ME433, hw 2, due Thu. 7 July by 4:30pm

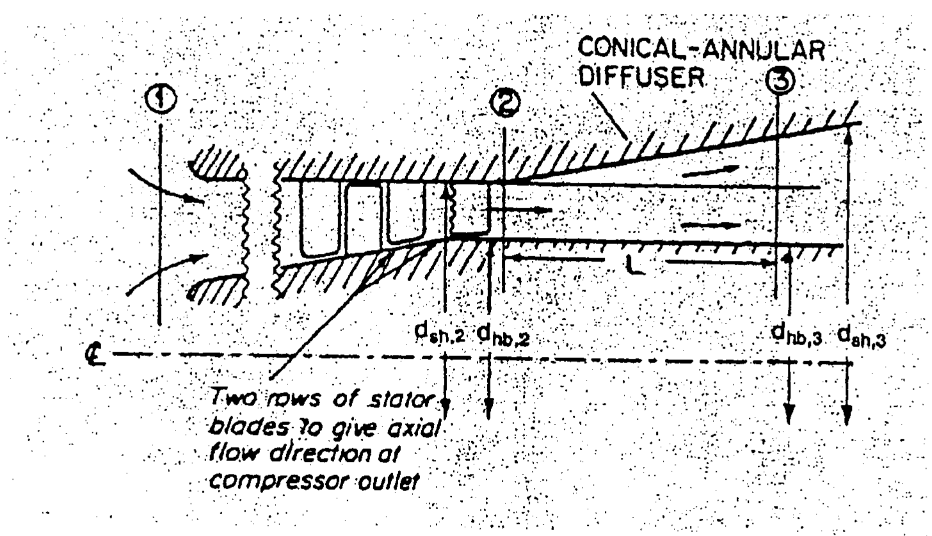
Problem 1: Axial compressor diffuser design

Design a conical-annular diffuser, shown diagrammatically below, for an axial compressor to have an ideal pressure rise coefficient Cp,i of 0.55.
The following data are specified:

mass flow, $\dot{m}$ =30 kg/s
Diffuser entrance stagnation pressure, P_{02}= 500 kPa
Diffuser entrance stagnation temperature, T_{02}= 450 K
Diffuser entrance velocity, C_2= 200 m/s
Diffuser stagnation pressure loss, $(P_{02} - P_{03}) = 0.1(P_{02} - P_2)$
Diffuser entrance hub/shroud diameter ratio, $d_{hb,2} / d_{sb,2} = 0.9$
$d_{hb,2} = d_{hb,3}$
$2L/(d_{sb,2} - d_{hb,2}) = 5$

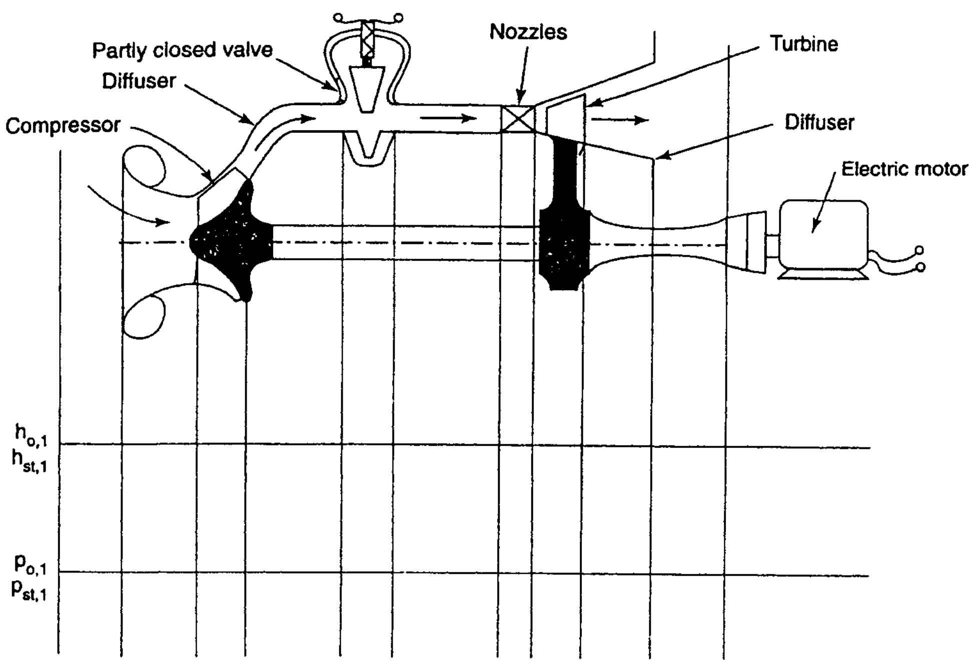
Assume the air is a perfect gas with γ (ratio of specific heat capacities) equal to 1.4.

a) Find the pressure rise coefficient $Cp = (P_3 - P_2) / (P_{02} - P_2)$
b) Find $d_{hb,2}$, $d_{sb,2}$, $d_{sb,3}$ for one-dimensional flow conditions.



Problem 2:

Draw lines approximating the changes of stagnation and static enthalpy and pressure through the compressor test rig shown diagrammatically below. The centrifugal compressor is driven by a motor and by the energy-recovery turbine, which expands the flow back to atmospheric pressure (as static pressure). A throttle valve is used to produce different back pressures on the compressor.



Stagnation and static pressure and enthalpy through a compressor test rig

Problem 3:

Calculate the rotor rotational speed, the static temperature and pressure at the nozzle exit, and the Mach number at that point, of a radial-inward-flow turbine expander of nozzle-outlet diameter (surface 1) of 250 mm. As an approximation, take this as the rotor-inlet diameter also. The nozzle-exit direction of the flow is 75° from the radial direction, and the axial height of the blade passage is 10% of the rotor diameter.
The turbine nozzles are supplied with 2 kg/s of air at 2 bars stagnation pressure and 125°C stagnation temperature. The rotor peripheral speed is 90% of the tangential velocity of the air at nozzle exit. The stagnation pressure losses of the flow through the nozzles are small enough to be neglected.
Sketch the nozzle expansion on a temperature-entropy diagram.