Preface

The aim of the book is to summarize the existing literature in the field of hydrodynamic cavitation investigations in the industrial field and to expand the current understanding by presenting new investigations covering both fundamentals and applications in a wide spectrum of industrial fields. Hydrodynamic cavitation occurs in flowing liquids when the local pressure drops below the saturation pressure threshold, forming vaporous cavities. Generally speaking, there are deviations from this description, as in exotic conditions (ultrapure environments or very fast dynamics), liquid tension may develop without the formation of cavities; however, in most cases, the fluid relaxes, forming a bubbly mixture well before reaching the tension regime.

The intriguing character of these gaseous bubbles stems from the fact that in practical flows, once pressure recovers, the bubbles collapse violently, focusing energy at very localized hot spots. Collapses can occur in a variety of ways, either symmetrically or asymmetrically with a characteristic jet formation, depending on the local pressure gradient. The energy concentration is so immense that during collapse, solid surfaces may be eroded, and luminescence may even be produced from the bubble contents as a result of compression heating.

Topics discussed in the book involve practical applications in which cavitation may be encountered. Such applications include turbomachinery (pumps and hydraulic turbines), marine applications and ship propulsion, fuel systems and positive displacement pumps, and microfluidics. The book also includes a literature review of modern methods of cavitation models and advanced experimental diagnostics for the quantification of density distribution in cavitating flows.

This book is intended for both new and experienced researchers who want to get up to speed with new developments in the field of cavitation in different disciplines and applied fields (marine and ship engineering, hydraulic machines, and fuel systems) and fundamental investigations of bubble dynamics (shock wave emission, jetting phenomena), with both experimental and numerical techniques. Further, it may appeal to engineers who are dealing with maritime applications, hydropower, and hydraulic/fuel systems and are interested in the advances in these fields.

The book contents summarize the research conducted in several institutions across the world with experience in multiphase flows and the respective

application. Among these are City, University of London; Otto-von-Guericke University of Magdeburg; Technical University of Delft; Chalmers University; National Technical University of Athens; University of Mississippi; and Friedrich-Alexander-University. Part of the research was largely supported by the European Union, either in form of Innovative Training Network or Global Fellowship projects, which are gratefully acknowledged.

Chapter 1, Review of Numerical Methodologies for Modeling Cavitation, presents a short overview of cavitation phenomena and physical mechanisms on cavitation generation. It also discusses different methodologies that can be applied to capture cavitation effects for either industrial and fundamental applications and provides a literature review on the recent developments in the field of cavitation simulation.

Chapter 2, Nonspherical Collapse of Single Bubbles Near Boundaries and in Confined Spaces, discusses single-bubble formation and collapse in microfluidics. Modes of bubble collapse are extensively discussed in terms of spherical and asymmetric collapse with jetting, reviewing classical work, and bringing it into context with recent scientific findings that may lead to applications in biomedical and engineering in the very near future.

On more practical applications, Chapter 3, Cavitation Nuisance in Ship Propulsion: A Review of Developments, gives a description of the cavitation problem in marine applications and reviews the understanding of physical mechanisms underlying the hindrance. It presents the state of the art in experimental research and reviews the latest numerical models for the assessment of cavitation hindrance.

Similarly, Chapter 4, Numerical Prediction of Cavitation and Related Nuisance in Marine Propulsion Systems, aims to give an overview of methodologies for numerical predictions of cavitation in marine engineering, relevant to both research and industry, with a discussion of the limitations and possibilities of different methods. Topics covered include the determination of cavitation inception points, hull pressure pulse predictions, and radiated noise levels. Finally, the chapter examines proposed methods for assessing the risk of cavitation erosion.

Chapter 5, Study and Detection of Cavitation in Centrifugal Pumps, discusses the interaction between cavitation and centrifugal pump operation. Topics that are covered include different types of large-scale vapor formation that appear in centrifugal pumps, the effect of the establishment design on the development of cavitation, and a summary of the state-of-the-art experimental and numerical works on the topic.

Focusing on turbomachinery, Chapter 6, Cavitation in Hydraulic Turbines, covers the effects of cavitation on the operation of hydraulic turbines. Experimental measurement techniques that can be incorporated into the study of the various cavitation phenomena observed in hydraulic turbines are discussed.

Also, the available numerical tools that have been developed and applied toward an in-depth understanding of the physical processes involved in cavitation in hydraulic turbines are reviewed.

Chapter 7, X-ray Measurement Techniques Used for Wall-Bounded Cavitating Flows, focuses on state-of-the-art experimental methods that can be applied in practical industrial cavitating flows. X-ray diagnostics are extensively analyzed and classified according to their potential to provide quantitative information about the volumetric distribution of cavitation in the form of fluid density, from densitometry to X-ray microcomputed tomography.

Chapters 8 and 9 discuss cavitation phenomena in fuel systems and, in particular, the effect cavitation has on fuel injectors. Chapter 8, Interaction of Cavitation with Sprays in High-Pressure Diesel Injection Systems, discusses mainly diesel injection systems and Chapter 9, Experimental Diagnostics and Investigations on Cavitation in Engine Injector Nozzles, discusses gasoline systems. Both chapters provide an overview of recent studies, including modern optical diagnostics for understanding the interaction between cavitation and spray formation.

With regard to fuel systems, Chapter 10, Cavitation in Positive Displacement Pumps, discusses cavitation in high-pressure positive displacement pumps. Theoretical details of these pumps are provided along with a discussion of the thermodynamic phenomena that take place, such as compression heating. Special focus is placed on gear pumps and piston pumps, and indicative examples are discussed.

Closing, we would like to thank all of the colleagues who devoted their time and were involved in the preparation of this book. Finally, our publisher, Elsevier, deserves special acknowledgment. We are particularly grateful to Brian Guerin for taking the initiative in this venture and to Rachel Pomery for her continuous motivation.

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