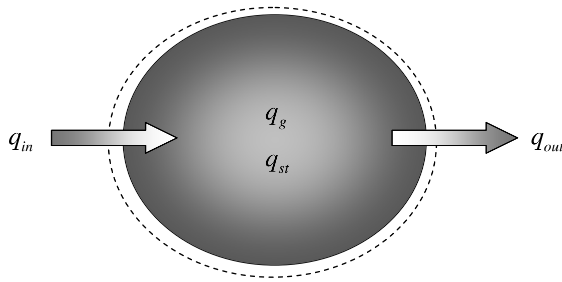
1.3 CONSERVATION OF ENERGY

control volume



energy balance:

$$q_{in} - q_{out} + q_g = q_{st}$$

V = *volume* $\left[m^3\right]$

ρ = *density* $\left[\frac{kg}{m^3}\right]$

c_p = *specific heat* $\left[\frac{J}{kg \cdot K}\right]$

k = *thermal conductivity* $\left[\frac{W}{m \cdot K}\right]$

$\alpha = \frac{k}{\rho c_p}$ *thermal diffusivity* $\left[\frac{m^2}{s}\right]$

q = *rate of heat transfer* $\left[W\right]$

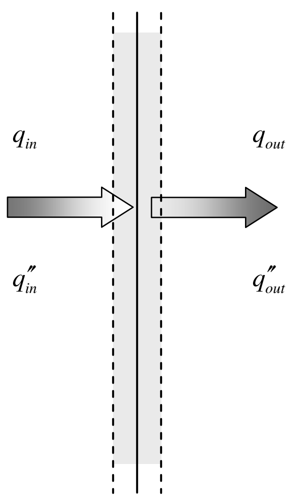
$q_g = \dot{q}V$ *rate of energy generation* $\left[W\right]$

$\dot{q}$ = *volumetric heat source* $\left[\frac{W}{m^3}\right]$

$$q_{st} = \rho c_p \frac{\partial T}{\partial t} V$$

rate of change of energy stored

control surface



energy balance:

$$q_{in} = q_{out}$$

$$q''_{in} = q''_{out}$$

Derivation of q_{st}

1st Law of Thermodynamics $\Rightarrow$ $\Delta Q - \cancel{W} = \Delta U$ $\left[J\right]$

change of internal energy is caused by heat transferred to a control volume during the process $\quad \Delta Q = \Delta U$

incompressible substance $\quad \Delta U = mc_p \Delta T$

Δt = *time of the process* $\quad \frac{\Delta Q}{\Delta t} = mc_p \frac{\Delta T}{\Delta t}$ $\left[\frac{J}{s}\right]$

take $\Delta t \rightarrow 0$ $\quad \dot{Q} = mc_p \frac{\partial T}{\partial t}$ $\left[W\right]$

denote $\dot{Q} \equiv q$ $\quad q = mc_p \frac{\partial T}{\partial t}$

$m = \rho V$ $\quad q = (\rho V) c_p \frac{\partial T}{\partial t}$