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Numerical Evaluation of Transient Flow Characteristics in a Transonic Centrifugal Compressor with Vaned Diffuser

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Abstract

Three-dimensional, compressible, unsteady Navier-Stokes equations are solved to investigate the flow field of a transonic centrifugal compressor with high compression ratio. The computational domain is consisted of an inlet bell mouth and an impeller with splitter blades, followed by a two-dimensional wedge vaned diffuser. The numerical method was validated by comparing the results with those of experiments in terms of aerodynamic compressor performance and flow field within the compressor passages. A detailed analysis of instantaneous and time-averaged flow field was conducted in the impeller and diffuser passages. The present study focuses on the pressure fluctuations and entropy production within the impeller and diffuser passages at the compressor design point. It is shown that the interaction between the impeller and diffuser blades leads to unsteadiness at the interface region and a pulsating behavior within the diffuser passages. Pressure waves with different convective velocities, generated by the impeller-diffuser interaction and pseudo-periodic unsteady separation bubbles, are captured in the time/space domain along the diffuser blade surfaces. The pressure fluctuation spectra were evaluated to analyze the noise characteristics of the centrifugal compressor as the main source of blade passing frequency noise. It is expected that the current unsteady Reynolds-Averaged Navier-Stokes (URANS) approach can be used as a tool for the prediction of unsteady flow

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