In a flow process, thermodynamics focuses on how energy, in the form of heat and work, interacts with a fluid moving through a system. This process is essential in many practical applications, such as turbines, compressors, heat exchangers, and nozzles. Understanding heat and work in flow processes is crucial for analyzing and designing such systems.

Heat and Work in Flow Processes

1. **Heat Transfer (QQQ) in Flow Processes:**
    - Heat is energy transferred due to a temperature difference between the system and its surroundings.
    - In flow processes, heat can be added to or removed from the fluid as it passes through the system.
    - The direction of heat transfer affects the fluid's enthalpy, internal energy, and temperature. For example, heating increases fluid energy, while cooling decreases it.

    Examples:

    - In a boiler, heat is added to water, turning it into steam.
    - In a condenser, heat is removed from steam, converting it back into water.
2. **Work (WWW) in Flow Processes:**
    - Work is energy transfer associated with forces acting through a distance. In flow systems, work is typically done by or on the fluid as it moves through devices like pumps, compressors, and turbines.
    - **Flow Work or Flow Energy** (PvP vPv): It is the work required to push the fluid into or out of a control volume, where PPP is the pressure and vvv is the specific volume. This work is inherently included in the enthalpy term.
    - **Shaft Work**: Work done by moving parts like pistons, turbines, or compressors on the fluid.
    - Unlike heat, work depends on the path taken and is not solely determined by the initial and final states of the system.

    Examples:

    - In a compressor, work is done on the fluid, increasing its pressure and enthalpy.
    - In a turbine, the fluid does work on the surroundings, producing mechanical energy.

First Law of Thermodynamics for a Flow Process (Steady-Flow Energy Equation)

The First Law for a steady-flow system relates heat, work, and changes in energy:

$$\dot{Q} - \dot{W} = \dot{m} \left(h_2 - h_1 + \frac{V_2^2 - V_1^2}{2} + g(z_2 - z_1) \right)$$

Where:

- $\dot{Q}$ = Rate of heat transfer to the system (kJ/s)

- W˙\dot{W}W˙ = Rate of work done by the system (kJ/s)
- m˙\dot{m}m˙ = Mass flow rate (kg/s)
- h1,h2h_1, h_2h1,h2 = Specific enthalpy at inlet and outlet (kJ/kg)
- V1,V2V_1, V_2V1,V2 = Fluid velocity at inlet and outlet (m/s)
- z1,z2z_1, z_2z1,z2 = Elevation at inlet and outlet (m)
- ggg = Gravitational acceleration (9.81 m/s2^22)

Applications

1. **Turbines:**
    - **Heat:** Minimal heat exchange is assumed; the primary energy interaction is through work.
    - **Work:** Fluid expands, converting thermal energy into shaft work.
2. **Compressors and Pumps:**
    - **Heat:** Often neglected, though some heat may be added due to friction.
    - **Work:** Work is done on the fluid to increase its pressure.
3. **Heat Exchangers:**
    - **Heat:** Primary interaction is heat exchange without work.
    - **Work:** No work is involved; energy is transferred solely by heat.