Exercise Problems (for Steam Turbines)

Q1. The adiabatic enthalpy drop in a given stage of a multi-stage impulse turbine is 22.1 KJ/kg of steam. The nozzle outlet angle is 16^o, and the efficiency of the nozzle, defined as the ratio of the actual gain of kinetic energy in the nozzle to adiabatic heat drop, is 92%. The mean diameter of the blades is 1473.2 mm and the revolution per minutes is 1500. Given that the carry over factor ϕ is 0.88, and that the blades are equiangular (the blade velocity coefficient is 0.87). Calculate the steam velocity at the outlet from nozzles, blade angles, and gross stage efficiency.

Q2. The following particulars relate to a two row velocity compounded impulse wheel which forms a first stage of a combination turbine.

Steam velocity at nozzle outlet = 579.12m/s

Mean blade velocity = 115.82m/s

Nozzle outlet angle = 16^o

Outlet angle first row of moving blades = 18^o

Outlet angle fixed guide blades = 22^o

Outlet angle, second row of moving blades = 36^o

Steam flow rate = 2.4 kg/s

The ratio of the relative velocity at outlet to that at inlet is 0.84 for all blades. Determine for each row of moving blades the following

- The velocity of whirl
- The tangential thrust on blades
- The axial thrust on the blades
- The power developed

What is the efficiency of the wheel as a whole?

Q3. A velocity compounded impulse wheel has two rows of moving blades with a mean diameter of 711.2 mm. The speed of rotation is 3000rpm, the nozzle angle is 16^o and the estimated steam velocity at the nozzle outlet is 554.73m/s. The mass flow rate of the steam passing through the blades is 5.07 kg/s.

Assuming that the energy loss in each row of blades (moving and fixed) is 24% of the kinetic energy of the steam entering the blades and referred to as the relative velocity, and that the outlet angles of the blades are:

(1) first row of moving blades 18^o,

(2) intermediate guide blade 22^o,

(3) second row of moving blades is 38^0, draw the diagram of relative velocities and derive the following.

- Blade inlet angles
- Power developed in each row of blades
- Efficiency of the wheel as a whole

Q4. The following particulars refer to a stage of an impulse-reaction turbine.

Outlet angle of fixed blades = 20^o

Outlet angle of moving blades = 30^o

Radial height of fixed blades =100mm

Radial height of moving blades =100mm

Mean blade velocity = 138m/s

Ratio of blade speed to steam speed = 0.625

Specific volume of steam at fixed blade outlet =1.235 m^3/kg

Specific volume of steam at moving blade outlet =1.305 m^3/kg

Calculation the degree of reaction, the adiabatic heat drop in pair of blade rings, and the gross stage efficiency, given the following coefficients which may be assumed to be the same in both fixed and moving blades : $\eta_m = 0.9, \phi = 0.86.$

Q5. Steam flows into the nozzles of a turbine stage from the blades of preceding stage with a velocity of 100m/s and issues from the nozzles with a velocity of 325 m/s at angle of 20^o to the wheel plane. Calculate the gross stage efficiency for the following data:

Mean blade velocity=180m/s

Expansion efficiency for nozzles and blades = 0.9

Carry over factor for nozzles and blades = 0.9

Degree of reaction = 0.26

Blade outlet angle = 28^o