Course Name: Theory of Fire Propagation (Fire Dynamics)

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Week – 01

Lecture – 05

Module 1 – Basics of Fires

Definitions related to fire (Ignition)

Fire is initiated by ignition of a material. Ignition occurs when the surface reached a minimum temperature called ignition temperature. From room temperature, the material has to be heated to its ignition temperature. For this a critical heat flux is required. Time taken for a material to be ignited depends on thermal inertia (ρ x k x c), heat of gasification, ignition temperature and product yield during pyrolysis. These parameters put-together is thermal response parameter.

Ignition is classified as piloted ignition and auto-ignition. Piloted ignition requires a minimum (critical) volume of a flammable reactant mixture and a minimum ignition energy. Auto-ignition occurs when the reactant mixture within flammability limits (proper proportions) is at its auto-ignition temperature. No external source is required for ignition. Phenomenon of auto-ignition can occur in a layer of combustible dust settled over a hot surface. Here, based on the thickness of the dust layer and the temperature of the hot surface, a temperature rise beyond the surface temperature is observed. This is referred to as spontaneous ignition. Auto-ignition of reactant mixtures present in confined space may lead to an explosion. Here, heat release causes an increase in both temperature as well as pressure. This scenario is also observed in compartment (room) fires, wherethe ventilation is much less. Simultaneous auto-ignition of several commodities in a compartment is referred to as flashover. Auto-ignition also causes a phenomenon called backdraft. This happens when hot fuel gases and vapors are suddenly exposed toa stream of air from atmosphere.

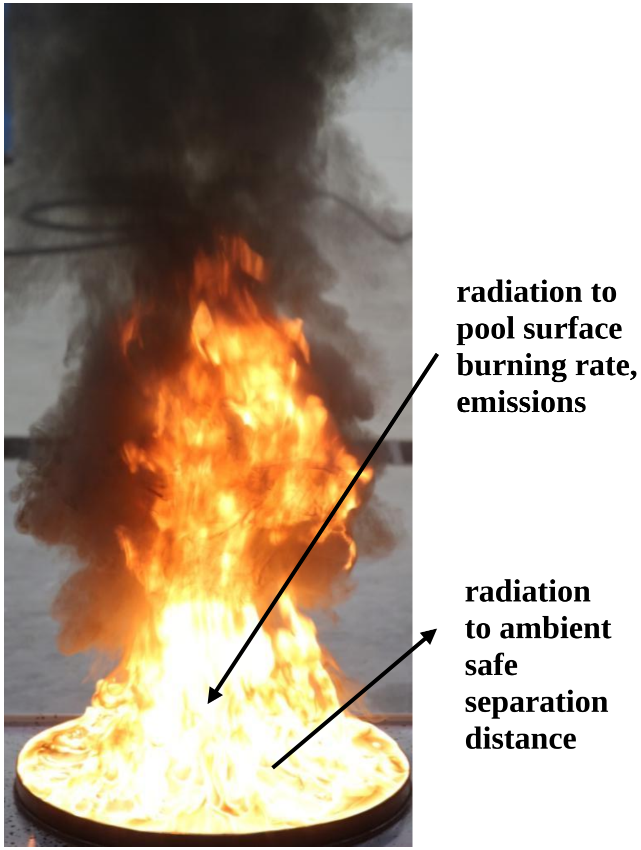
Definitions (Flame heat flux)

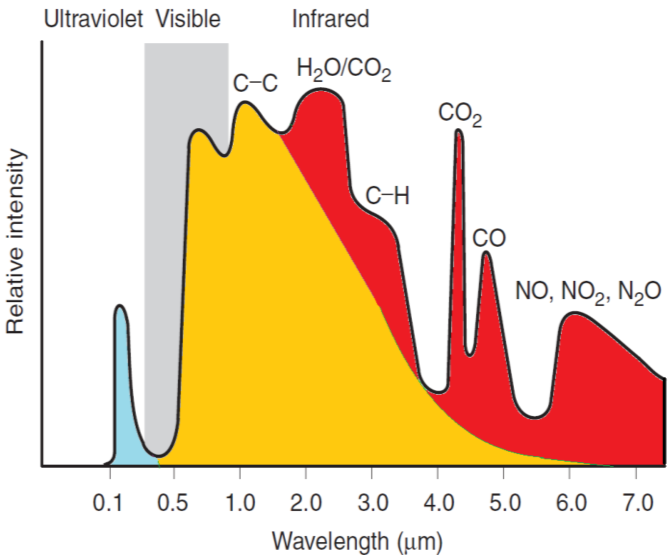
Once a flame is initiated over the fuel surface, a parameter called flame heat flux dictates its sustained burning. Flame heat flux is the fraction of heat transferred from the flame back to the surface.

Heat released from the flame per unit mass of the material pyrolyzed is called the heat of combustion. Part of this heat is transferred by the product gases during their transport, called convective heat flux, and a part is transferred from the flame (hot zone) by radiation, called radiative heat flux, calculated per unit area of the fire source. Surface receives the remaining heat by conduction, convection as well as radiation (depending upon the absorptivity of the surface).

The ratio of the heat released in fire from unit mass of material pyrolyzed to the heat required to pyrolyze unit mass of the materialis called heat release parameter.

Flame heat flux



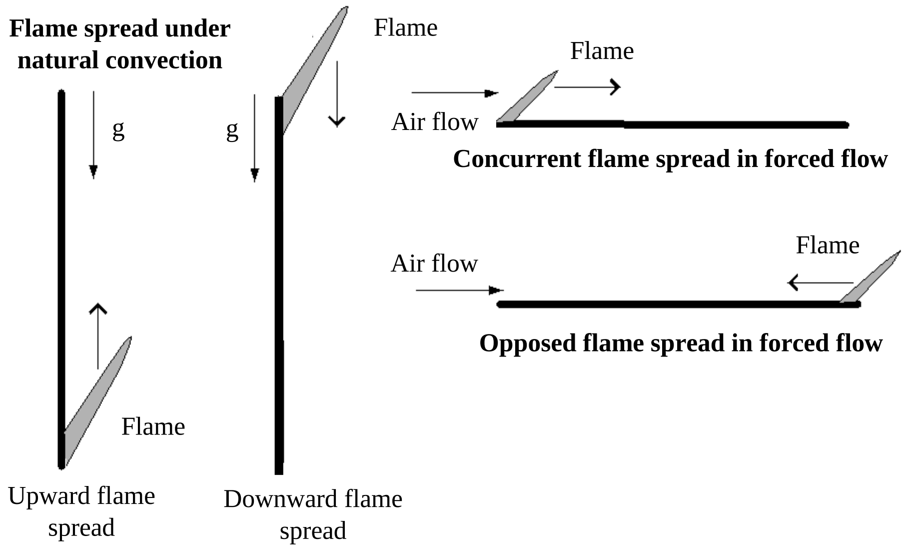


Definitions (Flame spread)

A flame forms on a material after ignition and this flame spreads over the material depending upon several factors. The extent of the flame and its rate of spread over the material is quantified by Flame Propagation Index (FPI). Higher the value of FPI higher is the flame spread rate over the material.

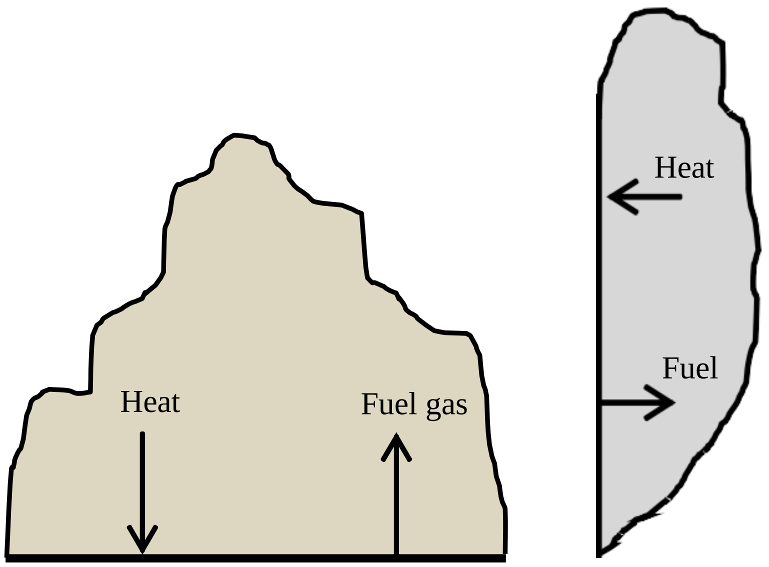
Ignition and flame spread also depend upon thickness of the material. A solid material is classified as thermally thin or thermally thick. If the temperature gradient within the solid is close to zero, it is called thermally thin, else it is thermally thick.

The flame spread rate depends on air flow direction, gravity vector, orientation of the material that is burning. It is classified as concurrent flame spread and opposed flame spread. Concurrent flame spread is rapid and unsteady. Opposed flame spread is usually gradual and steady.



Definitions (Mass burning rate)

Once a flame spreads over the entire surface of the material, depending upon several factors, the flame consumes the material almost steadily. This is called mass burning rate. Mass burning rate is dictated by the fuel thickness, gas-phase convection and heat loss, and material properties.



Steady burning of the liquid and the solid slabs