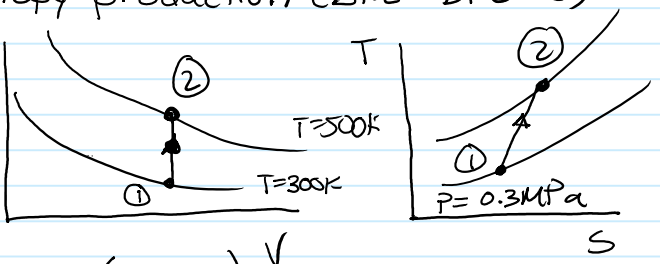
Entropy for Closed Systems Example

Given: 2kg of Air in a closed, rigid, insulated tank fitted with a paddle wheel
- $P_1 = 0.3$ MPa, $T_1 = 300$ K
- The air is stirred by the paddle wheel until $P_2 = 0.5$ MPa & $T_2 = 500$ K

Determine: The Work Done and the entropy production ($\Delta KE = \Delta PE = 0$)

State ①
$T_1 = 300$K

State ②
$T_2 = 500$K



$$\cancel{Q}^{\,0} - W = m(u_2 - u_1) \qquad W = -m(u_2 - u_1)$$

$$m(s_2 - s_1) = \int \frac{\cancel{\delta Q}^{\,0}}{T} + \sigma$$

$$s_2 - s_1 = \left(s_2^\circ - s_1^\circ\right) - R \ln\left(\frac{P_2}{P_1}\right)$$

T = 300K
$u_1 = 214.07$ kJ/kg
$s_1^\circ = 1.070203$ kJ/kg·K

T = 500K
$u_2 = 359.49$ kJ/kg
$s_2^\circ = 2.21952$ kJ/kg·K

$$W = -(2\text{kg})(359.49\ \text{kJ/kg} - 214.07\ \text{kJ/kg})$$

$$\boxed{W = -290.84\ \text{kJ}}$$

$$s_2 - s_1 = \left(2.21952\ \text{kJ/kg·K} - 1.070203\ \text{kJ/kg·K}\right) - \left(0.287\ \text{kJ/kg·K}\right)\ln\left(\frac{0.5\ \text{MPa}}{0.3\ \text{MPa}}\right)$$

$$s_2 - s_1 = 0.371\ \text{kJ/kg·K}$$

$$\sigma = m(s_2 - s_1) = (2\text{kg})(0.371\ \text{kJ/kg·K})$$

$$\boxed{\sigma = 0.742\ \text{kJ/K}}$$