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Evaporation Features of Water Droplets with Typical Subsoil Impurities During the Motion Through High-Temperature Gas Environment: Research Experience at Tomsk Polytechnic University

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Abstract

This paper investigates experimentally the evaporation rate of water droplets with typical subsoil impurities (clay, silt, soil, sand) during the motion through high-temperature gas environment. The experiments were conducted at Tomsk Polytechnic University using high-speed video recording and modern video processing methods. Here, we analyze the influence of the impurity concentration on the intensity of heating and phase changes. The present study defines, how the preheating of impurities affects the completeness of the evaporation of water droplets with impurities. As a result, of studies, we draw the conclusion that it is possible to use water from natural reservoirs without prior preparation for wildfires extinguishing.

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Keywords: Droplet; water; subsoil impurities; high-temperature gases; high-speed video recording.

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1. Introduction

Fire-fighting equipment and technologies are constantly developing due to increasing security requirements, traditionally large material losses during fires and ignitions, as well as the rapid progress of science and technology. Currently, there are dozens of ways to extinguish fires, which are used depending on the specificity of fire. Despite the variety of techniques for fire elimination, the most frequently used quenching substance is water. Among the most promising methods for extinguishing by water as quenching medium, there are technologies relating to water spray and the formation of emulsions based on it (Försth & Möller, 2013; Gupta, et al., 2012; Tang, et al., 2013; Vysokomornaya, et al., 2014; Xiao, et al., 2011; Zhou, et al., 2012; Yao & Cong, 2012). It should be noted that when water mist is used for extinguishing, flame elimination occurs mainly due to the decrease of the temperature and the concentration of components entering into a chemical reaction by phase transition. However, the access to water supply may be limited during large wildfire elimination. Therefore, water from natural reservoirs is used for extinguishing forest fires without pretreatment. At the same time, there is a high probability of the presence of impurities in water in the form of the particles of sand, silt, clay, soil, and etc. Under such conditions, it is possible to change the evaporation rate of sprayed liquid droplets; this may affect fire-fighting efficiency.

Among the scientists involved in the study of the designated problem, there is professor P. A. Strizhak, research engineer O. V. Vysokomornaya, graduate student A. O. Zhdanova and others, who work at the Department of Heat and Power Process Automation of the Institute of Power Engineering in National Research Tomsk Polytechnic University. The team works within the educational direction “Thermal Engineering and Heat Engineering” during the 2014/2015 academic year. Scientific results obtained during this period of time were applied in academic disciplines “Modern problems of power engineering, heat engineering and heat technologies”, “Engineering Experiment”.

The aim of this paper is to conduct experimental investigations to determine the effect of typical subsoil impurities (mud, clay, soil, sand) on the characteristics of water spray evaporation. Experiments were performed to develop the fundamentals of resource-efficient and safe technologies for extinguishing large forest fires distributed in time and space by polydisperse water droplet flows using aviation.

2. The experimental setup and methods

Our experimental setup (Fig. 1) included two high-speed video cameras *1* (the frame rate was up to $6 \cdot 10^5$ frames per second), a cross-correlation video camera *2*, a signal synchronizer *3*, and a specialized working station *4* (for data processing).