Consider a conic nozzle feeded by a tank containing air at temperature $T_0 = 1000\,K$ and pressure $p_0 = 3\,x\,10^5\,Pa$. The mass flow rate through the nozzle is $Q = 8\,kg/s$ and the Mach number at the exit section is $M_e = 3.95$.

1) Compute the values of the pressure and the temperature at the nozzle exit
2) Find the area of the throat the area of the exit section.
3) Find the different values of the pressure that identify different working regimes of the nozzle, in particular
   a) limit subsonic
   b) limit supersonic
   c) over-expanded

Consider a conic nozzle feed by a tank containing air at pressure $p_0 = 10^5\,Pa$ and temperature . $T_0 = 1000\,K$, with throat area $A_T = 0.01\,m^2$. Assume that a normal shock wave is present in the divergent at $A_s = 0.035\,m^2$. Find the flow conditions (pressure, temperature, speed of sound, total pressure) after the shock wave.

Solution

Es 1

$p_e = 2225\,Pa$ $T_e = 242.69\,K$ $A_e / A_T = 10.25$ $\rho^* = 0.663\,kg/m^3$ $T^* = 833.3\,K$
$a^* = 578.64\,m/s$ $A^* = 0.021\,m^2$ $A_e = 0.214\,m^2$

Working regimes:

a) $p_e = 299.48\,kPa$
b) $p_e = 2225\,Pa$
c) $p_e = 40\,kPa$

Es 2

$M_1 = 2.8$ $p_1 = 3684.8\,Pa$ $T_1 = 389.4\,K$ $a_1 = 395.6\,m/s$ $M_2 = 0.488$ $p_2 = 33\,kPa$
$T_2 = 954.5\,K$ $p_{02} = 38.95\,kPa$ $a_2 = 619.3\,m/s$