Absorption and Transmittance of Radiant Heat Flux from Flame through Water Droplets

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Suppression system by water spray such as sprinkler system (SP) is installed in many buildings and well-known as one of highly effective fire protection methods for enclosure. On the other hand, SP would have other effects expected in fire such as cooling effect in a fire compartment, cooling effect of building structure elements and attenuate effect of radiant heat flux from fire, because evaporating droplets extract energy from the flame and combustion products as well as attenuate thermal radiation by absorption and scattering. In this research, attenuate effect of radiant heat flux through water droplets were investigated by full-scale experiments and developed prediction method.

In the experimental study, the fuels were used n-heptane and ethanol for comparison of influence on soot particle. Five kinds of sprinkler heads were used in the experiment. And also, the measurement about fundamental characteristic data of SP and flame such as droplets diameter, droplets velocity and distribution of SP and radiant spectrum emitted from flame were carried out to bring them out.

Two kinds of experiments were conducted to reveal the influence on soot particle. One is in the compartment. Another is outside of compartment for extract of the influence on soot by using the mechanical exhaust fan. The experimental data indicates that the infrared energy of flame is absorbed by water droplets. And, it is depend on the mean diameter of droplet, droplet size distribution, droplet loading density and the extent of SP. Attenuate effect of radiant heat flux was calculated by using the Mie theory and the radiant heat transfer theory, which can predict radiation by a two-flux model for radiant attenuate through water droplets. As the result, it was consistent with experimental data except n-heptane of combustion in compartment fire. This reason is probably influenced by hot smoke layer including many soot particles generated by combustion. However, the recalculated results in case of the n-heptane data extracted the influence on hot smoke layer agree with the Mie theory.

Radiant spectrum emitted from a flame must be required in order to predict the absorption and transmittance of radiant heat flux using the Mie theory. The radiant spectrum can be predicted by improved the previous studies on prediction of radiant spectrum. As the result, it was consistent with experimental data of radiant spectrum emitted from a flame. Absorption and transmittance of radiant heat flux was calculated by above the radiant spectrum and the fundamental characteristic data of SP. It increases with decreases of droplets diameter. And, it increase approximately linearly depends on droplet loading density of SP. However, if droplets diameter is too small in case of actual facilities, it will become less than prediction by the radiant spectrum model. Because, water droplets received a great amount of influence from convection by flame and droplets were vaporized by heat from thermal flow. The spectrum and absorptances and transmittances reported in this research would provide fundamental understanding of radiant attenuation by water droplets.