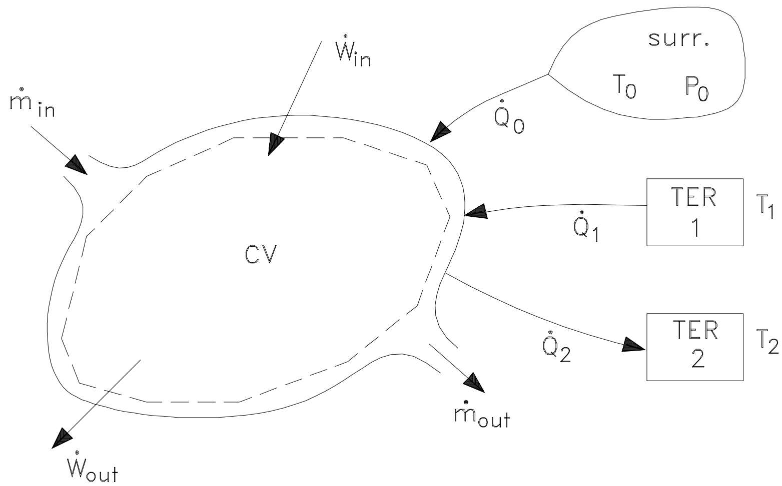
Week 3: Lecture 3

The General Exergy Equation



From the 1st law

$$\frac{dE_{cv}}{dt} = \dot{W}_{in} - \dot{W}_{out} + \dot{Q}_0 + \dot{Q}_1 - \dot{Q}_2 + [\dot{m}(e + Pv)]_{in} - [\dot{m}(e + Pv)]_{out}$$

From the 2nd law

$$\frac{dS_{cv}}{dt} = \left(\dot{m}s + \frac{\dot{Q}_0}{T_0} + \frac{\dot{Q}_1}{T_1}\right)_{in} - \left(\dot{m}s + \frac{\dot{Q}_2}{T_2}\right)_{out} + \dot{\mathcal{P}}_s$$

Which leads to the generalized exergy equation

$$\begin{aligned}\frac{d\Phi_{CV}}{dt} &= P_0\frac{dV_{CV}}{dt} + \left[\dot{W} + \dot{m}\psi + \dot{Q}\left(1 - \frac{T_0}{T_{TER}}\right)\right]_{in} \\ &\quad - \left[\dot{W} + \dot{m}\psi + \dot{Q}\left(1 - \frac{T_0}{T_{TER}}\right)\right]_{out} - \dot{I}\end{aligned}$$

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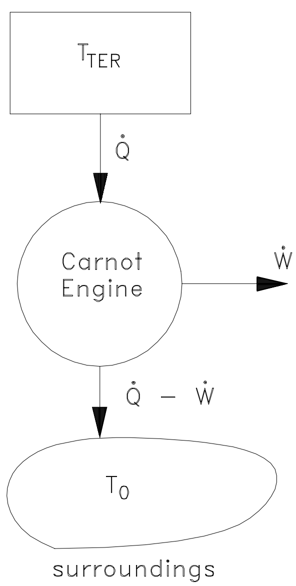
where

$$
\begin{aligned}
\dot{I} &= T_0 \dot{\mathcal{P}}_s = exergy\ destruction\ rate \\
\Phi_{CV} &= [(E - E_0) + P_0(V - V_0) - T_0(S - S_0)]_{CV} = nonflow\ exergy \\
\psi &= (h - h_0) - T_0(s - s_0) + \frac{1}{2}[(v^*)^2 - (v_0^*)^2] + g(z - z_0) = flow\ exergy \\
\dot{W}_{useful} &= \underbrace{(\dot{W}_{in} - \dot{W}_{out})}_{\dot{W}_{actual}} - \left(P_0 \frac{dV_{CV}}{dt} \right)
\end{aligned}
$$



Notice that:

$$\eta = \frac{\dot{W}}{\dot{Q}} = 1 - \frac{T_0}{T_{TER}}$$

Therefore

$$\dot{W} = \underbrace{\dot{Q}\left(1 - \frac{T_0}{T_{TER}}\right)}_{\text{appears in the general exergy equation}}$$

This term represents the work potential (exergy) of a given TER with respect to the surroundings (dead state) at T_0.