

$= 22.81\ K$ — (1)

Work done per unit mass $= U \Delta C_w$

$= 180\, \Delta C_w = C_p \Delta T_0/\text{stage}$

$\therefore \Delta C_w = \dfrac{1005 \times 22.81}{180} = 127.36\ m/s$ — (1)

For symmetrical stages, $\Delta C_w = C_a(\tan\beta_1 - \tan\beta_2)$

$127.36 = 150(\tan\beta_1 - \tan\beta_2)$ — (1)

or $\tan\beta_1 - \tan\beta_2 = 0.849$

Also, $R_x = \dfrac{C_a}{2U}(\tan\beta_1 + \tan\beta_2)$, $\tan\beta_1 + \tan\beta_2 = 1.2$ — (1)

$\therefore \beta_1 = 45.69^\circ$ — (1)

$\beta_2 = 9.95^\circ$ — (1)