Fire Dynamics
Compartment fire phenomena II

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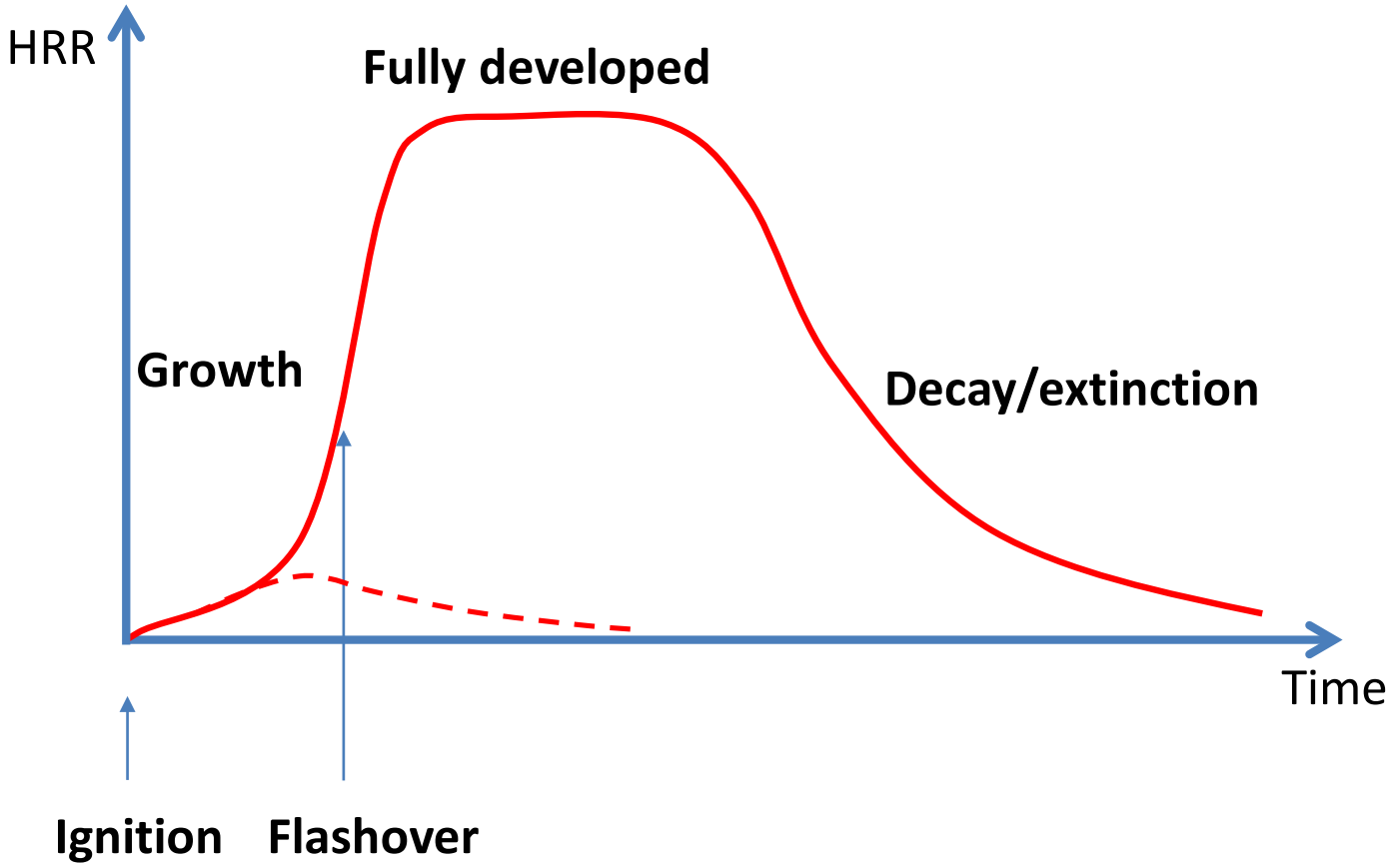
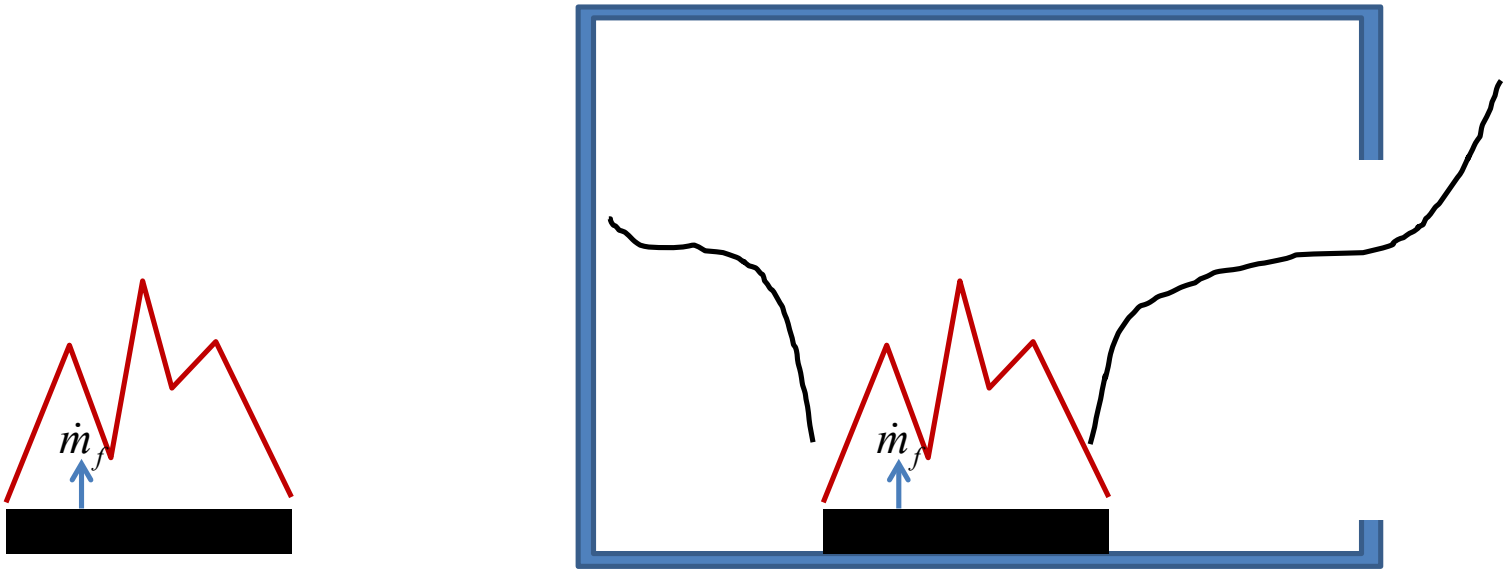
Objectives

- Understanding compartment fire phenomena
  - Burning rate

Compartment fire HRR curve



Free burn vs. compartment fire



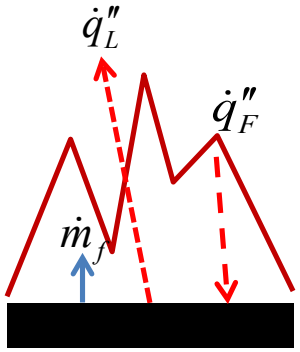
- Free burn fire (in an open space) vs. compartment fire

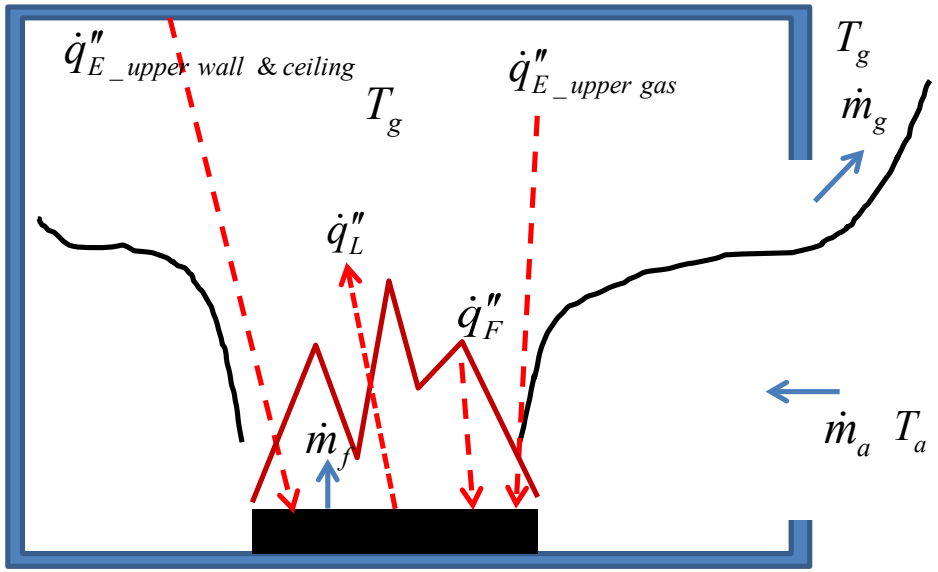
$A. \dot{m}_{f,free} < \dot{m}_{f,comp}$?

$B. \dot{m}_{f,free} \approx \dot{m}_{f,comp}$?

$C. \dot{m}_{f,free} > \dot{m}_{f,comp}$?

Free burn vs. compartment fire





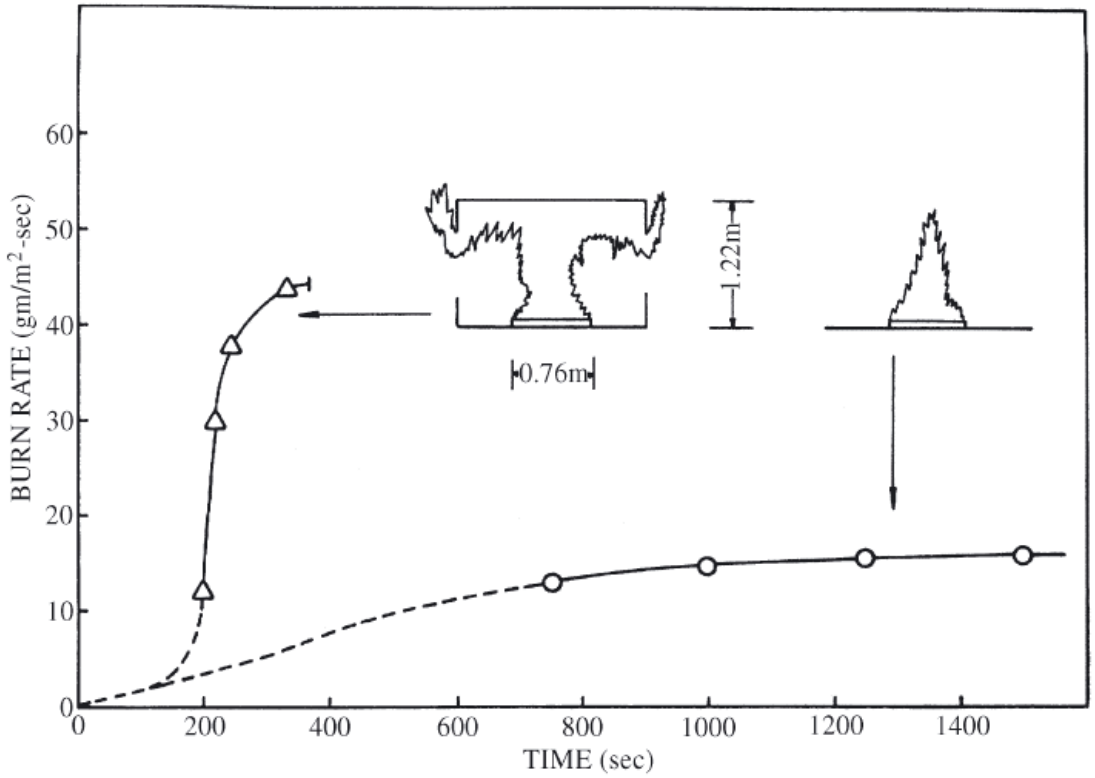
$$\dot{m}''_{f,free} = \frac{(\dot{q}''_F - \dot{q}''_L)}{\Delta H_{vap}}$$

$$\dot{m}''_{f,comp} = \frac{(\dot{q}''_{E\_upper\ wall\ \&\ ceiling} + \dot{q}''_{E\_upper\ gas} + \dot{q}''_F - \dot{q}''_L)}{\Delta H_{vap}}$$

ΔH_{vap} can be replaced with $\Delta H_{eff,gasification}$ for solids

Compartment effect on burning rate

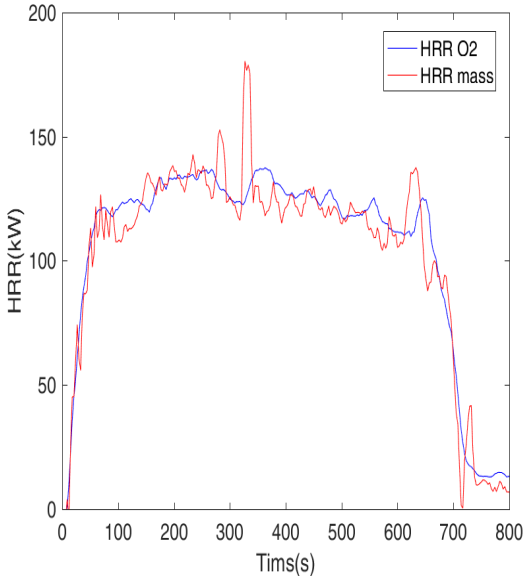
- $\dot{m}$_freeburn < $\dot{m}$_compartment ?

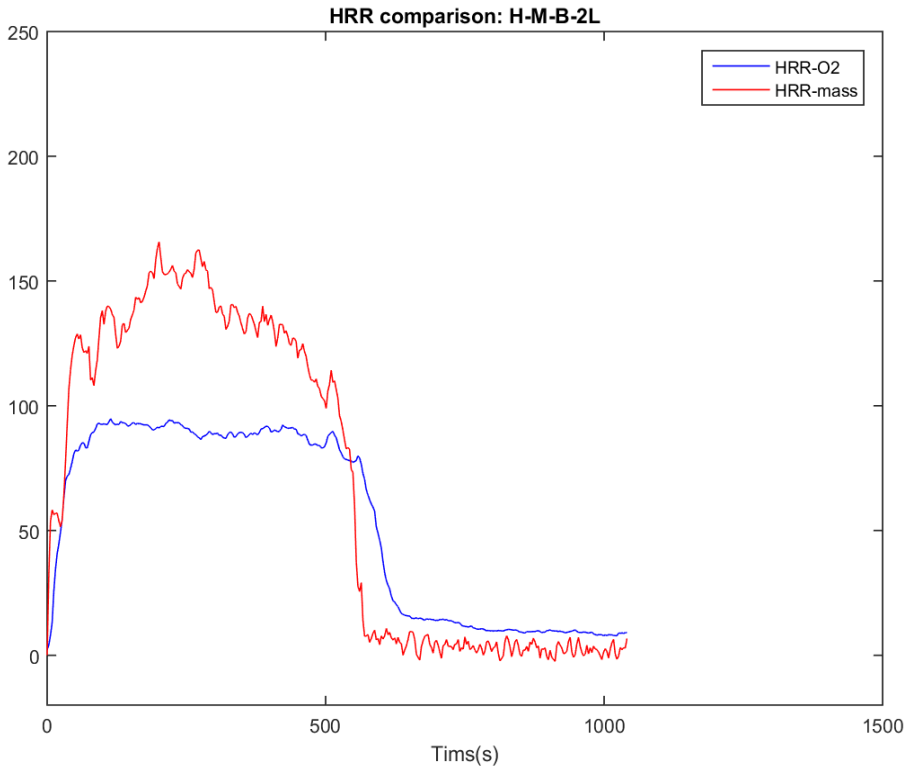


Friedman, R. (1975). 'Behavior of fires in compartments'. International Symposium on Fire Safety of Combustible Materials, pp.100-113, Edinburgh University

Compartment effect on burning rate

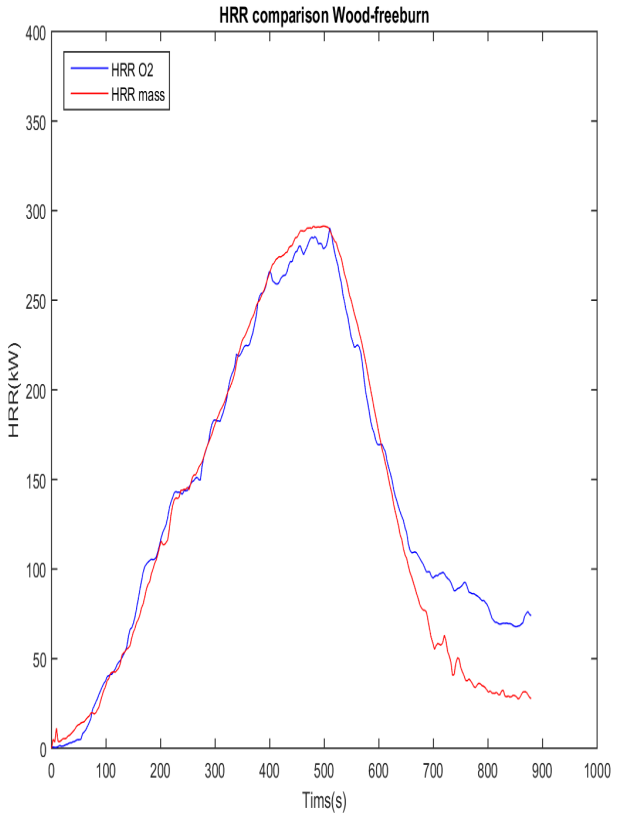
- $\dot{m}$_freeburn $\approx \dot{m}$_compartment ?

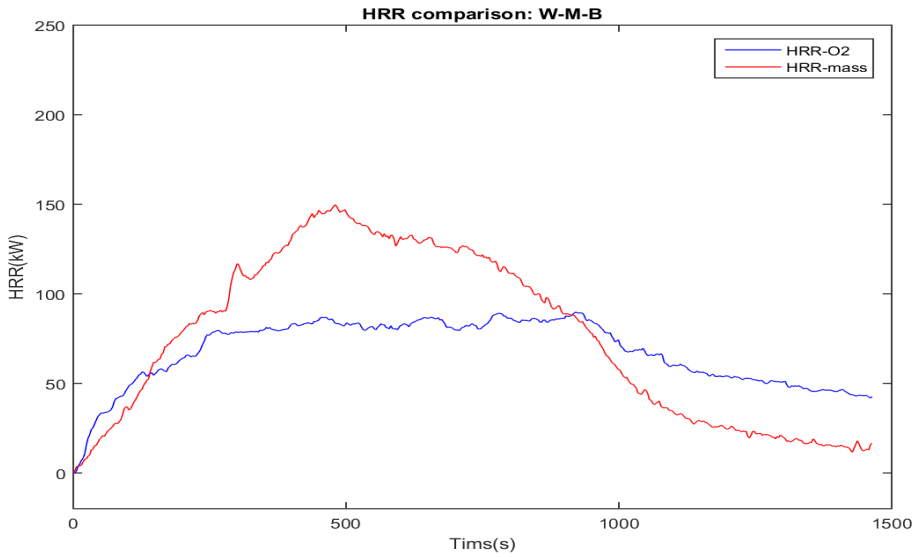




Compartment effect on burning rate

- $\dot{m}$_freeburn $>$ $\dot{m}$_compartment ?

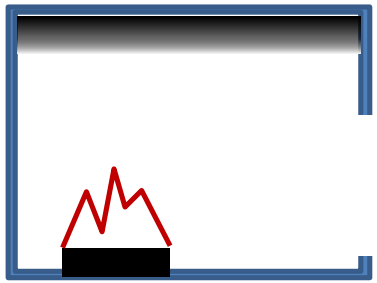




Fire development and burning rate

$$\dot{m}''_{f,free} = \frac{\dot{q}''_F}{\Delta H_{vap}} - \frac{\dot{q}''_L}{\Delta H_{vap}}$$

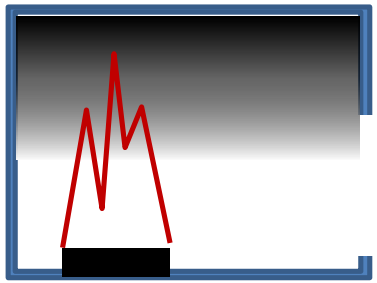
$$\dot{m}''_{f,comp} = \frac{\dot{q}''_{E\_upper\ wall\ \&\ ceiling}}{\Delta H_{vap}} + \frac{\dot{q}''_{E\_upper\ gas}}{\Delta H_{vap}} + \frac{\dot{q}''_F}{\Delta H_{vap}} - \frac{\dot{q}''_L}{\Delta H_{vap}}$$



$\dot{m}_{f,free} \approx \dot{m}_{f,comp}$

$\dot{m}_{f,free} < \dot{m}_{f,comp}$

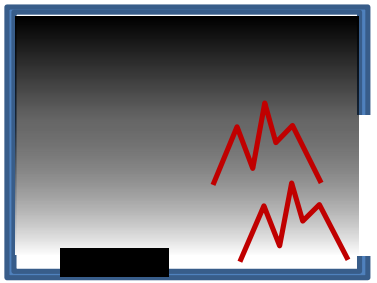
$\dot{m}_{f,free} > \dot{m}_{f,comp}$



$\dot{m}_{f,free} < \dot{m}_{f,comp}$

$\dot{m}_{f,free} \approx \dot{m}_{f,comp}$

$\dot{m}_{f,free} > \dot{m}_{f,comp}$



$\dot{m}_{f,free} > \dot{m}_{f,comp}$

$\dot{m}_{f,free} < \dot{m}_{f,comp}$

$\dot{m}_{f,free} \approx \dot{m}_{f,comp}$

Compartment fire HRR

$$HRR_{within\ compartment} = \Delta H_{c,a}\dot{m}_a \quad (\phi > 1)$$

$$= \Delta H_{c,f}\dot{m}_f \approx \Delta H_{c,a}\dot{m}_a \quad (\phi < 1)$$

$$\Delta H_{c,a} = 3 \text{ kJ/g}$$

$$\Delta H_{c,f} = \text{heat of combustion of fuel [kJ/g]}$$

$$\dot{m}_a = 0.5 A_o \sqrt{H_o}$$

$$HRR_{\max\ within\ compartment} = (3000)(0.5 A_o \sqrt{H_o}) = 1500 A_o \sqrt{H_o} \quad [kW]$$