

Preface

The attainment of higher power densities in modern hydraulic turbomachinery is invariably obtained by running the impeller at the maximum allowable speed and lower shaft torque. Accordingly, operation under cavitating conditions can occur under special circumstances in hydroturbines and nuclear power plant cooling systems and is often tolerated in liquid propellant rocket feed systems, exposing the machine to the onset of dangerous self-sustained, cavitation-induced fluid dynamic and rotordynamic instabilities. Since these phenomena actually represent the major source of life and reliability degradation of the machine, fundamental information on their nature and behavior is of crucial importance for the effective design of today's high-performance hydraulic turbomachinery. However, the extreme complexity and imperfect understanding of the phenomena involved pose formidable obstacles to the modeling, prediction, and control of cavitation-induced instabilities. For this reason, nowadays theoretical analyses and simulations alone are still of limited value for the solution of specific technical problems and progress in this field must rely on the support of dedicated experimentation.

The objective of this monograph consists in providing the reader with a comprehensive approach to the physics, fluid dynamics, modeling, experimentation, and numerical simulation of cavitation phenomena and their implications on the design and operation of high-performance hydraulic turbomachinery. The material presented herein is, therefore, intended to illustrate some of the most recent advancements concerning both the occurrence of cavitation-induced instabilities and rotordynamic effects in high-performance turbopumps and hydroturbines, as well as the development of more refined and efficient numerical tools for the simulation of the complex cavitating flows involved in these machines.

The book contains most of the material presented in the lectures given by some of the world leading experts at the advanced school Cavitation Instabilities and Rotordynamic Effects in Turbopumps and Hydroturbines, held at the Centre International des Sciences Mecaniques (CISM), Udine, Italy, in July 2014.

The course opens with an introduction by d'Agostino and coworkers to the fundamental aspects of cavitation phenomena and induced flow instabilities, with special emphasis to the operation of hydraulic turbomachinery for space propulsion

applications. Next, Ceccio and Mkiharju review the traditional and novel experimental methods for the investigation of hydrodynamic cavitation, and illustrate some of their recent developments in the use of ionizing radiation as a means to visualize cavitating flows. Tsujimoto presents the experimental results, theoretical analyses and numerical simulations he and his collaborators have been using for their pioneering work on cavitation-induced instabilities and rotordynamic effects in inducers, turbopumps and hydroturbines. The fundamental aspects of the preliminary hydraulic design of inducers and centrifugal turbopumps is discussed by d'Agostino et al., which illustrate the development and experimental validation of their reduced-order models capable of jointly providing the geometrical definition and performance prediction of these machines. The last three contributions concern the numerical simulation of cavitating flows. The article by Goncalves presents a comparison of different turbulence and cavitation models, with and without thermal effects, in unsteady RANS simulations, while the contribution by Salvetti focuses on numerical simulation of cavitating flows in complex geometry. Finally, Saurel et al. present a flow model for the numerical simulation of interfacial flows with phase transition and its applications to cavitating nozzle flows.

The monograph is addressed to doctoral/postdoctoral students, researchers, scientists, scholars, and professionals interested in perfecting their knowledge and understanding of cavitating flow phenomena and research occurring in a wide range of applications in aerospace, mechanical, hydraulic, naval and chemical engineering, applied mechanics, applied mathematics, industrial chemistry, and applied physics.

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Pisa, Italy

Luca d'Agostino
Maria Vittoria Salvetti

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Turbopump and Inducer Cavitation, Experiments and
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d'Agostino, L.; Salvetti, M.V. (Eds.)

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