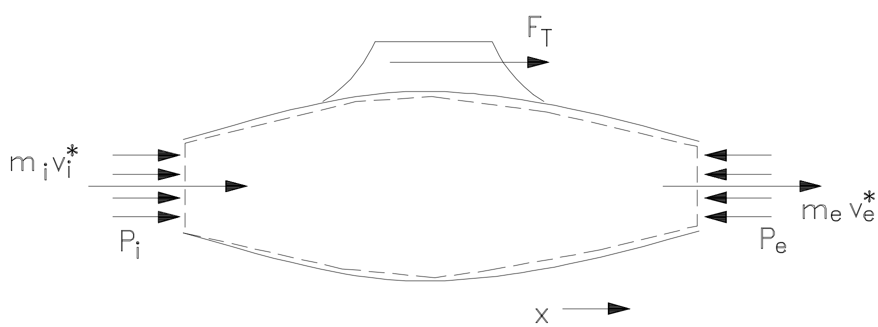
Week 9: Lecture 1

Gas Turbines for Aircraft Propulsion

- gas turbines are well suited to aircraft propulsion because of their favorable power-to-weight ratio
- the exhaust pressure of the turbine will be greater than that of the surroundings
- since the gases leave at a high velocity, the change in momentum that the gas undergoes gives a thrust to the aircraft
- gases are expanded in the turbine to a pressure where the turbine work is just equal to the compressor work plus some auxiliary power for pumps and generators i.e. the net work output is zero
- typically operate at higher pressure ratios, often in the range of 10 to 25

Conservation of Momentum



$$\frac{d(Mom)_{x,cv}}{dt} = (Mom)_{x,in} - (Mom)_{x,out} + \sum F_x$$

for steady flow $\Rightarrow \dfrac{d}{dt} = 0$ and

$\dot{m}_{fuel} << \dot{m}_i \Rightarrow \dot{m}_i \approx \dot{m}_e$

Therefore

$$\begin{aligned} F_T &= \dot{m}_e v_e^* - \dot{m}_i v_i^* - \underbrace{P_{atm}(A_i - A_e)}_{negligible} \\ &= \dot{m}_i (v_e^* - v_i^*) \end{aligned}$$

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Specific Impulse: $I = \dfrac{F_T}{\dot{m}_i} = v_e^* - v_i^*$

Propulsive Power: $\dot{W}_T = F_T v_i^* \approx \dot{m}_i (v_e^* - v_i^*) v_i^*$

Propulsive Efficiency: $\eta = \dfrac{\dot{W}_T}{\dot{Q}_{in}}$

Since the net work output is zero, we must define the propulsive efficiency as propulsive power over the heat flow rate in the combustion process. This then becomes a measure of how efficiently the energy released during the combustion process is converted to propulsive energy.