MECHANICAL ENGINEERING

The Department of Mechanical Engineering presents:

The Master's Dissertation Defense of:

Sunday Omodan

Tuesday, March 10, 2015
11AM, Bourns Hall A341

Fire Behavior Modeling - Experiment on Surface Fire Transition to the Elevated live Fuel

Master of Science, Graduate Program in Mechanical Engineering
University of California, Riverside, June 2015
Dr. Marko Princevac, Chairperson

Recent increase in the number of wildfires globally over the last decade has made fire behavior modelling a major subject of scientific concern. Although, there have been wildfire studies since the beginning of 19th century, and this effort is accelerating over the last decade, the behavior of wild fire still remains largely unknown. Using the State of California, United States as a case study, increase of wildland fires in wild-urban interface is alarming. There was an estimated 9,907 wildland fires claiming 577,675 acres and additional 542 prescribed fires used to treat 48,544 acres by various agencies in 2013. Fire behavior modeling and measurements can lead to tools for decision making in both combating wild fires and validating fire predictions. Earlier studies focused on coniferous forest crown fires but very little research has been conducted on chaparral crown fires. Five percent of California land is covered by elevated shrubs of chaparral which contributes to a large source of fuel in the fire season. These elevated chaparral fuels approximately 1 foot from surface can be modeled as crown fires.

This thesis discusses the numerical simulation of fire behavior using Fire Dynamic Simulator (FDS) and laboratory experiments designed to model surface/crown fire behavior. FDS is a computational fluid dynamic (CFD) model that is developed to analyze fire behavior under various conditions. The conditions in FDS were set as close as possible to match the laboratory experiments used. The observed variables were surface temperature, bulk density, fuel heights, wind, heights between fuel beds and hot spots. Laboratory experiment were conducted at the United States Department of Agriculture Forest Service Pacific Southwest (USDA FS PSW) Research Station. The experiments focused on understanding chaparral crown fire behavior, particularly the ignition, mechanisms of flame propagation, spreading, flame front velocity and fuel consumption rates. Impacts of surface fires on crown fuels in both continuous and intermittent flame heights were studied together with the effects of winds, humidity, environmental temperature and fuel moisture content. Experiments conducted under no wind conditions showed surface fires with narrow column flames producing lower radiation rates to the crown which some time resulted in crown ignition failure. On the other hand, introduction of wind speed of 1 m/s led to a larger surface fuel flames up to 3 times the size when compared to the no wind conditions. These large flames led to 100% crown ignition.

Results from FDS were in qualitative agreement with laboratory experiments of surface fire. However, in numerical simulations crown would be ignited only when surface and elevated fuels are of the same kind. The analysis of this model behavior is out of the scope of this thesis and will be subject of future research.