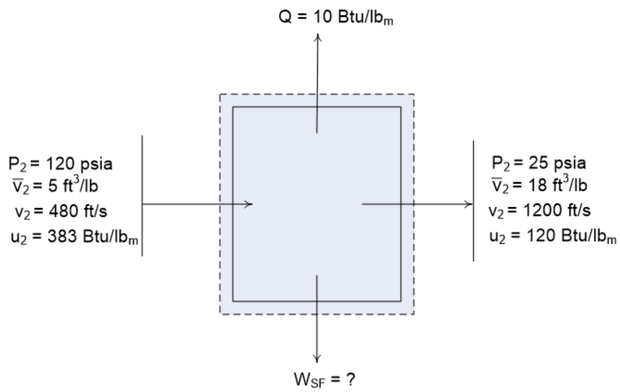
In engineering thermodynamics, evaluating an open thermodynamic device running under stable conditions requires the application of **The First Law of Thermodynamics for Open or Steady-Flow Systems**. This principle states that energy can neither be created nor destroyed; hence, the total energy carried into a control volume by a moving fluid mass must perfectly balance the total energy departing from the system plus or minus any heat and work exchanges with the surroundings.



To determine the work steady flow (W_{SF}) in this problem, we can apply the First Law of Thermodynamics for open or steady-flow systems.

$$\left[E_{in} = E_{out}\right]$$

$$KE_1 + U_1 + W_{f1} = W_{SF} + Q + KE_2 + U_2 + W_{f2}$$

$$-\ Q = W_{SF} + \Delta KE + \Delta U + \Delta W_f$$

For change in kinetic energy, ΔKE:

$$\frac{\Delta KE}{m} = \frac{1}{2g_c}\left(v_2^{\ 2} - v_1^{\ 2}\right) = \frac{1}{2\left(32.2\ \frac{lb_m - ft}{lb_f - sec^2}\right)}\left(1200^2 - 480^2\right)\frac{m^2}{sec^2} = 18,782.6087\ \frac{lb_f - ft}{lb_m}$$

Note: $1\ Btu = 778.169\ lb_f - ft$

$$\frac{\Delta KE}{m} = 24.1369\ \frac{Btu}{lb_m}$$

For change in work flow, ΔW_f:

$$\frac{\Delta W_f}{m} = \left(P_2 \underline{v}_2 - P_1 \underline{v}_1\right) = \left[\left(25\frac{lb_f}{in^2}\right)\left(18\frac{ft^3}{lb_m}\right) - \left(120\frac{lb_f}{in^2}\right)\left(5\frac{ft^3}{lb_m}\right)\right]\left(\frac{144\ in^2}{1\ ft^2}\right) = -\ 21,600\ \frac{lb_f - ft}{lb_m}$$

$$\frac{\Delta W_f}{m} = -\ 27.7575\ \frac{Btu}{lb_m}$$

For change in internal energy, Δu:

$$\frac{\Delta u}{m} = u_2 - u_1 = (120\ -\ 383)\frac{Btu}{lb_m} = -\ 263\frac{Btu}{lb_m}$$

Substitute values:

$$-\ 10\frac{Btu}{lb_m} = W_{SF} +\ 24.1369\ \frac{Btu}{lb_m} -\ 263\frac{Btu}{lb_m} -\ 27.7575\ \frac{Btu}{lb_m}$$

$$W_{SF} =\ 256.6206\ \frac{Btu}{lb_m}$$

Because the final value is **positive**, mechanical work is successfully **produced by the fluid system** on its surroundings.

In power plant operations, mechanical engineers minimize the heat radiation variable (Q) by packing the turbine housings with thick insulation blankets. Eliminating radiation loss keeps that energy inside the fluid stream, maximizing the conversion efficiency into usable shaft power (W_{SF})