Preface

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The continuous increase of worldwide energy consumption and the need to drastically abating greenhouse emissions demand for a significant increase of the renewable share in the global mix of primary energy sources, as well as the development and deployment of novel technologies to enhance the efficiency of transportation systems and industrial processes.

Thermal engines based on thermodynamic cycles where the energy conversion process exploits unconventional fluids, namely other than steam, air, and flue gases, will play a key role in this scenario. The use of unconventional substances, however, entails that the flow behavior within the components of such engines can depart from that of an ideal gas as the underlying physical process occurs partly or entirely in the non-ideal compressible flow regime. Such regime is typical of dense vapors, flows in supercritical states or close to the saturation curve and the critical point, and two-phase vapor-liquid flows.

Examples of thermal engines where non-ideal flows typically occur are those based on the concept of the organic Rankine cycle (ORC) and the supercritical CO_2 cycle (sCO_2) like ORC turbogenerators, heat pumps, and sCO_2 power systems. Turbomachinery and heat exchangers are components of these systems whose performance is affected by the occurrence of non-ideal flow effects. Other engineering applications operating with non-ideal flows are fluid machinery for the oil and gas industry, fuel injectors for high-pressure combustors, rocket engines, compressors for refrigeration systems, and flow devices for cryogenic plants.

Given that the non-ideal compressible flow regime is characterized by strong nonlinear variations of fluid property, the accurate performance assessment and the optimal design of internal flow devices require accurate modeling of the thermodynamic and transport properties of the working fluid, as well as specialized numerical methods and tools based on highly predictive physical models. The development of models and methods tailored to non-ideal compressible fluid dynamics (NICFD) calls for a combination of theoretical, numerical, and experimental activities that can only be pursued by synergistic research efforts. The biannual NICFD conference has been established to provide evidence of the latest progress and discoveries made by the community and to share the derived knowledge, with emphasis on propulsion and power technologies. Key themes of the conference are: experiments; fundamentals; numerical methods; optimization and uncertainty quantification (UQ); critical and supercritical flows; turbulence and mixing; multi-component fluid flows; applications in ORC power systems; applications in supercritical sCO_2 power systems; cryogenic flows; condensing flows in nozzles; cavitating flows; super/trans-critical fluids in space propulsion. A Special Interest Group on NICFD (SIG-49) was established in 2019 within ERCOFTAC, the European Research Community On Flow, Turbulence And Combustion.

This volume contains the papers presented at NICFD 2020: 3rd International Seminar on Non-Ideal Compressible-Fluid Dynamics for Propulsion & Power held during October 29–30, 2020, at Delft University of Technology, The Netherlands. The conference website is: NICFD2020.

The collection of proceedings is composed of 18 papers reporting on cutting-edge research activities. The papers are divided in five thematic areas: Fundamentals, Supercritical Combustion, Numerical Methods, Rigs and Components, Experiments and Measurement Techniques. The covered topics encompass theoretical modeling of canonical NICFD flows, high-fidelity numerical simulation of reacting and non-reacting flows, turbulence and loss modeling for turbomachinery, modeling of two-phase and multi-component flows, experiments in turbine flows, and advanced optimization techniques.

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Delft, October 2020; Dr. Matteo Pini, Delft University of Technology, Chairman; Dr. Andrea Spinelli, Politecnico di Milano, Vice-Chairman; Dr. Carlo De Servi, VITO, Vice-Chairman; Prof. Francesca Di Mare, Ruhr Universität Bochum, Review Chairman; Prof. Alberto Guardone, Politecnico di Milano, Founding Chairman.