Simulation of firebrands transport generated by the seat of fire

Oleg V. Matvienko[a,b], Alexander I. Filkov[*a]
[a]Dept. of Physical and Computational Mechanics, [a]Tomsk State University, 36, Lenin av, Tomsk, 634050, Russia; [b]Dept. of Theoretical Mechanics, Tomsk State University of Architecture and Building, 2, Solyanaya sq., Tomsk, 634003, Russia

ABSTRACT

Physical and mathematical model of the seat of fire, taking into account the transport of firebrands from the combustion zone was developed. The results received in the study are tentative and can be used only for a qualitative description of the process. The motion of firebrands is mainly determined by the aerodynamic processes accompanying the combustion process. At the initial stage of the motion the medium and large size firebrands are transported by the rising flow in the direction to the upper boundary of the thermal column, then are trapped by a toroidal vortex and are transported from the combustion zone to the external boundary of the circulating flow, where they are deposited on the underlying surface.
The maximum rise height of the particles transported from the peripheral area is smaller, and the transport range is greater compared to the particles transported from the central area. Large firebrands have a small specific surface area (the ratio between the particle surface area and volume) compared to small firebrands. As a result, the temperature of large firebrands during landing is above the critical one in contrast to small firebrands, which may initiate the ignition of the underlying surface and the formation of the secondary seat of fire.

Keywords: seat of fire, convective plume, simulation, firebrands, transport

1. INTRODUCTION

Over the last years, the amount of wildfires has increased. These wildfires cause huge damage: destroy property, pose a threat to human life and health. The examples of such wildfires which can be equated to emergency situations and which have led to catastrophic consequences and substantial property damage may be the forest and peat fires in the European part of Russia in July and early August (2010), in Siberia and the Russian Far East (2012), in Khakassia and TransBaikal (Russia 2015), fires in Greece (2007, 2009), in Portugal (2003, 2005), in Australia (2009), in the USA (2008, 2009, 2011 and 2013). Fires destroyed about 3000 buildings in the United States in 2014. During fires in 2010 and 2012 the regions in Russia suffered from emissions, and more than 2 million hectares were destroyed by fire. Dozens of settlements were burned partially or completely and led in same cases to casualties among the population and fire brigades.

In April (2015), more than 1200 buildings were burned in 42 settlements, 30 people were died, about 5000 people were left homeless in Khakassia due to large fires which occurred in the steppe regions. The reason for increasing the amount of wildfires, on the one hand, is connected with the preferences of people to live in forest areas and the increasing risks of fires, on the other hand, with wrong understanding of the physics of wildfires and, in particular, the transition of fire to settlements. The effect of these fires is expected to dramatically increase [1], since the number of residential buildings in forest areas rapidly increases [2]. In addition, the global climate change increases the probability and intensity of forest fires [3].

The main factors influencing on the ignition of structures and propagation of such fires are radiative and convective heat transfer from the flame and the transport of firebrands as well [4]. Formation of firebrands is the process, when fuels, such as shrubs, trees and building materials, are heated and separated into smaller burning particles during fires [5, 6]. Then the particles are transported from the fire by convective plume [7], creating a spot fires and causing the ignition of structures.

* aifilkov@gmail.com; phone 7 3822 529-669; fax 7 3822 529-669; tsu.ru

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