Course Name: Theory of Fire Propagation (Fire Dynamics)

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Week – 01

Lecture – 01

Module 1: Basics of Fires

Fire is a rapid exothermic oxidation reaction (combustion reaction) involving several types of fuels (solid, liquid and gas). Heat and toxic combustion products are released during a fire. It is generally turbulent in nature and predominantly consists of gas-phase reactions (in solid fuels, surface reactions may occur).

Fire occurs usually in non-premixed mode (as diffusion flames). The heat generated from the fire helps in gasifying solid and liquid fuels, and the air from the ambient provides necessary oxygen for the oxidation reaction. The reactants feed the fire (reaction zone) to continue the cycle. Hence, the heat release, the oxygen entrainment and the fuel availability are coupled, forming the main elements for the fire. The fire ceases to exist if one of the elements depletes.

The temperature variations in the fire zone create density differences, which alter the flow field due to the buoyancy force. Thus, in several fire scenarios, natural convection of wide range of scales exists. Fire formed over solid and liquid fuels (condensed phases) are heterogeneous in nature.

In solid fuel fires, chemical reactions are also observed over the surfaces (surface reactions) of solid fuels. For instance, wood, when heated or burnt, moisture and volatiles leave, and carbon and ash (called char) remain. If char is hot enough, the ambient air diffuses towards its surface and reacts with it. In many cases, no flame (or visible fire) is seen; however, the surface becomes incandescent (glowing with bright red color). This is called smoldering process. Smoldering occurs either before or after the occurrence of fire (flame mode). It results in release of hot products (in the form of smoke) as well as some fuel species.

Fire is caused by natural means such as lightening, volcanoes, earth quakes as well as by underground fires, usually caused by self-heating of coal. These fires are often huge. For example, the Ruth Mullins underground coal fire in Kentucky, USA has been burning for more than 4 decades and spans a vast network of underground smoldering regions spanning several square miles. Similar underground coal fires are found in several regions of the world.

Based on the atmospheric conditions, a fire whirl is formed, which displays a high intensity burning at a highly rapid rate such as the Kanto fire whirl in Japan that resulted in the death of 38000 people in 15 minutes.