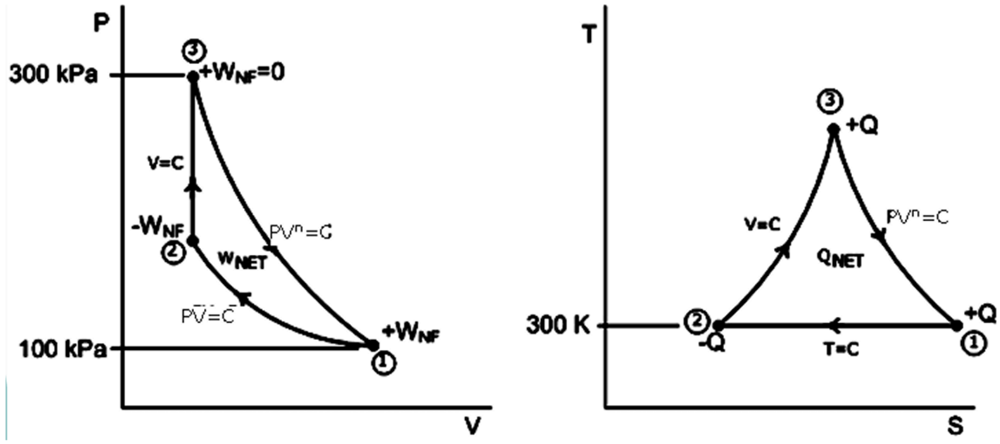

Step 1: **Isothermal Process (Process 1-2)** For an ideal gas undergoing an isothermal process, internal energy depends only on temperature (ΔU = 0). Therefore, according to the First Law of Thermodynamics, heat transfer exactly equals work done:

$$Q_{1-2} = W_{1-2} = \left(0.5\ \frac{kg}{s}\right)\left(-\ 74\frac{kJ}{kg}\right) = -\ 37\ kW$$

Step 2: Compute Isometric Heat Addition (Process 2-3)

Process 2-3 is a constant-volume (isometric) heat addition stage, meaning the final state achieves the maximum cycle pressure (P_3 = 300 kPa). Since State 3 connects back to State 1 via a polytropic path ($P_3V_3^n = P_1V_1^n$) and $V_3 = V_2$ due to the isometric path:

$$T_3 = T_1\left[\frac{P_3}{P_1}\right]^{\frac{n-1}{n}} = (300\ K)\left[\frac{300\ kPa}{100\ kPa}\right]^{\frac{1.3-1}{1.3}} = 386.5682\ K$$

The heat added at constant volume is:

$$Q_{1-2} = mC_v\left(T_3 - T_2\right) = \left(0.5\ \frac{kg}{s}\right)\left(0.7431\frac{kJ}{kg-K}\right)(386.5682\ -\ 300)K\ =\ 32.1644\ kW$$

Step 3: Compute Polytropic Expansion Heat Transfer (Process 3-1)

To determine the heat exchange during a polytropic process, we calculate the polytropic specific heat capacity (C_n). Using the secondary reference constants (C_v = 0.7442 kJ/kg-K and k = 1.399):

$$C_n = C_v\left[\frac{k-n}{1-n}\right] = \left(0.7431\frac{kJ}{kg-K}\right)\left[\frac{1.399-1.3}{1-1.3}\right] = -\ 0.2456\frac{kJ}{kg-K}$$

Now, we calculate the heat transfer for the expansion path from State 3 to State 1:

$$Q_{3-1} = mC_n\left(T_1 - T_3\right) = \left(0.5\ \frac{kg}{s}\right)\left(-\ 0.24561\frac{kJ}{kg-K}\right)(300\ \ -\ 386.5682)K\ =\ 10.6306\ kW$$

Step 4: Evaluate the Total Net Work Output (W_{NET})

Because a thermodynamic cycle operates in a closed loop, the net work output must exactly equal the net heat transfer across all process paths ($\Sigma W_{NET} = \Sigma Q_{NET}$):

$$\Sigma W_{NET} = \Sigma Q_{NET} = (-\ 37\ +\ 32.1644\ +\ 68.8089\ +\ 10.6306)\ kW\ =\ 5.795\ kW$$

The positive net work output of **5.795kW** confirms that this cycle functions as a net power producer (a heat engine). By balancing efficient isothermal compression (which keeps required work low) against high-temperature isometric heat addition, the system successfully extracts usable mechanical energy from the thermal inputs.