

Research Article

Mathematical Modeling of Heat and Mass Transfer Processes with Chemical Reaction at Polymeric Material Ignition by Several Small-Size Hot Particles

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Received 9 May 2014; Revised 7 July 2014; Accepted 13 October 2014

Academic Editor: Christopher Gunaseelan Jayadason

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Numerical research of interconnected heat and mass transfer processes in the “two hot particles—polymeric material—air” system was executed. The joint effect of several local heat sources on the main integrated characteristic of ignition process (ignition delay time) was established. Two ignition models characterized by the relative positioning of hot particles on a polymeric material surface were revealed. Besides, there were established characteristics of local heat sources and the distance between them ($700\text{ K} < T_p < 1150\text{ K}$ and $L > 1.5$ or $T_p > 1150\text{ K}$ and $0.25 < L < 1.5$) when regularities of heat and mass transfer processes in the “two hot particles—polymeric material—air” system are similar to regularities of heat and mass transfer processes in the “single hot particle—polymeric material—air” system.

1. Introduction

In recent years, polymeric materials (polymethyl methacrylate, polystyrene, polyethylene, etc.) have been widely adopted in various industries as decorative and constructive elements. Polymeric material products are very susceptible to thermal effects [1–4] even at rather low outside temperature ($T = 400\text{--}600\text{ K}$). Under conditions of some technological processes (at increased ambient temperature) strength characteristics are changed, melting occurs, dangerous carcinogens and are emitted. Possible temperatures of technological processes for power production can reach more than 1000 K . Under such conditions, the probability of local power sources (metal and nonmetallic particles warmed to high temperature with sizes about several millimeters) formation is high [5–9].

The numerical research results [10, 11] were obtained for thermal conduction and thermal convection processes during a polymeric material ignition by a single metal particle heated to high temperature. Established theoretical consequences can be used for developing guidelines and methods to reduce the flammability, ignition preventing, and

subsequent stages of polymeric material combustion processes. However, in practice, several (two, three, etc.) small-size particles heated to high temperature can cause fires. Ignition conditions and heat transfer characteristics may be different for the “single hot particle—polymeric material—air” system and the “two hot particles—polymeric material—air” system. For example, it is known that ignition delay time of solid condensed substance (composite propellant) at high concentration (large number per unit area surfaces) of hot particles in the gas stream equals the values of ignition delay time at condensed substance heating by a massive plate with constant (during ignition period) high temperature [5, 6]. Therefore, more detailed information about characteristics of physical and chemical processes at polymeric material heating by several hot particles is necessary for the development of relevant precautionary activities.

The purpose of the present study was to develop the mathematical model and analyze the characteristics of interconnected heat and mass transfer processes during interaction of two small-size metal particles heated to high temperatures with a polymeric material at the accounting

Mathematical Modelling Of Heat And Mass Transfer Processes

Md Monwar Hossain



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Mathematical Modelling of Heat and Mass Transfer Processes V.G. Danilov, Victor P. Maslov, K.A. Volosov, 2012-12-06 In the present book the reader will find a review of methods for constructing a certain class of asymptotic solutions which we call self stabilizing solutions This class includes solitons kinks traveling waves etc It can be said that either the solutions from this class or their derivatives are localized in the neighborhood of a certain curve or surface For the present edition the book published in Moscow by the Nauka publishing house in 1987 was almost completely revised essentially up dated and shows our present understanding of the problems considered The new results obtained by the authors after the Russian edition was published are referred to in footnotes As before the book can be divided into two parts the methods for constructing asymptotic solutions Chapters I V and the application of these methods to some concrete problems Chapters VI VII In Appendix a method for justification some asymptotic solutions is discussed briefly The final formulas for the asymptotic solutions are given in the form of theorems These theorems are unusual in form since they present the results of calculations The authors hope that the book will be useful to specialists both in differential equations and in the mathematical modeling of physical and chemical processes The authors express their gratitude to Professor M Hazewinkel for his attention to this work and his support

Heat and Mass Transfer Md Monwar Hossain, 2011-09-22 This book covers a number of topics in heat and mass transfer processes for a variety of industrial applications The research papers provide advances in knowledge and design guidelines in terms of theory mathematical modeling and experimental findings in multiple research areas relevant to many industrial processes and related equipment design The design of equipment includes air heaters cooling towers chemical system vaporization high temperature polymerization and hydrogen production by steam reforming Nine chapters of the book will serve as an important reference for scientists and academics working in the research areas mentioned above especially in the aspects of heat and mass transfer analytical numerical solutions and optimization of the processes

Heat and Mass Transfer Processes: New Developments and Applications J.M.P.Q. Delgado, 2015-02-05 Special topic volume with invited peer reviewed papers only

Proceedings of the 8th International Symposium on Heating, Ventilation and Air Conditioning Angui Li, Yingxin Zhu, Yuguo Li, 2013-09-24 Proceedings of the 8th International Symposium on Heating Ventilation and Air Conditioning is based on the 8th International Symposium of the same name ISHVAC2013 which took place in Xi an on October 19 21 2013 The conference series was initiated at Tsinghua University in 1991 and has since become the premier international HVAC conference initiated in China playing a significant part in the development of HVAC and indoor environmental research and industry around the world This international conference provided an exclusive opportunity for policy makers designers researchers engineers and managers to share their experience Considering the recent attention on building energy consumption and indoor environments ISHVAC2013 provided a global platform for discussing recent research on and developments in different aspects of HVAC systems and components with a focus on

building energy consumption energy efficiency and indoor environments These categories span a broad range of topics and the proceedings provide readers with a good general overview of recent advances in different aspects of HVAC systems and related research As such they offer a unique resource for further research and a valuable source of information for those interested in the subject The proceedings are intended for researchers engineers and graduate students in the fields of Heating Ventilation and Air Conditioning HVAC indoor environments energy systems and building information and management Angui Li works at Xi an University of Architecture and Technology Yingxin Zhu works at Tsinghua University and Yuguo Li works at The University of Hong Kong

Numerical Analysis of Heat and Mass Transfer in Porous Media J.M.P.Q. Delgado, Antonio Gilson Barbosa Lima, Marta Vázquez da Silva, 2012-06-25 The purpose of Numerical Analysis of Heat and Mass Transfer in Porous Media is to provide a collection of recent contributions in the field of computational heat and mass transfer in porous media The main benefit of the book is that it discusses the majority of the topics related to numerical transport phenomenon in engineering including state of the art and applications and presents some of the most important theoretical and computational developments in porous media and transport phenomenon domain providing a self contained major reference that is appealing to both the scientists researchers and the engineers At the same time these topics encounter of a variety of scientific and engineering disciplines such as chemical civil agricultural mechanical engineering etc The book is divided in several chapters that intend to be a resume of the current state of knowledge for benefit of professional colleagues

Numerical Simulation of Fluid Flow and Heat/Mass Transfer Processes N.C. Markatos, D.G. Tatchell, M. Cross, N. Rhodes, 2012-12-06 Computational fluid flow is not an easy subject Not only is the mathematical representation of physico chemical hydrodynamics complex but the accurate numerical solution of the resulting equations has challenged many numerate scientists and engineers over the past two decades The modelling of physical phenomena and testing of new numerical schemes has been aided in the last 10 years or so by a number of basic fluid flow programs MAC TEACH 2 E FIX GENMIX etc However in 1981 a program perhaps more precisely a software product called PHOENICS was released that was then and still remains arguably the most powerful computational tool in the whole area of endeavour surrounding fluid dynamics The aim of PHOENICS is to provide a framework for the modelling of complex processes involving fluid flow heat transfer and chemical reactions PHOENICS has now been in use for four years by a wide range of users across the world It was thus perceived as useful to provide a forum for PHOENICS users to share their experiences in trying to address a wide range of problems So it was that the First International PHOENICS Users Conference was conceived and planned for September 1985 The location at the Dartford Campus of Thames Polytechnic in the event proved to be an ideal site encouraging substantial interaction between the participants

Current Trends and Advances in Computer-Aided Intelligent Environmental Data Engineering Goncalo Marques, Joshua O. Ighalo, 2022-03-20 Current Trends and Advances in Computer Aided Intelligent Environmental Data Engineering merges computer engineering and

environmental engineering The book presents the latest finding on how data science and AI based tools are being applied in environmental engineering research This application involves multiple domains such as data science and artificial intelligence to transform the data collected by intelligent sensors into relevant and reliable information to support decision making These tools include fuzzy logic knowledge based systems particle swarm optimization genetic algorithms Monte Carlo simulation artificial neural networks support vector machine boosted regression tree simulated annealing ant colony algorithm decision tree immune algorithm and imperialist competitive algorithm This book is a fundamental information source because it is the first book to present the foundational reference material in this new research field Furthermore it gives a critical overview of the latest cross domain research findings and technological developments on the recent advances in computer aided intelligent environmental data engineering Captures the application of data science and artificial intelligence for a broader spectrum of environmental engineering problems Presents methods and procedures as well as case studies where state of the art technologies are applied in actual environmental scenarios Offers a compilation of essential and critical reviews on the application of data science and artificial intelligence to the entire spectrum of environmental engineering

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Handbook of Food and Bioprocess Modeling Techniques Shyam S. Sablani,Ashim K. Datta,M. Shafiur Rahman,Arun S. Mujumdar,2006-12-19 With the advancement of computers the use of modeling to reduce time and expense and improve process optimization predictive capability process automation and control possibilities is now an integral part of food science and engineering New technology and ease of use expands the range of techniques that scientists and researchers have at the

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 transfer characteristics design for SC turbine energy storage and the effect of ambient crosswinds *Mathematical
 Modeling and Numerical Techniques in Drying Technology* Ian Turner, Arun S. Mujumdar, 1996-09-19 Offers information
 necessary for the development of mathematical models and numerical techniques to solve specific drying problems The book
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 Hertog, B M Nicolai, 2001-06-14 Food process modelling provides an authoritative review of one of the most exciting and
 influential developments in the food industry The modelling of food processes allows analysts not only to understand such
 processes more clearly but also to control them more closely and make predictions about them Modelling thus aids the
 search for greater and more consistent food quality Written by a distinguished international team of experts Food process
 modelling covers both the range of modelling techniques and their practical applications across the food chain **Applied
 Mechanics Reviews**, 1962 **Energy: a Continuing Bibliography with Indexes**, 1977 **Proceedings**, 1976
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 background to a number of techniques is introduced and general data analysis techniques and examining the application of
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 of processes essential to the food industry are explained in this text Instead of concentrating on detailed theoretical analysis
 and mathematical derivations important mathematical prerequisites are presented in summary tables Readers attention is
 focused on understanding modeling techniques rather than the finer mathematical points Topics covered include modeling of
 transport phenomena kinetic processes and food engineering operations Statistical process analysis and quality control as
 applied to the food industry are also discussed The book s main feature is the large number of worked examples presented
 throughout Included are examples from almost every conceivable food process most of which are based on real data given in
 the many references Each example is followed by a clear step by step worked solution *Desiccant-Assisted Cooling* Carlos
 Eduardo Leme Nóbrega, Nisio Carvalho Lobo Brum, 2013-11-19 The increasing concern with indoor air quality has led to air
 quality standards with increased ventilation rates Although increasing the volume flow rate of outside air is advisable from
 the perspective of air quality it is detrimental to energy consumption since the outside air has to be brought to the comfort

condition before it is insufflated to the conditioned ambient Moreover the humidity load carried within outside air has challenging HVAC engineers to design cooling units which are able to satisfactorily handle both sensible and latent contributions to the thermal load This constitutes a favorable scenario for the use of solid desiccants to assist the cooling units In fact desiccant wheels have been increasingly applied by HVAC designers allowing distinct processes for the air cooling and dehumidification In fact the ability of solid desiccants in moisture removal is effective enough to allow the use of evaporative coolers in opposition to the traditional vapor compression cycle resulting in an ecologically sound system which uses only water as the refrigerant Desiccant Assisted Cooling Fundamentals and Applications presents different approaches to the mathematical modeling and simulation of desiccant wheels as well as applications in thermal comfort and humidity controlled environments Experts in the field discuss topics from enthalpy lumped models for heat and mass transfer and desiccant assisted radiant cooling systems among others Aimed at air conditioning engineers and thermal engineering researchers this book can also be used by graduate level students and lecturers in the field

Systems Analysis and Modeling in Food and Agriculture K.C.Ting,David H. Fleisher,Luis F. Rodriguez,2009-02-12 Systems Analysis and Modeling in Food and Agriculture is a component of Encyclopedia of Food and Agricultural Sciences Engineering and Technology Resources in the global Encyclopedia of Life Support Systems EOLSS which is an integrated compendium of twenty one Encyclopedias Systems analysis and modeling is being used increasingly in understanding and solving problems in food and agriculture The purpose of systems analysis is to support decisions by emphasizing the interactions of processes and components within a system Frequently investigated systems level questions in agriculture and food are relevant to the 6 E s Environment Energy Ecology Economics Education and Efficiency The theme on Systems Analysis and Modeling in Food and Agriculture with contributions from distinguished experts in the field provides information on key topics related to food and agricultural system The coverage include an overview of food system system level aspects related to energy environment and social policy issues knowledge bases and decision support computer models for crops food processing water resources and agricultural meteorology collection and analysis methods for data from field experiments use of models and information systems This volume is aimed at the following a wide spectrum of audiences from the merely curious to those seeking in depth knowledge University and College students Educators Professional practitioners Research personnel and Policy analysts managers and decision makers and NGOs

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