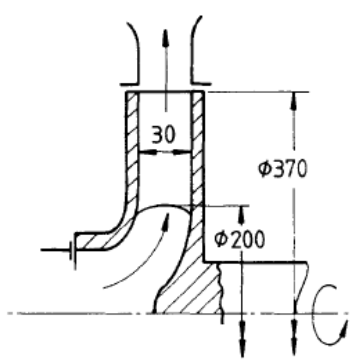
DEPARTMENT OF MECHANICAL ENGINEERING
I.I.T. KANPUR
ME – 401A: Energy System II
Assignment #1
Instructor: S. Sarkar

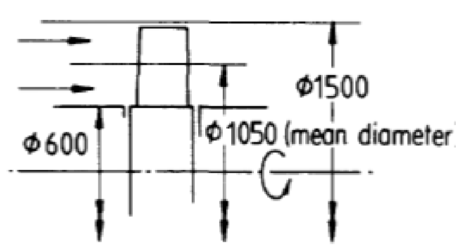
Due Date: 07.02.2018, 5pm

Note: Please submit in time.

1. Define a turbomachine. What are the different types of rotating machines. Explain the differences between the machines in terms of specific speed, features and working principle.
2. Show the arrangement of blades in an axial compressor with two stages. Show graphically the variation of static pressure and absolute velocity through the machine. Why is this type of compressor more suitable for a turbo-jet engine ?
3. Describe with the aid of illustrative sketches the working of a centrifugal compressor stage. State the difference between centrifugal compressor and axial compressor.
4. Using the expression for the head developed and work done by a pump, derive the nature of the head-flow (H-Q) characteristics for a Forward-Curved-Vane, Backward-Curved-Vane and a Radial Vane.
5. The pump sketched below is driven at 1470 rpm and delivers 100 *l/s* with a specific energy change of 400 J/kg. Sketch the inlet and outlet velocity triangles, assuming a hydraulic efficiency of 85% and zero inlet whirl.



6. An axial machine sketched in the figure below is driven at 45 rad/s. This may work either as a pump or a turbine. If the energy change is 120 J/kg. Sketch the velocity triangles when it works as a pump or a turbine assuming axial velocity *Vz*=12 m/s. Ignore efficiency and assume zero inlet whirl for the pump and zero outlet whirl for the turbine.



7. A fan operating at 1750 rev/min at a volume flow rate of 4.25 m^3/s develops a head of 153 mm measured on a water filled U-tube manometer. It is required to build a larger, geometrically similar fan which will deliver the same head at the same efficiency as the existing fan, but at a speed of 1440 rev/min. Calculate the volume flow rate of the larger fan. (6.29m^3/s).

8. A water turbine is to be designed to produce 27 MW when running at 93.7 rev/min under a head of 16.5 m. A model turbine with an output of 37.5 kW is to be tested under dynamically similar conditions with a head of 4.9 m. Calculate the model speed and scale ratio. Assuming a model efficiency of 88%, estimate the volume flow rate through the model. It is estimated that the force on the thrust bearing of the full-size machine will be 7.0 GN. For what thrust must the model bearing be designed ? (551 rev/min, 1:10.8, 0.885 m^3/s, 17.85 MN).

9. Calculate the specific speed for a centrifugal compressor which develops a pressure ratio of 2.0 while running at 24000 R.P.M and discharging 1.5 kg/s of air. (0.693)

10. A compressor cascade has the following data :
    Velocity of air at inlet = 75m/s.
    Air angle at entry = 48^o.
    Air angle at exit = 25^o.
    Pitch-Chord ratio (S/C) = 1.1
    Stagnation Pressure Loss = 11mm. of W.G.
    Density of Air = 1.25 kg/m^3.
    Determine Loss Coefficient, Drag Coefficient, Lift Coefficient, and Maximum Diffuser Efficiency. (0.0307, 0.03653, 1.084, 0.933).

11. Air enters the test section of a turbine blade ($\alpha 1$ = 40o, $\alpha 2$ = 65o) cascade tunnel at 100m/s (ρ = 1.25 kg/m3). The pitch-chord ratio of the cascade is 0.91. The average loss in the stagnation pressure across the cascade is equivalent to 17.5 mm W. G. Determine for the cascade a) The pressure loss coefficient, b) The drag coefficient, c) The lift coefficient, d) The tangential and axial force coefficients.

    (a = 0.0275, b = 0.082, c = 4.608, d = 0.972, 0.656).

12. A centrifugal pump, while running at 1000 R.P.M, discharges 0.08 m^3/s against a net head of 16 m. The hydraulic efficiency of the pump is 85%. If the vane angle is 35^o and the velocity of flow is constant throughout at 1.5 m/s, estimate the outer diameter of the impeller and its width at that diameter. Assume K_2 = 1.5 at exit. (Assume zero inlet swirl at inlet). (Diameter = 28.1 cm., Width = 4 cm.)

13. A centrifugal pump impeller has an outer diameter of 30 cm and an inner diameter of 15 cm. The pump runs at 1200 R.P.M. The impeller vanes are set at a blade angle of 30^o at the outlet. If the flow velocity is constant at 2.0 m/s and zero inlet swirl at inlet, calculate
    (a) Absolute Velocity of flow and its direction with horizontal at outlet.
    (b) Head developed by the pump, given the hydraulic efficiency, η_H = 85%.
    (c) Blade angle at inlet.
    (a) 15.15m/s at 7.4086^o to the horizontal. (b) 25.11m. (c) 12^o.