Understanding Heat Transfer Mechanisms in Forest Fire Spread: Convection, Radiation, Fluid Dynamics, and Their Applications for Firefighter Protection in a High Temperature Fine Fuel Particle Environment

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The purpose of this experiment was to study the interactive effects of radiation, convection, and fluid vortices in a forest fire heat transfer environment. Applying these principles to firefighter protection, new designs of emergency fire shelters were created and tested to minimize flame heat flux. The first experiment isolated thermal fluid dynamics in an empirical model using water flow and infrared photography. The second experiment used computational thermal fluid dynamic software to replicate fine-particle heat transfer. The final experiment was a scale-model test of variations in emergency fire shelter design. The results of the CFD simulations affirmed the vitality of system interaction in forest fires; however, in some test cases, the flow and heat transfer were too uniform. The second experiment's results overwhelmingly supported the presence of vortex shedding in heated flow past a particle. Infrared imaging showed progression from the birth of the first vortices to steady, sinusoidal flow to the birth of more vortices from intra-flow interaction. An analysis of change in temperature for the shelter trials revealed the conditions ideal for lowest heat flux are an air curtain and a "wing" geometry with silver reflective material. These two modifications decreased the change in temperature inside the shelter by 84%. Using the knowledge that vortex shedding is a predominant heat transfer mechanism, new predictive models can be created to improve wildland fire fighting accuracy. An improved shelter design is being considered to potentially reduce heat flux experienced by the firefighter in order to decrease risk of death and serious injury.

Awards Won:

Second Award of $2,000