since mass is conserved

$$\rho_i V_c = \rho_{Lf} V_c + \rho_f \cancel{AL} \rightarrow V_{cyl}$$

$$1 = \frac{\rho_{cf}}{\rho_i} + \frac{\rho_f}{\rho_i} \frac{V_{cyl}}{V_c}$$

at final state in cylinder

$$P_f = \rho_f R T_{cyl\,f}$$

and in chamber

$$P_f = \rho_{cf} R T_{cf}$$

initial state in chamber is

$$P_i = \rho_i R T_i$$

$\Rightarrow$

$$\frac{P_f}{P_i} = \frac{\rho_f}{\rho_i} \frac{T_{cyl\,f}}{T_i} \qquad \frac{P_f}{P_i} = \frac{\rho_{cf}}{\rho_i} \frac{T_{cf}}{T_i}$$

want this