

Characterization of Candle Flames

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ABSTRACT: Common household open flame and radiant ignition sources are the actual or suspected cause for many fires. The purpose of this research is to identify the burning behavior and properties of common candles in order to provide additional tools for use by fire investigators. The properties of paraffin wax are obtained from the literature and from experiments. The candles are burned under controlled laboratory conditions to measure the mass burning rate, candle regression rate, flame height, and heat flux. Using the properties of paraffin wax and characteristics of the candles, numerous simulations are performed with the NIST Fire Dynamics Simulator (FDS) to model the burning rate and heat flux profile of the candle flame. The modeling results are then compared with the flame height and heat flux data obtained experimentally. The model facilitates an enhanced understanding of the structure of candle flames.

KEY WORDS: arson, candles, fire model, flames, ignition, paraffin, wax.

INTRODUCTION

THE USE OF candles in the US has been increasing annually since the early 1990s. According to the National Candle Association (NCA), candles are used in 7 out of 10 homes, and retail candle sales exceed approximately \$2.3 billion annually with a growth rate exceeding 15% [1]. The increased use of candles has resulted in a corresponding increase in the number of candle-related fires. In 1998, the US Consumer Product Safety

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S. E. Dillon



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Characterization Techniques for Polymer Nanocomposites Vikas Mittal, 2012-08-07 With its focus on the characterization of nanocomposites using such techniques as x ray diffraction and spectrometry light and electron microscopy thermogravimetric analysis as well as nuclear magnetic resonance and mass spectroscopy this book helps to correctly interpret the recorded data Each chapter introduces a particular characterization method along with its foundations and makes the user aware of its benefits but also of its drawbacks As a result the reader will be able to reliably predict the microstructure of the synthesized polymer nanocomposite and its thermal and mechanical properties and so assess its suitability for a particular application Belongs on the shelf of every product engineer Government Reports Announcements & Index ,1996 Kirk-Othmer Encyclopedia of Chemical Technology, Pigments to Powders, Handling Kirk-Othmer, 1996-07-08 **Characterization of Candle Flames** A. Hamins, 2005 **Encyclopedia of Chemical**

Technology: Pigments to powders, handling Raymond Eller Kirk, Donald Frederick Othmer, 1991 Contains a library of information for the chemical industry The 4th edition has undergone a complete revision with the inclusion of many new subjects which reflect the growth in chemical technology through the 1990s The book includes expanded coverage of biotechnology and materials science **Analysis and Measurement of Candle Flame Shapes** Gregory A. Tabaka, 2008

Ignition Propensity and Heat Flux Profiles of Candle Flames for Fire Investigation S. E. Dillon, 2003 *On the Structure and Stability of Diffusion Flames* Sally Ann Cheatham, 1997 Diffusion flames are flames in which fuel and oxidant initially separate come together to react chemically in a relatively thin combustion zone Asymptotic methods supplemented by numerical computation are used to analyze the structure and dynamical properties of such flames Attention is first focused on diffusion flames in arbitrary fluid flows for general fuel and oxidant Lewis numbers in which the combustion is complete or nearly complete Thus the limit of large Damkohler number and large activation energy is considered The resulting mathematical formulation consists of a free boundary problem with the flame as the free boundary Such a treatment greatly simplifies the governing system of equations and provides a framework for the analysis of the flame structure as well as its dynamical properties The stability of a planar flame is next considered with attention focused on diffusional thermal effects A dispersion relation is obtained which relates the growth parameter and wavenumber of disturbances to the fuel and oxidant Lewis numbers supply temperatures and supply concentrations Analysis of the dispersion relations indicates that instability corresponding to cellularity of the flame may occur for lean flames under near extinction conditions when the Lewis numbers of fuel and oxidant are sufficiently low The asymptotic model is also used to identify conditions under which flame extinction occurs In particular the burning characteristics of a dilute spray diffusion flame have been examined The presence of fuel droplets in the fuel supply is shown to alter the extinction characteristics of the flame The onset of oscillations in the spherical diffusion flame surrounding a fuel droplet is also considered Motivated by recent microgravity candle flame

experiments the constraint of a weak oxidant environment is imposed A linear stability analysis indicates that oscillations may indeed result when radiative heat losses and the Lewis numbers of fuel and oxidant are sufficiently large Estimates for the critical conditions are given along with a prediction of the resulting frequency of oscillation A weakly non linear analysis is then used to more fully investigate the transition to an oscillatory burning state

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