M1-4: Material and Energy Balance

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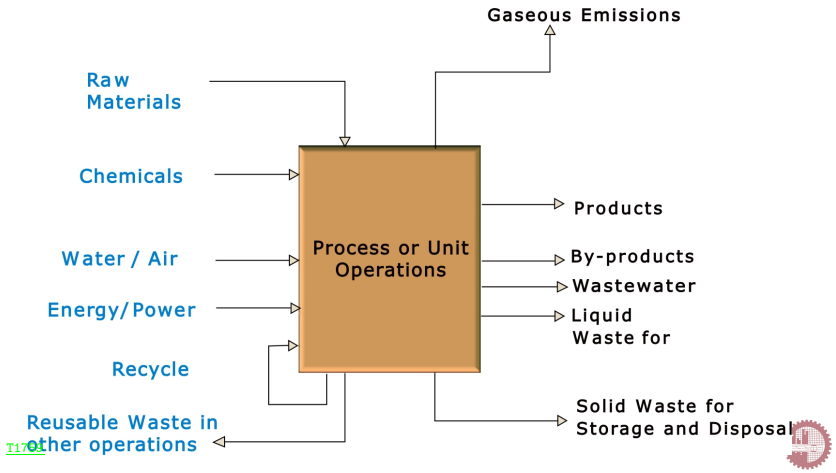
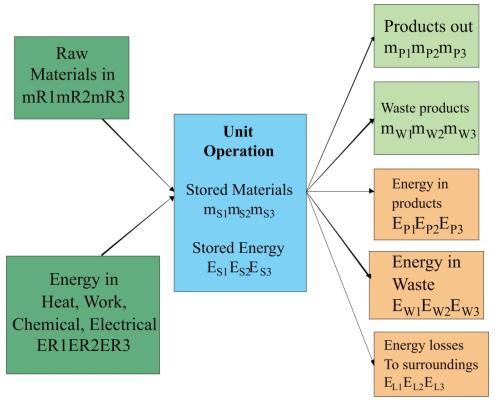
Capacity Development Training Program on
Energy Auditing and Energy Management

Components of Material & Energy Balance



T1762

Mass & Energy Balance

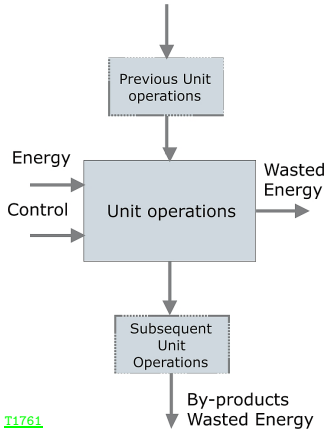


T1760

$$\sum m_R = \sum m_P + \sum m_W + \sum m_S$$

$$\sum E_R = \sum E_P + \sum E_W + \sum E_S + \sum E_L$$

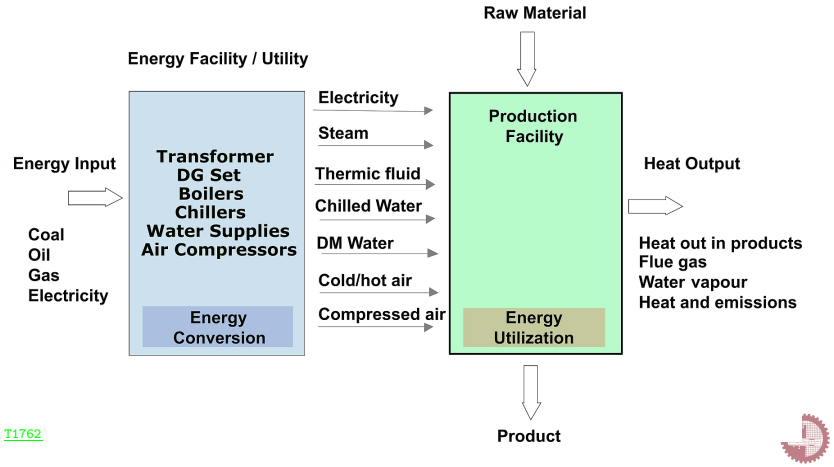
Classifications of Processes



T1761

1. Based on process variation with time
   1. Steady-state process
   2. Unsteady-state process
2. Based on how the process is designed to operate
   1. Continuous process
   2. Batch process

Typical Process Energy Systems



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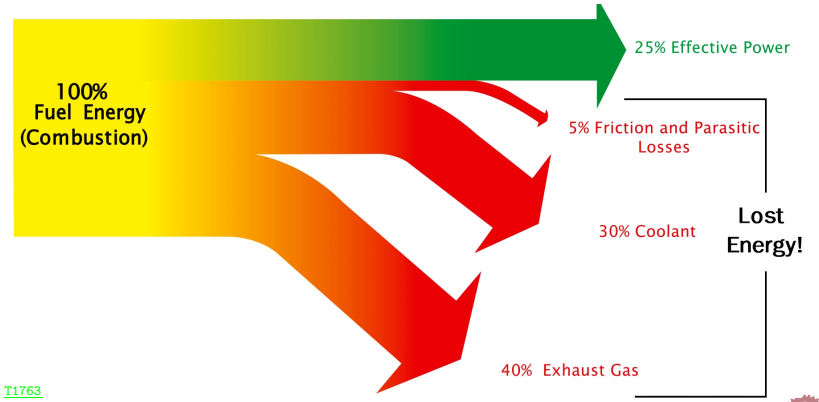
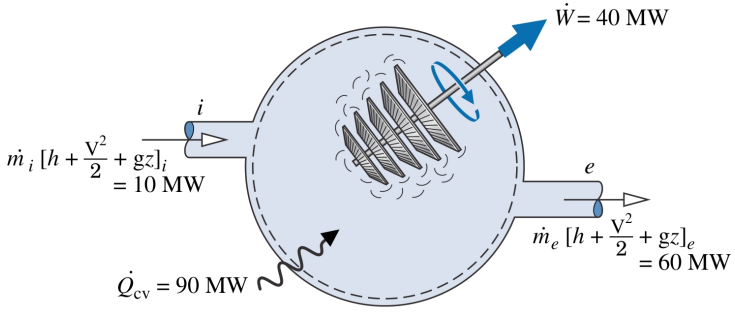
Energy Balance Diagram (Sankey Diagram)



T1763

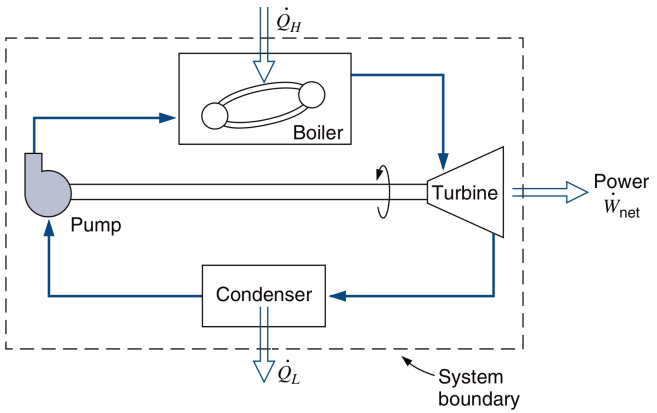
Typical Energy Balance



Energy In	Energy Out
90 MW (heat transfer)	40 MW (power)
10 MW (at inlet i)	60 MW (at exit e)
100 MW	100 MW

T1764

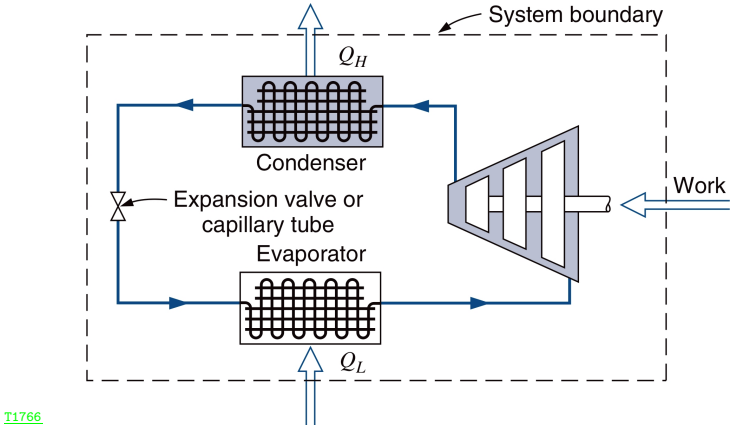
Typical Energy Balance: Power Plant



T1765

$$\dot{W}_{net} = \dot{Q}_H - \dot{Q}_L$$

Typical Energy Balance: Refrigeration/Air-conditioning



T1766

$$\dot{Q}_H = \dot{W}_{net} + \dot{Q}_L$$

A solution which is 80% oil, 15% usable by-products and 5% impurities, enters a refinery. One output is 92% oil and 6% usable by-products. The other output is 60% oil and flows at the rate of 1000 lit/hr assume no accumulation, percent by volume)

- *What is the flow rate of input?* [2666.7 l/hr]
- *What is the percent composition of the 1000 lit/hr output?* [60%,30%,10%]

In a textile mill, an evaporator concentrates a liquor containing solids of 6% by w/w (weight by weight) to produce an output containing 30% solids w/w. Calculate the evaporation of water per 100 kg of feed to evaporator?

[80kg]

A furnace shell has to be cooled from 90 °C to 55 °C. The mass of the furnace shell is 2 tonnes; the specific heat of furnace shell is 0.2 kcal/kg°C. Water is available at 28 °C. The maximum allowed increase in water temperature is 5 °C. Calculate the quantity of water required to cool the furnace. Neglect heat loss.

[2800 kg]

Production rate from a paper machine is 340 tonnes per day (TPD). Inlet and outlet dryness to paper machine is 40% and 95% respectively. Evaporated moisture temperature is 80 °C. To evaporate moisture, the steam is supplied at 35 kg/cm^2. Latent heat of steam at 35 kg/cm2 is 513 kcal/kg. Assume 24 hours/day operation a) Estimate the quantity of moisture to be evaporated b) Input steam quantity required for evaporation (per hour). Consider enthalpy of evaporated moisture as 632 kCal/kg.

[24 TPH]