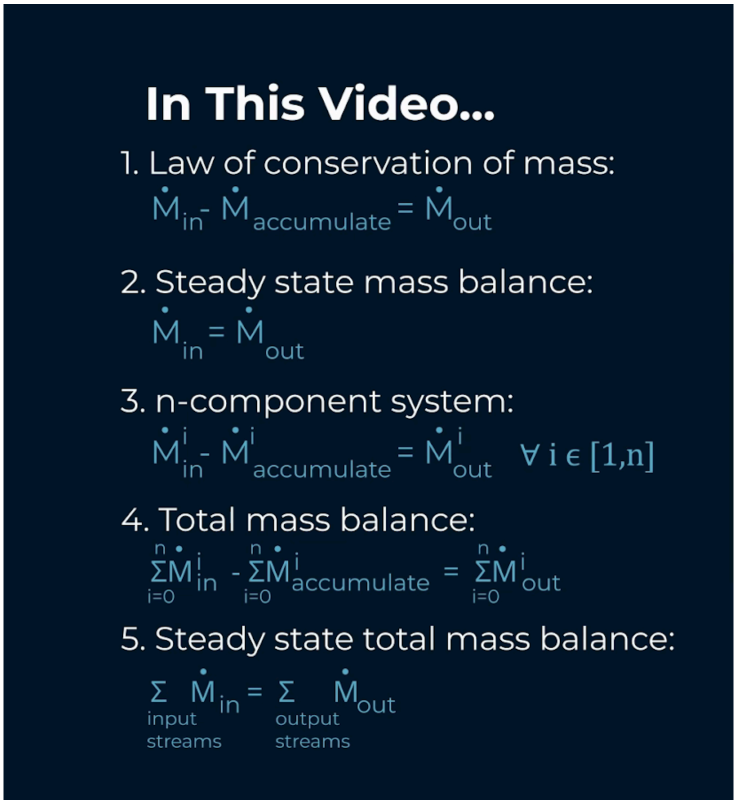
Material Balances

Video Series Notes & Cheatsheets

Part 1: Material Balance Made Easy | Basic Theory Explained

- Matter can neither be created nor destroyed
- Law of Conservation of Mass: M_{in}- $M_{accumulate}$ = M_{out}
- Accumulation:
  - Change in the mass contained inside the system
  - Can be negative if the system loses mass overall
- The mass balance equation we write depends on the state of the system at a given time:
  - The terms represent the TOTAL mass that has entered, left, or accumulated UP TILL the time of observation
  - Subtracting the mass balance equations at two different time instants gives the total change in the mass entering, leaving, or accumulating in the system
  - Dividing the total change by the time interval gives the average rate of change
  - At $\Delta t \rightarrow 0$: the average rate of change becomes the time derivative
- Mass flow rate balance:
  - Rate of mass entering the system - Rate of mass accumulating in the system = Rate of mass leaving the system
  - $(dM_{in} / dt) - (dM_{accumulate} / dt) = (dM_{out} / dt)$
- At steady state, the system does not change with time:
  - $M_{accumulate} = 0$
  - $dM_{accumulate} / dt = 0$
  - $(dM_{in} / dt) = (dM_{out} / dt)$
- The material balance equation (both total mass and mass flow rate forms) holds for:
  - Every component individually
  - Total system (i.e., the sum of all components)

Summary of equations derived:



Part 2: Solve EVERY Material Balance Problem that EVER Existed

- Conservation of Mass is always valid
- Number of equations must be equal to number of unknown variables to be able to solve the problem
- Mass can be expressed in the form of:
  - Count
  - Density
  - Moles
  - Concentration
    - Concentration = (quantity of one component) / (quantity of mixture)
- Additional relationships may come from:
  - Summing up composition fractions
  - Stoichiometry
  - Selectivity
  - Conversion
- Ensure consistency of:
  - Units within an equation
  - Basis within the whole system of equations
- Basis is a reference quantity to simplify calculations. It can be

    - Material quantity
    - Process time
    - System constraint
- Material transformations:

Type	Physical	Chemical
Examples	Melting ice, grinding salt, mixing paint, etc.	Burning wood, rusting, drying paint, etc.
Molecular Identity	Preserved	Changed
Mass Conserved	-Molecule type -Material form	-Atom type

- Transformations are accounted for in the multi-component material balance equations:
    - Mass of component ADDED - Mass of component accumulating = Mass of component REMOVED
    - [Mass of component entering + Mass of component formed] - Mass of component accumulating = [Mass of component leaving + Mass of component consumed]
- Synonymous terminologies:
    - Formation: produced, generated, released, created
    - Consumption: converted, reacted, absorbed, destroyed
- Complete Solution Strategy: