Course Name: Theory of Fire Propagation (Fire Dynamics)

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Week – 01

Lecture – 02

Module 1 – Basics of Fires

Fire Sources and classification

Wood (cellulose), polymers and fabrics are examples of common sources in domestic fires. Solvents, gases and flammable chemicals are examples of fire sources in industries, while wild (forest) fires are contributed by natural vegetation. Fires are classified as class A, B, C, D and K.

a) Class A fire occur from solid materials; wood, paper and other material that produces char (carbon and ash residue). When combustible solid is heated, moisture and volatiles (gases) are released. Volatiles have fuel components, which burn with air. A gas- phase flame forms over the solid fuel surface. Char is heated up, oxygen from ambient diffuses to the hot char surfaceand surface chemical reaction (char oxidation) occurs – smoldering. Class A fires can be quenched by cooling the fuel (water sprinkling).

b) Class B fires occur from liquid and gaseous fuels; solvents, flammable chemicals, alcohols and so on. When combustible liquid is heated, vapors are formed from its surface, once enough vapor forms and mixes with ambient

air, a gas-phase flame is established over the liquid surface. Flame supplies heat to the fuel pool surface for evaporation and fuel vapor feeds the flame – heat and mass transfer are coupled. Rate of burning of liquid pool depends upon the fuel volatility (how fast fuel can vaporize), ambient conditions and gas-phase convection. Fires from gaseous fuels are generally hazardous as additional rate limiting process such as gasification or evaporation is not present during their burning. Agents such as foams are used to quench liquid pool fires as seen in copper mines, which use kerosene pools as solvents. Agents those inhibit the chemical reaction are effectively used to quench fires from gas fuels.

c) Class C fires occur from energized electrical devices, such as electronic devices, computers, motors and transformers. Apart from fire hazards, electric shock and re-ignition of fire may occur as a result of electrical spark. Power is disconnected. Water cannot be used to quench electrical fires. Dry sand or powders, which are non-reactive with the metals, and non-conductive, are used to quench such fires.

d) Class D fires occur from combustible metals. Here, the heat release is quite intensive, with the flame temperature being more than 2000 °C. Class D fires are also quenched used dry sand or powders.

e) Class K: occurs from cooking oil, greases, animal and vegetable fats. These occur as a result of material heated up well above its fire point. Wet chemical agents such as potassium acetate or potassium carbonate are used to extinguish such fires.

Properties of combustible materials

Calorific value (J/kg): One of the important properties for all the combustible materials - heat released when one kg of the material is completely burnt.

Important thermo-physical properties: Thermal conductivity, k, (W/m-K), specific heat, c, (J/kg-K) and density, ρ kg/m^3). From these, two more properties are derived: thermal diffusivity - $k/(\rho c)$ and thermal inertia – ρkc.

Stoichiometric air: Quantity of air (in kg) required to burn one kg of the material completely.

Standard heat of combustion (J/kg-fuel): Heat released when one kg of combustible material from standard condition (1 atm, 298 K) is burnt completely using air and the products are cooled to 298 K. This is also same of calorific value; called lower calorific value when all the water in the product of combustion is in vapor-phase and called higher calorific value, if water is in liquid-phase. Heat of combustion is also written in terms of per kg of oxygen (J/kg-O_2) and are calculated based on the chemical composition of the fuel.