Proceedings of the 9th World Congress on Mechanical, Chemical, and Material Engineering (MCM'23)
Brunel University, London, United Kingdom –August 06-08, 2023
Paper No. HTFF 185
DOI: 10.11159/htff23.185

Influence of Span Length on Flow Instability Downstream of Inlet Guide Vanes

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Extended Abstract

At energy and power plants, inlet guide vanes are mostly installed at the intake of large multi-stage centrifugal compressors to control the flow rate and reduce collision losses using pre-swirling. However, below a certain flow angle, flow instability occurs in the inward swirling flow generated downstream of the inlet guide vanes [1-2]. This flow instability is similar to the instability that occurs downstream of a vaneless diffuser [3]. This phenomenon involves a disturbance comprising a pair of low- and high-pressure regions, called a cell, that propagates in the circumferential direction. Both experimental and theoretical investigations have indicated that the number of cells depends on the angle at which the inlet guide vanes are installed and the ratio of inner and outer diameters expressed by the device outlet and the inlet guide vane outlet. The circumferential propagation velocity of the cell and the pressure fluctuation amplitude correspond to the flow rate, and the pressure fluctuation amplitude is found to be larger when the number of cells is smaller [1-2]. This flow instability is fundamentally a two-dimensional flow, and controlling the pressure fluctuation amplitude by breaking the two-dimensionality of the flow has been extensively researched [3-4]. Despite its significance in analyzing the two-dimensional nature of flow instability, the authors have been unable to determine a systematic investigation of the impact of the aspect ratio, denoted by the span length of inlet guide vanes and the ratio of inner to outer diameters.

This study investigates the impact of span length (aspect ratio) on flow instability downstream of an inlet guide vane using both experiment and Computational Fluid Dynamics (CFD) analysis. This analysis assumes three-dimensional viscous flow with Unsteady Reynolds-averaged Navier-Stokes (URANS) equation. The number of cells was determined by measuring the phase difference and pressure fluctuation frequency and amplitude in the downstream channel of the inlet guide vanes using multiple pressure transducers. The velocity field and vorticity distribution of the internal flow in the channel were investigated by CFD. The findings obtained examined the relationship between the span length and the number of disturbance cells as well as the pressure fluctuation amplitude, with consideration for a constant installation angle and inner/outer diameter ratio.

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