**HEAT ENGINE: EXAMPLE PROBLEM**

An automobile engine consumes fuel at a rate $\dot{V} = 22$ L/hr and delivers $\dot{W} = 55$ kW of power to the wheels. If the fuel has a heating value $q_{fuel} = 44,000$ kJ/kg and a density $\rho_{fuel} = 0.8$ g/cm$^3$:

1. Determine the thermal efficiency $\eta_{th}$ of this engine
2. Determine the rate at which heat is released to the environment ($\dot{Q}_L$)

**Device schematic**

1- **Thermal efficiency calculation**

- Thermal efficiency definition:

  \[ \eta_{th} = \frac{\dot{W}}{\dot{Q}_{in}} \]  

  \[ (1) \]

- Rate of heat supply:

  \[ \dot{Q}_{in} = \dot{V} \cdot q_{fuel} \cdot \rho_{fuel} \]

  \[ \dot{Q}_{in} = 22 \text{ L/hr} \times 44,000 \text{ kJ/kg} \times 0.8 \text{ g/cm}^3 \]

  \[ \Rightarrow \]

  \[ (2) \]

Substituting (2) into (1):

**Numerical application:**
2- Rate of heat waste

- System definition:

- 1\textsuperscript{st} law of thermodynamics:

  On a time rate basis:

  \[ \Rightarrow \]

Numerical application: