Basic Mechanism of Cigarette Smoldering and Smoke Formation

Muramatsu Motohiko
Tobacco Institute of Japan (TIOJ) Testing Laboratory

It has been considered to be important to deepen understanding of the mechanism of smoldering and smoke formation processes in order to design a cigarette. Our knowledge of smoldering and smoke formation processes was rapidly extended during the 1970's - 1980's.

In this presentation, basic mechanisms of the cigarette smoldering and smoke formation have been briefly reviewed as well as the temperature distribution inside the smoldering cigarette.

Two major reaction zones exist in the smoldering cigarettes: (1) the distillation-pyrolysis zone (below 450℃), and (2) the high-temperature combustion zone (above 450℃). The smoldering cigarette undergoes a self-sustaining combustion cycle in which there is a feedback of heat form the combustion zone to the distillation-pyrolysis zone. Supply of oxygen to the combustion zone is governed by a free convection during the natural smolder and by a forced convection during the puff. The feedback of heat is governed by heat conduction between tobacco shreds during the natural smolder and by forced heat convection during the puff.

Since smoke formation is closely related to the temperature distribution inside the smoldering cigarette, many studies have focused on the measurement of the temperature. Baker measured the variations of the temperature distributions of both the solid and gas phases during the puff cycle in detail. The two phases are in near thermal equilibrium and have similar temperature distributions during the natural smolder, with a peak temperature of about 800℃ at the top of the burning

coal. During the puff the two phases have different temperature distributions near the surface of the burning coal. The highest temperature more than 900℃ occurs at the solid phase near the periphery of the burning coal.

More than 90% of the smoke constituents will be generated from the distillation-pyrolysis zone where oxygen is deficient. There are two major mechanisms for the generation of smoke constituents in this zone: (1) the direct transfer of tobacco constituents to the smoke stream, and (2) the transfer of thermal decomposition products of tobacco constituents to the smoke stream. The direct transfer depends on the volatility, thermal stability and type of functional group of each tobacco constituent.