

## 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  $1000\text{ K}$ . 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

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## **Mathematical Modelling Of Heat And Mass Transfer Processes:**

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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

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The study of software engineering and its applications to system engineering is critical in computer science research Modern research methodologies as well as the use of machine and statistical learning in software engineering research are covered in this book This book contains the refereed proceedings of the Software Engineering Perspectives in Systems part of the 11th Computer Science On line Conference 2022 CSOC 2022 which was held in April 2022 online

**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

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**Food Process Modelling** L M M Tijskens, M L A T M 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

**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

**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

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**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 is 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 Handbook of Food Process Modeling and Statistical Quality Control Mustafa Ozilgen,1998-09-16 Fundamental techniques of mathematical modeling 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

**Solar Chimney Power Plant Generating Technology** Tingzhen Ming,2016-03-15 Solar Chimney Power Plant Generating Technology presents the latest advanced solar chimney power generating technologies to help engineers acquire a comprehensive understanding of the

fundamental theories technologies and applications of solar chimney power generating systems The book includes comprehensive theories very detailed technologies and many well illustrated basic configurations of different types of systems enabling readers to understand the fundamental theory the design methods of solar chimney systems and the basic parameters of the construction and operation of these systems Includes comprehensive theories very detailed technologies and many basic configurations of different types of systems Covers the basic mechanisms of fluid flow heat transfer power output energy storage and operational procedures of SCPPS solar chimney power plant system turbines Focuses on thermodynamic theory helio aero gravity effect fluid flow and heat transfer characteristics design for SC turbine energy storage and the effect of ambient crosswinds **Thermal Protection Modeling** A.S. Yakimov,2023-02-11 Thermal Protection Modeling presents the fundamental knowledge applications and methods of heat transfer augmentation techniques for current and future thermal protection systems This book covers common challenges and their most appropriate solutions presenting boundary conditions for the simulations of heat transfer and design of combined and active thermal protection Important application aspects of heat transfer augmentation techniques in a single phase system are compared in a practical way with a strong modeling approach This book will provide a strong understanding of the current and future state of thermal protection systems and assist the reader in their own problem solving and modeling approaches Provides a clear understanding of heat and mass transfer as well as modeling and thermal protection concepts Offers a mathematically and practically balanced approach to provide readers with various problems and solutions Covers active thermionic and combined thermal protection **Applied Mechanics Reviews** ,1962 Process Modeling in Pyrometallurgical Engineering Henrik Saxén,Marco A. Ramírez-Argáez,Alberto N. Conejo,Abhishek Dutta,2021-09-01 The Special Issue presents almost 40 papers on recent research in modeling of pyrometallurgical systems including physical models first principles models detailed CFD and DEM models as well as statistical models or models based on machine learning The models cover the whole production chain from raw materials processing through the reduction and conversion unit processes to ladle treatment casting and rolling The papers illustrate how models can be used for shedding light on complex and inaccessible processes characterized by high temperatures and hostile environment in order to improve process performance product quality or yield and to reduce the requirements of virgin raw materials and to suppress harmful emissions 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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**Modeling Food Processing Operations** Serafim Bakalis,Kai Knoerzer,Peter J Fryer,2015-04-28 Computational modeling is an important tool for understanding and improving food processing and manufacturing It is used for many different purposes including process design and process optimization However modeling goes beyond the process and can include applications to understand and optimize food storage and the food supply chain and to perform a life cycle analysis Modeling Food Processing Operations provides a comprehensive overview of the various applications of modeling in conventional food processing The needs of industry current practices and state of the art technologies are examined and case studies are provided Part One provides an introduction to the topic with a particular focus on modeling and simulation strategies in food processing operations Part Two reviews the modeling of various food processes involving heating and cooling These processes include thermal inactivation sterilization and pasteurization drying baking frying and chilled and frozen food processing storage and display Part Three examines the modeling of multiphase unit operations such as membrane separation extrusion processes and food digestion and reviews models used to optimize food distribution Comprehensively reviews the various applications of modeling in conventional food processing Examines the modeling of multiphase unit operations and various food processes

involving heating and cooling Analyzes the models used to optimize food distribution Proceedings, 1976 Rapporteurs summaries pages xxxi cxxxii *Advances in Intelligent Systems and Computing V* Natalya Shakhovska, Mykola O. Medykovskyy, 2020-12-22 This book reports on new theories and applications in the field of intelligent systems and computing It covers cutting edge computational and artificial intelligence methods advances in computer vision big data cloud computing and computation linguistics as well as cyber physical and intelligent information management systems The respective chapters are based on selected papers presented at the workshop on intelligent systems and computing held during the International Conference on Computer Science and Information Technologies CSIT 2020 which was jointly organized on September 23 26 2020 by the Lviv Polytechnic National University Ukraine the Kharkiv National University of Radio Electronics Ukraine and the Technical University of Lodz Poland under patronage of Ministry of Education and Science of Ukraine Given its breadth of coverage the book provides academics and professionals with extensive information and a timely snapshot of the field of intelligent systems and is sure to foster new discussions and collaborations among different groups

**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



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### **Table of Contents Mathematical Modelling Of Heat And Mass Transfer Processes**

1. Understanding the eBook Mathematical Modelling Of Heat And Mass Transfer Processes
  - The Rise of Digital Reading Mathematical Modelling Of Heat And Mass Transfer Processes
  - Advantages of eBooks Over Traditional Books
2. Identifying Mathematical Modelling Of Heat And Mass Transfer Processes
  - Exploring Different Genres
  - Considering Fiction vs. Non-Fiction
  - Determining Your Reading Goals
3. Choosing the Right eBook Platform
  - Popular eBook Platforms
  - Features to Look for in an Mathematical Modelling Of Heat And Mass Transfer Processes
  - User-Friendly Interface
4. Exploring eBook Recommendations from Mathematical Modelling Of Heat And Mass Transfer Processes

- Personalized Recommendations
- Mathematical Modelling Of Heat And Mass Transfer Processes User Reviews and Ratings
- Mathematical Modelling Of Heat And Mass Transfer Processes and Bestseller Lists
- 5. Accessing Mathematical Modelling Of Heat And Mass Transfer Processes Free and Paid eBooks
  - Mathematical Modelling Of Heat And Mass Transfer Processes Public Domain eBooks
  - Mathematical Modelling Of Heat And Mass Transfer Processes eBook Subscription Services
  - Mathematical Modelling Of Heat And Mass Transfer Processes Budget-Friendly Options
- 6. Navigating Mathematical Modelling Of Heat And Mass Transfer Processes eBook Formats
  - ePub, PDF, MOBI, and More
  - Mathematical Modelling Of Heat And Mass Transfer Processes Compatibility with Devices
  - Mathematical Modelling Of Heat And Mass Transfer Processes Enhanced eBook Features
- 7. Enhancing Your Reading Experience
  - Adjustable Fonts and Text Sizes of Mathematical Modelling Of Heat And Mass Transfer Processes
  - Highlighting and Note-Taking Mathematical Modelling Of Heat And Mass Transfer Processes
  - Interactive Elements Mathematical Modelling Of Heat And Mass Transfer Processes
- 8. Staying Engaged with Mathematical Modelling Of Heat And Mass Transfer Processes
  - Joining Online Reading Communities
  - Participating in Virtual Book Clubs
  - Following Authors and Publishers Mathematical Modelling Of Heat And Mass Transfer Processes
- 9. Balancing eBooks and Physical Books Mathematical Modelling Of Heat And Mass Transfer Processes
  - Benefits of a Digital Library
  - Creating a Diverse Reading Collection Mathematical Modelling Of Heat And Mass Transfer Processes
- 10. Overcoming Reading Challenges
  - Dealing with Digital Eye Strain
  - Minimizing Distractions
  - Managing Screen Time
- 11. Cultivating a Reading Routine Mathematical Modelling Of Heat And Mass Transfer Processes
  - Setting Reading Goals Mathematical Modelling Of Heat And Mass Transfer Processes
  - Carving Out Dedicated Reading Time
- 12. Sourcing Reliable Information of Mathematical Modelling Of Heat And Mass Transfer Processes

- Fact-Checking eBook Content of Mathematical Modelling Of Heat And Mass Transfer Processes
  - Distinguishing Credible Sources
13. Promoting Lifelong Learning
- Utilizing eBooks for Skill Development
  - Exploring Educational eBooks
14. Embracing eBook Trends
- Integration of Multimedia Elements
  - Interactive and Gamified eBooks

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