AE 311A (Compressible Aerodynamics)

Additional Problems on Rayleigh Flow (Assignment 3 Continued) – Due Oct 01, 2019

Problem 1:

Show that for a constant area, frictionless, steady, one-dimensional flow of a perfect gas, the maximum amount of heat that can be added to the system is given by the expression

$$\frac{q_{max}}{C_p T_1} = \frac{(M_1^2 - 1)^2}{2M_1^2(\gamma + 1)}$$

Problem 2:

At some point in a flow system of air in a duct $M_1 = 3.0$, $T_{o1} = 600$ K and $p_1 = 3$ atm. At a section farther along in the duct, the Mach number has been reduced to $M_2 = 1.5$ by heat transfer.

a) Find the static and stagnation temperatures and pressures at the downstream section.
b) Determine the direction and amount of heat transfer that took place between these two sections.

Problem 3:

Air enters a 15 cm diameter duct with a velocity of 120 m/s. The pressure is 1 atm and the temperature is 100°C.

a) How much heat must be added to the flow to create the maximum static temperature?
b) Determine the final temperature and pressure for the conditions of part (a).

Problem 4:

Air enters a converging diverging nozzle with stagnation conditions of 35×10^5 N/m^2 and 450 K. The area ratio of the nozzle is 4. After passing through the nozzle, the flow enters a duct where heat is added. At the end of the duct there is a normal shock, after which the static temperature is found to be 560 K.

a) Draw a T-s diagram for the system.
b) Find the Mach number after the shock.
c) Determine the amount of heat added in the duct.