THE EFFECT OF SURFACE REGRESSION ON THE DOWNWARD FLAME SPREAD OVER A SOLID FUEL IN A QUIESCENT AMBIENT

by

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Original scientific paper
UDC: 662.992.8
BIBLID: 0354-9836, *11* (2007), 2, pp. 67-86

The present work is addressed to the numerical study of the transient laminar opposed-flow flame spread over a solid fuel in a quiescent ambient. The transient governing equations – full Navier-Stokes, energy, and species (oxygen and volatiles) for the gas phase, and continuity and energy equations for the solid phase (fuel) with primitive variables are discretized in a staggered grid by a control volume approach. The second-order Arrhenius kinetics law is used to determine the rate of consumption of volatiles due to combustion, and the zero-order Arrhenius kinetics law is used to determine the rate of degradation of solid fuel. The equations for the fluid and solid phases are solved simultaneously using a segregated technique. The physical and thermo-physical properties of the fluid (air) such as density, thermal conductivity, and viscosity vary with temperature. The surface regression of the solid fuel is modeled numerically using a discrete formulation, and the effect upon the results is analyzed. The surface regression of the solid fuel as shown affects on the fuel surface and gas temperature, mass flux and velocity of volatiles on the top surface of fuel, total energy transferred to the solid phase, etc. It seems the results to be realistic.

Key words: *flame spread, downward, polymethyl methacrylate,, surface regression, computational fluid dynamics, ignition*

Introduction

Flame spread over solid fuel surfaces has been a subject of intensive experimental and theoretical investigations [1-15] due to its importance to fire safety. A review of modeling and simulation of combustion processes of charring and non-charring solid fuels was be done by Di Blasi [1]. Wichman [2] reviewed the theory of opposed-flow flame spread. Fernandez-Pello and Williams [3] studied experimentally laminar flame spread over polymethyl methacrylate (PMMA) surfaces. They measured spread rates, temperature and velocity field for various thicknesses of fuel. Mao *et al*. [4] numerically studied the downward flame spread over thin solid of PMMA. They solved the steady-state, two dimensional, laminar non radiative conservation equations of mass, momentum, energy, and species for volatiles and oxygen in the gas phase.