B.E. Mechanical Engineering - Second Year - Second Semester 2023

FLUID MACHINERY – 1

Time: Three Hours **Full Marks: 100**

Symbols used in this question paper if any, carry their usual meanings.

Assume any relevant data** if necessary **with suitable justifications.

***SYMBOLS** should be **properly described** along with the **necessary SKETCHES** whenever applicable.*

Answer any FIVE QUESTIONS.

All the parts of a question** must be **answered together.

1. (i) Define fluid machinery and discuss its classification based on a) direction of energy conversion, b) principle of operation, and c) type of fluid used. Provide examples for each type.

   (ii) With necessary assumptions and sketch, derive the one dimensional Euler's equation of turbomachinery.

   [(1+3+3+3)+10]

2. (i) Obtain the wheel or bucket efficiency of a Pelton turbine through appropriate analysis. Under what conditions the wheel efficiency of the turbine will become maximum?

   (ii) A double jet Pelton wheel has a specific speed of 14 and is required to deliver 1000kW. The turbine is supplied through a pipeline from a reservoir whose level is 400m above the nozzles. Allowing 5% for friction loss in the pipe, calculate (a) speed in rpm, (b) diameter of the jets, and (c) mean diameter of the bucket circle. Take Cv = 0.98, Speed ratio = 0.46 and overall efficiency = 85%.

   [(10+2)+8]

3. (i) Sketch a layout of a typical reaction turbine installation with proper labeling and obtain the difference in head across the turbine.

   (ii) What is the role of inlet guide vanes or wicket gates in the working of a reaction turbine?

   (ii) With the help of a neat velocity vector diagram for a Francis runner, find the expression of Power transmitted to the shaft by the water. All notations in the velocity diagram have to be clearly defined.

   [(6+4)+2+(4+4)]

4. (i) A Francis turbine discharges 4 m3/s under a total head of 100m. The outer diameter of the rotor is 1.25m and its rotational speed is 35 rad/s. The absolute water velocity leaving the stationery inlet gates (wicket gates) makes an angle of 0.35 rad with the tangential velocity. The area perpendicular to this absolute velocity is 0.15 m2. Assuming that the absolute velocity leaving the rotor is in the radial direction, determine the torque and power applied to the turbine shaft. What is the hydraulic efficiency of the turbine?

   (ii) A Kaplan turbine develops 15000kW power at a head of 30m. The diameter of the boss is 0.35 times the diameter of the runner. Assuming a speed ratio of 2.0, a flow ratio of 0.65, and an overall efficiency of 90%, calculate the (i) diameter of the runner, (ii) rotational speed, and (iii) specific speed.

   [10+10]

[Turn over

5. (i) Draw a schematic of a general pumping system with proper labeling and obtain the expression of the manometric head.

(ii) A centrifugal pump impeller has an outer diameter of 30cm and an inner diameter of 15cm. The pump runs at 1200 rpm. The impeller vanes are set at a blade angle of 30° at the outlet. If the radial component of the velocity of flow is constant at 2.0 m/s, calculate a) the velocity and direction of water at the outlet, b) the head developed if the manometric efficiency is 0.85, and c) the blade angle at the inlet.

[(6+4)+(4+3+3)]

6. (i) Elaborating the working of a single-acting reciprocating pump, obtain a general expression of its acceleration head.

(ii) A single-acting reciprocating pump has a cylinder diameter of 15cm, stroke length of 30cm, and suction head of 2.5m. The diameter of the suction pipe is 5.0cm and the length is 5.0m. Assuming atmospheric pressure as 10.0m of water (abs) and vapor pressure as 2.0m of water (abs) determine the maximum speed at which the pump can be run without cavitation.

[(8+6)+6]

7. (i) Derive Froude efficiency for a propeller using slipstream and actuator disc theory. What will be the Froude efficiency of an aircraft before take-off?

(ii) An ideal wind turbine, 12 m diameter, operates at its maximum efficiency in a 14 m/s wind. If the air density is 1.235 kg/m^3 determine the thrust on the wind turbine, the air velocity through the disc, the mean pressures immediately in front of and behind the disc, and the shaft power developed.

[(10+2)+8]

8. Write short notes on the following. (ANY FOUR) **[5×4 = 20]**

i) Degree of reaction
ii) Surge Tank
iii) Cavitation in Centrifugal pump
iv) Jet Pump
v) Draft tubes
vi) Indicator diagram