chamber pressure

So in the given condition we assume that the engine is in choked condition, ie mach no at throat = 1.

$\therefore$ Speed of sound at throat $= \sqrt{\frac{\gamma R_u (T)}{M_0}}$

$= \sqrt{\frac{1.2(8.314)(3300)}{0.026}} = 1{,}125 \ ms^{-2}$

now we assume the ambient temperature at the nozzle exit to be 30°C or 303K

$\therefore$ Speed of sound there $= 340.98 \ ms^{-1}$

$\therefore$ the M_e or exit mach no. $= 3.29$

now according to isoentropic flow analysis of the rocket engine we get the eq^n for chamber pressure as

$$\frac{P_c}{P_a} = \left[1 + \left(\frac{\gamma-1}{2}\right) M_e^2\right]^{\gamma/\gamma-1} \quad P_a = \text{ambient pressure}$$

$$P_c = \left[1 + (0.1)(3.29)^2\right]^{1.2/0.2} P_0$$

$$P_c = 81.54 P_0$$

assuming P_0 to be 1atm we get

$P_c = 81.54$ Atm or 8.154 MPa.

Thrust produced by the engine

$C_F = 1.6$

So as we have assumed that the flow is choked, we take

$$\dot{m} = \text{mass flow rate} = \frac{A p_t}{\sqrt{T_t}} \left(\sqrt{\frac{\gamma}{R}} \left(1 + \frac{\gamma-1}{2}\right)^{-(\gamma+1)/2(\gamma-1)}\right)$$

A = exit area.

No according to rocket propulsion element guidelines the

p_t = chamber stagnation pressure = 8.154 MPa.

PageWork

exit diameter should be 5 times the throat diameter :

$d_e = 0.2(5) = 1m$

$\therefore A_e = 3.14 \, m^2 \, (0.25) \, m^2 = 0.7850 \, m^2$

A_t = nozzle throat area $= 3.14 \, (0.1)^2 = 0.0314 \, m^2$

$$\therefore \dot{m} = \frac{(0.0314)(8.154 \times 10^6)}{\sqrt{319.76 \times 3300}} \left[1.2 \left(\frac{2}{2.2} \right)^{\frac{2.2}{0.2}} \right]^{1/2}$$

$= 161.64 \, kg \, s^{-1}$

the exit velocity is given by

$$u_e = \left\{ \frac{2\gamma}{\gamma-1} \frac{R_u T}{M_w} \left[1 - \left(\frac{P_e}{P_c} \right)^{\gamma-1/\gamma} \right] \right\}^{1/2}$$

$P_e = 0.1 MPa$

$P_c = 8.154 MPa$

$= 2,565.52 \, ms^{-1}$

$\therefore$ thrust force is given as $F = C_F \times \rho \times A \times V^2$

The reference area A, is the exit area of the nozzle

$A_e = 0.7850 \, m^2$

ρ = density of ambient air

$F = 1.6 \times 1 kg m^{-3} \times 0.7850 \times (2565.52)^2$

$= 8.26$ MNewtons