INDUSTRIAL COMBUSTION TESTING

Charles E. Baukal, Jr.

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Preface

This book is intended to fill a gap in the literature for books on industrial combustion testing. It should be of interest to anyone working in or with the field of industrial combustion. This includes burner and furnace designers, researchers, end users, government regulators, and funding agencies. It can also serve as a reference work for those teaching and studying combustion. The book covers a wide range of testing techniques used in a broad array of applications in the metals, minerals, thermal oxidation, hydrocarbon/petrochemical, and power generation industries. There are 61 authors from 10 countries representing 33 prominent combustion organizations, and these authors have hundreds of years of combined experience with industrial combustion testing.

The book contains 34 chapters divided into five sections. Section I is a general section with 11 chapters: Introduction, Testing Safety, Experimental Design, Fluid Flow, Temperature, Heat Flux, Pollution Emissions, Combustion Noise, Flame Impingement Measurements, Physical Modeling in Combustion Systems, and Virtual Testing. It is designed to provide some of the basic information referenced in succeeding chapters. Section II contains six chapters on advanced diagnostics: Laser Measurements, CARS Temperature Measurements in Flames in Industrial Burners, Diode Laser Temperature Measurements, Image-Based Techniques for the Monitoring of Flames, High Temperature Cameras, and Liquid Fuel Atomization Testing. Section III has ten chapters on burner testing: Process Burners, Commercial Boiler Burners, Power Burners, Regenerative Combustion Using High Temperature Air Combustion Technology (HiTAC), Characterization of Ribbon Burners, Flameless Burners, Radiant Tube Burners, Metallic Mat Gas Combustion, Performance Prediction of Duct Burner Systems Via Modeling and Testing, and Oxy-Fuel and Oxygen-Enhanced Burner Testing. Section IV has three chapters on flare testing: Large-Scale Flare Testing, Flare Experimental Modeling, and Flare Radiation. Section V has four chapters on testing in combustors: Cement Kilns, Glass Furnaces, Thermal Oxidizer Testing, and Utility Boilers.

The purpose of this work is to compile testing techniques utilized in industrial combustion for use by practitioners. No such book currently exists, which means that those in this field must consult a range of sources such as journals, magazines, and conference proceedings to get this kind of information. This is generally impractical because those practicing in the field usually do not have the time or the resources to extensively research this topic. While academics have access to the information, they generally do not work at the large scales associated with industrial combustion and therefore may not be familiar with how techniques are applied in production applications. This book is designed to help practitioners both in the field and in academics.

Besides providing a single-source reference, this book also provides information for specific applications. This means that someone practicing in a particular area can immediately go to their application, without necessarily having to read through other chapters. They can determine for themselves what is useful for them. The reader can save time and more quickly use the information provided by experts in each area. Nearly 1300 references and over 800 figures, and 140 tables are provided for those that need further information on a particular topic.

The book provides case studies and examples to show how to apply the information for particular applications. This includes identifying potential problems that could be very costly if not avoided. For example, failure to properly measure pollution emissions could lead to large fines from regulatory agencies. The book is designed to be more hands-on and less theoretical so the information can be easily applied to real situations in a variety of industries.

This book tells the reader how to make measurements and conduct tests in industrial combustion systems including full-scale burners, furnaces, heaters, boilers, flares, and thermal oxidizers.

There are some topics that are not covered and some that are not treated extensively. Since the majority of industrial applications use gaseous fuels, there is more treatment of that type of fuel, with less discussion of liquid and solid fuels. This book concerns atmospheric pressure combustion, which is the predominant type used in most industrial applications. There are some burner designs, combustors, and applications that are not considered.

As with any book of this type, there are sure to be author preferences and biases, but the coverage is fairly extensive and comprehensive. There are also generous discussions of many common industrial applications to help the reader better understand the requirements for different types of tests. Particularly because of the increasing emphasis on the environment, most industrial tests include some type of pollution emission measurements. While industrial combustion testing is a dynamic area of continuing research, the principles considered here are expected to be applicable well into the foreseeable future.

Editor

Charles E. Baukal, Jr., PhD, is the Director of the John Zink Institute for the John Zink Co., LLC (Tulsa, Oklahoma) where he has been since 1998. He has also been the Director of Research and Development and the Director of the Research and Development Test Center at Zink, which is a leading supplier of industrial combustion equipment to a variety of industries. Previously, Dr. Baukal worked for 13 years at Air Products and Chemicals, Inc. (Allentown, Pennsylvania) in the areas of oxygen-enhanced combustion and rapid gas quenching in the ferrous and nonferrous metals, minerals, and waste incineration industries. He worked for Marsden, Inc. (a burner supplier in Pennsauken, New Jersey) for five years in the paper, printing, and textile industries, and Selas Corp. (a burner supplier in Dresher, Pennsylvania) in the metals industry, both in the area of industrial combustion equipment. He has 30 years of experience in the fields of industrial combustion, pollution control, and heat transfer and has authored more than 100 publications in those areas. Dr. Baukal is an adjunct instructor for Oral Roberts University and the University of Tulsa, both in Tulsa, Oklahoma. He is the author or editor of seven books in the field of industrial combustion including: *Oxygen-Enhanced Combustion* (1998), *Heat Transfer in Industrial Combustion* (2000), *Computational Fluid Dynamics in Industrial Combustion* (2001), *The John Zink Combustion Handbook* (2001), *Industrial Combustion Pollution and Control* (2004), *Handbook of Industrial Burners* (2004), and *Heat Transfer from Flame Impingement Normal to a Plane Surface* (2009).

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furnaces, and industrial furnaces for metal processing. Current research efforts are focused on developing clean coal technologies: oxy-coal combustion and coal gasification for CO_2 capture, modeling CO_2 storage in subsurface environments, new computational fluid dynamic tools for nonexpert users, and assisting the power sector in China and Canada to burn coals more cleanly and efficiently through the use of simulation. Also, a new capability of microscale modeling has been developed under his supervision, presently being implemented on investigating solid oxide fuel cells. He has authored and co-authored over 150 publications in international journals, conference proceedings, industrial reports, and government departmental reports.

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and laser induced breakdown spectroscopy for trace metal detection in combustion emissions. She has authored over 60 technical documents, as journal publications, conference proceedings, presentations, and contract reports in the fields of optical spectroscopy and combustion applications of spectroscopic methods. In 1993 she received a Joint Staff Performance Award as a member of the Advanced Combustion Diagnostics Technique (Coherent anti-Stokes Raman Spectroscopy) team, of the Institute for Chemical Processes and Environmental Technology, National Research Council of Canada.

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burners, boiler burners, and vapor control; reduction of NO_x and other emissions from combustion processes; fluid flow and heat transfer in process and combustion equipment; noise elimination and control; vapor emissions control using recovery processes; hazardous waste site remediation; and permitting and operation of hazardous waste storage and disposal sites. His professional organizations and awards include: member of the American Society of Mechanical Engineers, the American Institute of Chemical Engineers and Sigma Xi, the Scientific Research Society; Registered Professional Engineer in the state of Oklahoma; recipient of the University of Missouri Honor Award for Distinguished Service in Engineering and election to the University of Tulsa Engineering Hall of Fame.

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