Transient Analysis

steady state => $\frac{d}{dt}(\cdots) = 0$

transient (aka not steady state, unsteady) => $\frac{d}{dt}(\cdots) \neq 0$

Conservation of Mass

$$\frac{dM_{CV}}{dt} = \sum_{in} \dot{m} - \sum_{out} \dot{m}$$

Integrating with respect to time…

$$\Delta M_{CV} = \sum_{in} m - \sum_{out} m$$

First Law of Thermodynamics

$$\frac{dE_{CV}}{dt} = \dot{Q}_{into\ CV} - \dot{W}_{\substack{by\ CV,other \\ than\ press}} + \sum_{in} \dot{m}(h + ke + pe) - \sum_{out} \dot{m}(h + ke + pe)$$

Integrating with respect to time, assuming specific total enthalpy terms at the inlets and outlets remain constant with time…

$$\Delta E_{CV} = Q_{into\ CV} - W_{\substack{by\ CV,other \\ than\ press}} + \sum_{in} m(h + ke + pe) - \sum_{out} m(h + ke + pe)$$