$$\frac{d\rho}{\rho} + \frac{du}{u} + \frac{dA}{A} = 0$$

$$\frac{dp}{\rho} + u\,du = -\frac{\tau_w \mathcal{C}\, dx}{\rho A} + G\left(\frac{1}{\eta} - 1\right)$$

$$c_p\,dT + u\,du = \delta q_{conv} + G(1/\eta)\left(\frac{1}{\eta} - 1\right)$$

$$\frac{dp}{p} = \frac{d\rho}{\rho} + \frac{dT}{T}$$

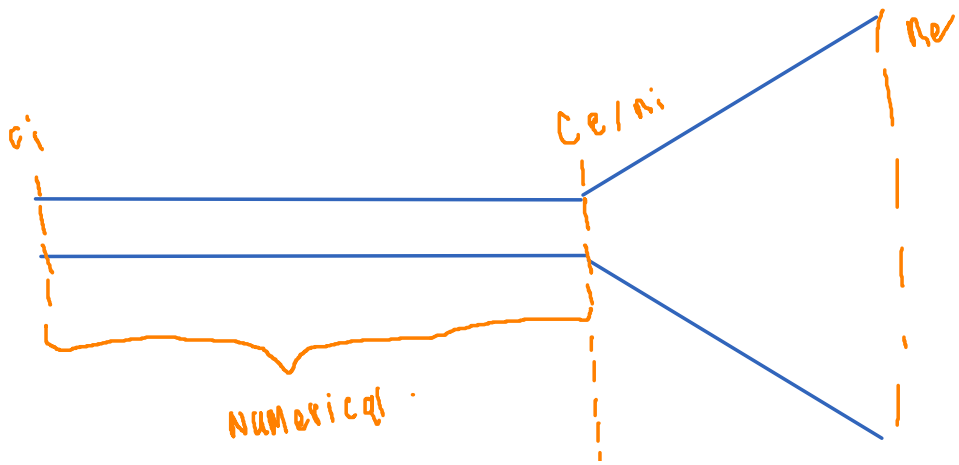
$$\dot{m}\left[G(1/\eta)\left(\frac{1}{\eta} - 1\right)\right] = \frac{Bu}{\eta} h \times j_w dx$$

$$\frac{\delta q_{conv}}{c_p T_t} = \frac{N_{St}(T_w - T_t)}{T_t}\,\frac{C}{A}\,dx$$

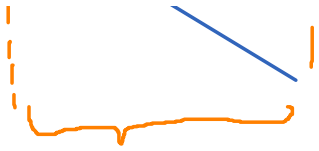
$$\delta q_{conv} = \frac{c_p c_f (T_w - T_t)}{2}\,\frac{C}{A}\,dx \qquad 2 c_p C_f (T_w - T_\infty)\,\frac{\pi D}{\left(\frac{\pi D^2}{4}\right)}$$

$$\frac{A_2}{A_1} G(M_1^2)$$

$$G(M_1^2) = \frac{1}{M_1}\left[\frac{2}{\gamma+1}\left(1 + \frac{\gamma-1}{2} M_1^2\right)\right]^{\frac{\gamma+1}{2(\gamma-1)}} = 1.16$$



numerical



analytical

$M_{ci} = 1.2$

$p_{ci} = 100\ kpa$

$T_{ci} = 320\ k$

$T_w = 220\ k$

$C_f = .002$

$A = .0625\ m^2$

$l = 1\ m$

$\frac{A_{re}}{A_{ni}} = 100$

$M_L = 500\ kg$

$$T_{+ci} = T_{ci}\left[1 + \frac{\gamma - 1}{2} M_{ci}^2\right] = 412.16\ K$$

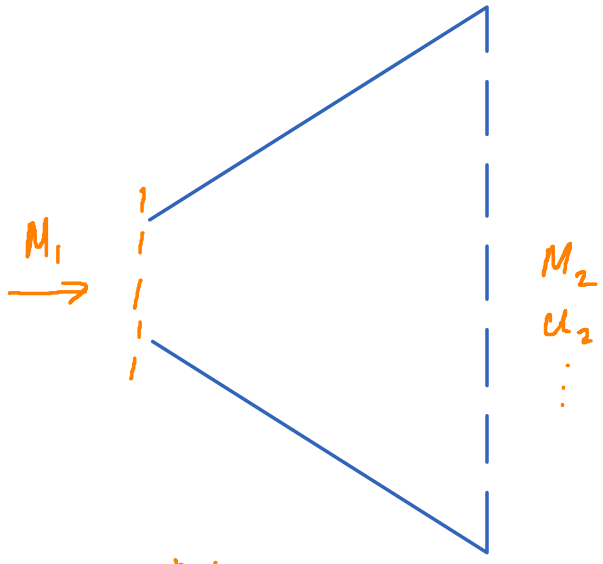
$$p_{+ci} = 242496\ N/m^2$$

$$\dot{m} = \frac{p}{RT} M \sqrt{\gamma R T}\, A = 0.308957\ kg/s$$

code

- $H_{ce} =$ 9388.87620582454
- $M_{ce} =$ 3.93814387583594
- $T_{ce} =$ 984.219759850445
- $T_+ =$ 4037.06812031099
- $P =$ 53447.7580351589
- $P_+ =$ 7470307.59327561

$$G(M_1)^2 \frac{A_{ue}}{A_{ce}} = G(M_2^2)$$



$$G(M_1^2) = M_1^{-1}\left[\frac{2}{\gamma+1}\left(1+\frac{\gamma-1}{2}M_1^2\right)\right]^{\frac{\gamma+1}{2(\gamma-1)}} = 10.1411376183559$$

$$\Rightarrow G(M_2^2) = 1014.11376183559 \Rightarrow M_2 = 11.4375817247634$$

$$T_2 = \frac{T_+}{\left(1+\frac{\gamma-1}{2}M_2^2\right)} = \frac{4037.06812031099}{1+.2\,M_2^2} = 148.620210102\ \text{K}$$

$$P_2 = \frac{P_+}{\left(1+\frac{\gamma-1}{2}M_2^2\right)^{\gamma/\gamma-1}} = 71.5121369045636\ \text{pa}$$

$$u_2 = M\sqrt{\gamma R T_2} = 10596.1754148476$$

$$\text{Thrust} = \dot{m}u_e + P_e A_e = 0.309057107275532*10596.1754148476+71.5121369045636*.05*.05 = 3275.002102239171\ \text{N}$$

$$I_{sp} = \frac{C}{g_0}\ ;\ C \cong u_e \Rightarrow I_{sp} = 10596.1754148476/9.81 = 1080.1402053871\ \text{sec}$$

$$m_F = m_e + m_L$$

$$m_e = 4976.64\ \text{kg}$$

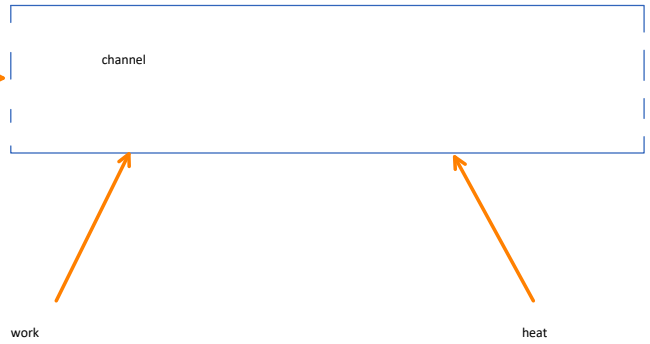
$$m_0 \Rightarrow \Delta V = V_e \ln\frac{m_F + m_p}{m_F}$$

$$m_0 = m_p + m_p$$

$$\left(e^{\frac{\Delta V}{V_e}}\right) \times m_F - m_F = m_p = 8595.94403928879\ \text{kg}$$

$$\dot{m}(h_2 - h_1) = W_{elec} + Q$$

$\dot{m}(h_2 - h_1) = W_{elec} + Q$



$\delta W = V\dot{I}$

$W = \int_0^t \delta W \Rightarrow$ 16593873.561485 W = 16593.873561485 kW

$\dot{m} C_p (T_{+2} - T_{+1}) =$ 0.309057107275532*14437.5(4037.06812031099-412.16)= 16169120.6650134 W =16169.1206650134 kW

$-W + \dot{m}(h_{+2} - h_{+1}) = Q$ =16169120.6650134 -16593873.561485 = --424752.896471599 W = -424.752 kW

cooling