SpringerBriefs in Energy

Zhaohao Li · Xiaoyu Wang · Junwei Shen · Yuning Zhang

Cavity Dynamics and Splashing Mechanism in Droplets

Springer

SpringerBriefs in Energy

SpringerBriefs in Energy presents concise summaries of cutting-edge research and practical applications in all aspects of Energy. Featuring compact volumes of 50 to 125 pages, the series covers a range of content from professional to academic. Typical topics might include:

- A snapshot of a hot or emerging topic
- A contextual literature review
- A timely report of state-of-the art analytical techniques
- An in-depth case study
- A presentation of core concepts that students must understand in order to make independent contributions.

Briefs allow authors to present their ideas and readers to absorb them with minimal time investment.

Briefs will be published as part of Springer's eBook collection, with millions of users worldwide. In addition, Briefs will be available for individual print and electronic purchase. Briefs are characterized by fast, global electronic dissemination, standard publishing contracts, easy-to-use manuscript preparation and formatting guidelines, and expedited production schedules. We aim for publication 8–12 weeks after acceptance.

Both solicited and unsolicited manuscripts are considered for publication in this series. Briefs can also arise from the scale up of a planned chapter. Instead of simply contributing to an edited volume, the author gets an authored book with the space necessary to provide more data, fundamentals and background on the subject, methodology, future outlook, etc.

SpringerBriefs in Energy contains a distinct subseries focusing on Energy Analysis and edited by Charles Hall, State University of New York. Books for this subseries will emphasize quantitative accounting of energy use and availability, including the potential and limitations of new technologies in terms of energy returned on energy invested. The second distinct subseries connected to SpringerBriefs in Energy, entitled Computational Modeling of Energy Systems, is edited by Thomas Nagel, and Haibing Shao, Helmholtz Centre for Environmental Research - UFZ, Leipzig, Germany. This sub-series publishes titles focusing on the role that computer-aided engineering (CAE) plays in advancing various engineering sectors, particularly in the context of transforming energy systems towards renewable sources, decentralized landscapes, and smart grids.

All Springer brief titles should undergo standard single-blind peer-review to ensure high scientific quality by at least two experts in the field.

Zhaohao Li · Xiaoyu Wang · Junwei Shen ·
Yuning Zhang

Cavity Dynamics and Splashing Mechanism in Droplets

Springer

Zhaohao Li
Key Laboratory of Power Station Energy Transfer Conversion and System
Ministry of Education
North China Electric Power University
Beijing, China

Xiaoyu Wang
Key Laboratory of Power Station Energy Transfer Conversion and System
Ministry of Education
North China Electric Power University
Beijing, China

Junwei Shen
Key Laboratory of Power Station Energy Transfer Conversion and System
Ministry of Education
North China Electric Power University
Beijing, China

Yuning Zhang
Key Laboratory of Power Station Energy Transfer Conversion and System
Ministry of Education
North China Electric Power University
Beijing, China

ISSN 2191-5520 ISSN 2191-5539 (electronic)
SpringerBriefs in Energy
ISBN 978-3-031-54245-9 ISBN 978-3-031-54246-6 (eBook)
https://doi.org/10.1007/978-3-031-54246-6

This Springer imprint is published by the registered company Springer Nature Switzerland AG
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

Paper in this product is recyclable.

Preface

Cavitation activity within the droplets is of great significance in improving the performance of fuel atomization and other industrial applications. In this book, the characteristics of the cavitation bubble and the droplet dynamics are investigated based on the high-speed photography experiments, the bubble dynamics theory, and the numerical simulations. For the cavitation bubble dynamics, firstly, the movement trajectory of the cavitation bubble from the nucleation to the collapse is introduced. Secondly, the influence of droplets on the formation of cavitation bubble jets is analyzed. Thirdly, the paramount parameters dominating the collapse are theoretically given together with the propagation of shock waves within droplets. For the droplet splash dynamics, the droplet splash patterns are investigated with different eccentricities and radius ratio of bubbles and droplets. Based on the analysis of the flow field, the critical stability of the droplet surface is discussed, and the droplet breaking mechanism induced by cavitation bubble collapse is revealed. In addition, taking the vapor bubble and the diesel droplet as examples, the dynamic characteristics of several typical types of the droplet containing bubbles are analyzed. For vapor bubbles, the influences of vapor condensation on the propagation behaviors of gas flow and shock waves are discussed in detail together with the collapse mechanism of vapor bubbles. For diesel droplets, the influences of droplet viscosity, density, surface tension, and other physical properties on the growth, and the collapse stages of the cavitation bubble are analyzed.

Beijing, China
December 2023

Zhaohao Li
Xiaoyu Wang
Junwei Shen
Yuning Zhang

Acknowledgement This book was financially supported by the National Natural Science Foundation of China (Project No.: 51976056).

Contents

Chapter 1
Introduction

1.1 Research Background

Atomization technology can convert continuous liquid into discrete droplets. As shown in Fig. 1.1, the atomization technology has been widely utilized in many fields, e.g., fuel atomization [1], spay extinguishing [2], medical atomization [3], flue gas desulfurization and denitrification [4], wastewater jet flash evaporation [5], and atomization dust removal [6]. The introduction of atomization technology can reduce the particle size of droplets, promote the uniform distribution of small droplets, and increase the contact area between liquids and gases. Among them, cavitation atomization technology can effectively reduce the particle size of droplets by inducing the violent oscillation and the rapid collapse of cavitation bubbles within the droplets, which is worthy of attention.

Other typical atomization technologies include pressure atomization, gas flow atomization, electrostatic atomization, and so on. Their main characteristics are shown in Table 1.1. The pressure atomization technology utilizes the way of pressurizing the liquid, so that it is sprayed from the nozzle with a high speed forming spray droplets. To obtain better atomization performance, the selected injection pressure is constantly increased. Wang [7] found that when the fuel injection pressure was increased from 200 to 250 MPa, fuel consumption could be saved by 3% with further 8% reduction of NO_x emission. However, the high injection pressure increases the energy consumption of the system. To obtain a higher injection pressure, the nozzle diameter is greatly reduced. Therefore, the problem of blockage is easy to occur during the long-term operation. The gas flow atomizing nozzle contains two sets of pipelines, which spray liquid and gas at the same time respectively. It relies on the shear effect of gas on the liquid to divide the continuous medium to form spray droplets. The gas–liquid ratio is an important factor affecting the atomization performance of this technology. Yao et al. [8] found that when the gas–liquid mass ratio approaches two, the particle size of spray droplets reaches the minimum value. Hence, the working of the gas flow atomizing nozzle requires a great amount of gas

Z. Li et al., *Cavity Dynamics and Splashing Mechanism in Droplets*,
SpringerBriefs in Energy, https://doi.org/10.1007/978-3-031-54246-6_1