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Uniform-State, Uniform-Flow Process (USUF)

The following assumptions lead to a useful model called the uniform-state, uniform-flow process (USUF).

- The control volume is stationary relative to some coordinate frame.
- The state of the mass may change at every point within the control volume (CV), but at any instant of time the state is uniform throughout the CV.
- The state of the mass crossing all areas of flow is constant with respect to the control surface, but the mass flow rates into and out of the control volume may vary with time.

The uniform state, uniform flow process is useful in the analysis of unsteady processes which involve rapid mixing within the control volume, eg, (a) filling of tanks, and (b) discharging from pressure vessels.

For this type of process we can write:

Continuity Equation
For a period of time $t_1 \leq t \leq t_2$:

$$M_{\mathrm{CV},2} - M_{\mathrm{CV},1} = M_{\mathrm{in},12} - M_{\mathrm{out},12}$$

First Law of Thermodynamics for Control Volume

For a period of time $t_1 \leq t \leq t_2$:

$$(M\,e)_{\mathrm{CV},2} - (M\,e)_{\mathrm{CV},1} = Q + W_{\mathrm{shaft}} + [M\,(e + P\,v)]_{\mathrm{in},12} - [M\,(e + P\,v)]_{\mathrm{out},12}$$

where

$$e = u + \frac{1}{2}\bar{V}^2 + g\,z$$

and

$$(M\,e)_{\mathrm{CV}} = M_{\mathrm{CV}}\,\left[u + \frac{1}{2}\bar{V}^2 + gz\right]_{\mathrm{CV}}$$