Department of Mechanical and Industrial Engineering

MIN 304: Fluid Machinery **Tutorial 3**

1. The impeller of a centrifugal pump rotates at 1450 rev min^{-1} and is of 0.25 m diameter and 20 mm width at outlet. The blades are inclined backwards at 30° to the tangent at outlet and the whirl slip factor is 0.77. If the volumetric flow rate is 0.028 m^3s^{-1} and neglecting shock losses and whirl at inlet, find the theoretical head developed by the impeller. Also, using Stodola's model of relative eddy, find the number of blades on the impeller. *[23.7 m, 8 blades]*

2. Show that for a centrifugal pump, neglecting losses, the condition for maximum efficiency is

   $$u_2 = 2\,V_{f2} / \tan\beta_2 ,$$

   where u_2 is the blade peripheral speed at outlet, V_{f2} is the outlet velocity of flow and β_2 is the blade angle at outlet measured with respect to the tangent.
   A centrifugal pump with an impeller diameter of 10 cm and an axial width of 1.5 cm has swept-back blades inclined at 25° to the tangent to the periphery. If the impeller speed is 12.4 rev s^{-1}, calculate the flow rate when the pump is operating at maximum efficiency. Assume zero swirl at inlet. *[0.0043 m^3s^{-1}]*

3. The diameter of the rotor of an axial flow fan is 300 mm on which 20 blades of height 100 mm and chord 49 mm are mounted. The blades are designed for uniform work out put at all radii, and the rotational speed is 1500 rpm. If nominal relative velocity 35 m/s at an angle of 25 degree with peripheral speed at mid radius, calculate the work done. Take C_L = 0.45, C_D=0.21 and ρ = 1.2 kg/m^3. Estimate the Euler's head if the mass flow rate of air is 4.5 kg/s. [861 W, 19.5 m]

4. At a particular diameter equal to 250 mm of an axial flow pump, the velocity at inlet to the impeller is 8 m/s and is in the axial direction. The speed of revolution is 1450 rpm. The blade section at this diameter is to be designed to develop a head H = 14 m of water column. The blade axial chord, e = 130 mm and z = 6. Estimate the blade angles β_{1b} and β_{2b}. Assume incidence is 0. Draw the inlet and exit velocity triangle. [22.8°, 44.7°]