**Problem # 11.2:**

Is an adiabatic expansion of air from 300 kPa (abs), 60°C, to 150 kPa (abs), 27°C, possible? Justify your answer. Show the process state points on a Ts diagram.

**Given :** Air at state (1) \( P_1 := 300 \text{ kPa (abs)} \quad T_1 := (60 + 273) \cdot K \)

expands to state (2) \( P_2 := 150 \text{ kPa (abs)} \quad T_2 := (27 + 273) \cdot K \)

**Find :** Is an adiabatic process possible? Justify.

**Solution :**

Basic equations

\[
T \cdot ds = dh - v \cdot dp
\]

**Assumptions :**

(1) Ideal gas

(2) Constant specific heats

From the second law, \( Tds \geq 0 \) for an adiabatic process. Thus process is possible if \( S_2 \geq S_1 \)

From the Tds equation,

\[
ds = \frac{1}{T} \cdot dh - \frac{1}{\rho \cdot T} \cdot dp = C_p \frac{dT}{T} - R \frac{dP}{P}
\]

Integrating,

\[
S_2 - S_1 = \int_{S_1}^{S_2} dS = C_p \int_{T_1}^{T_2} \frac{1}{T} \cdot dT - R \int_{P_1}^{P_2} \frac{1}{P} \cdot dP = C_p \ln \left( \frac{T_2}{T_1} \right) - R \ln \left( \frac{P_2}{P_1} \right)
\]

\[
\Delta S := C_p \ln \left( \frac{T_2}{T_1} \right) - R \ln \left( \frac{P_2}{P_1} \right)
\]

\[
\Delta S = 94.156 \frac{J}{kg \cdot K} > 0
\]

**Process is possible**