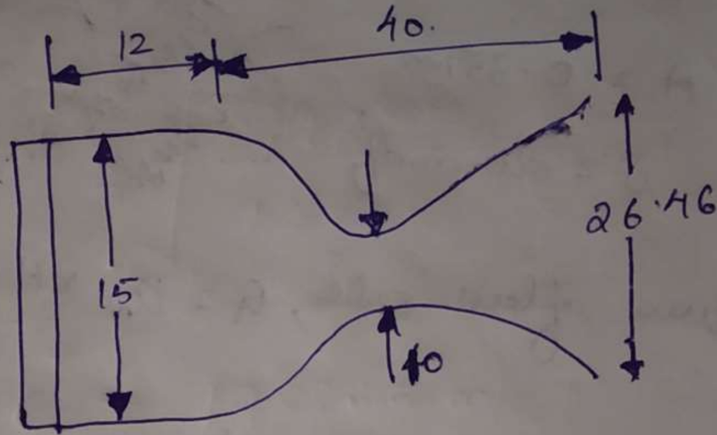
Answer

GIVEN DATA



(All dimensions are in cm)

Consider the following equation,

$$\frac{P_e}{P_c} = \left(1 + \frac{\gamma-1}{\gamma} M_e^2\right)^{\frac{-\gamma}{\gamma-1}}$$

(a) To find the thrust and specific impulse we can use the following equation,

$$F = \dot{m} V_e + A_e (P_e - P_a) \quad \longleftarrow (1)$$

$$I_{sp} = \frac{V_e}{g} + \frac{A_e}{\dot{m} g}(P_e - P_a) \quad (2)$$

Now, exit velocity,

$$V_e = \sqrt{\frac{2 \gamma R_u T_c}{M(\gamma - 1)}\left(1 - \left(\frac{P_e}{P_c}\right)^{\frac{\gamma-1}{\gamma}}\right)}$$

Pressure ratio, for gama, $\gamma = 1.2$ is, (from isentropic flow tables)

$$\frac{P_e}{P_c} = 0.02018$$

$$\therefore \quad V_e = \sqrt{\frac{2 \times 1.2 \times 8317 \times 3000}{15(1.2-1)}\left(1 - (0.02018)^{\frac{1.2-1}{1.2}}\right)}$$

[R_u = Gas Constant, T = 3000k given, M = 15 given]

$$\boxed{V_e = 3089.606 \text{ m/s}}$$

Now we need to find C^*

$$c^* = \sqrt{\frac{R_u T_c}{\gamma M}\left(\frac{2}{\gamma+1}\right)^{\frac{-(\gamma+1)}{2(\gamma-1)}}}$$

$$= \sqrt{\frac{8314 \times 3000}{1.2 \times 1.5}\left(\frac{2}{1.2+1}\right)^{\frac{1.2+1}{2(1.2-1)}}}$$

$$\boxed{c^* = 1988.55 \text{ m/s}}$$

Now, $\dot{m}$ (mass flow rate)

$$\dot{m} = \frac{P_c A_t}{c^*} = \frac{5 \times 10^6 \times \pi \times 0.5^2}{1988.55}$$

$$\boxed{\dot{m} = 19.748 \text{ kg/s}}$$

Now, we can find Specific Impulse ie, equation — 2

$$I_{sp} = \frac{V_e}{g} + \frac{A_e}{\dot{m} g}(P_e - P_a)$$

on substituting the values

$$I_{sp} = \frac{3089.606}{9.81} + \frac{\pi \times 0.1323^2}{19.748 \times 9.81}\left(5\times10^6 \times 0.02018 - 100900\right)$$

$$\boxed{I_{sp} = 314.824\ s}$$

Now, Thrust, equation (1)

$$F = 19.748 \times 3089.606 + \pi \times 0.1323^2 \left(5\times10^6 \times 0.02018 - 100900\right)$$

$$\boxed{F = 60978.21\ N}$$

So, The Nozzle is perfectly expanded as the exit and atmospheric pressure are nearly identical.

(b) Assume isentropic flow in the nozzle. The area ratio from chamber to throat is 2.25

Now Assume Subsonic flow, then from flow tables,

Mach number, $M = 0.28$

Pressure ratio, $\frac{P_t}{P} = 1.05$

Temperature ratio, $\frac{T_t}{T} = 1.01$

So, we know Actual Stagnation pressure in the chamber is,

$$P_{tc} = P_c \times \frac{P_t}{P} = 5 \times 1.05 = 5.25 \text{MPa}$$

Similarly stagnation Temperature,

$$T_{tc} = T_c \times \frac{T_t}{T} = 3000 \times 1.01 = 3030 K$$

Repeat the same analysis done in part (a) we can find

$$\boxed{F = 60989.3\,N}$$

So, there is only 11.1 N difference.

Likes: 0 **Dislikes: 0**