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Investigation of Internal Flow near Return Guide Vane Using Jet and Suction Flow

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Extended Abstract

The Performance and efficiency of multistage centrifugal compressors, which are required to operate continuously over a long time, are expected to further improve in the future. Many studies have been conducted to optimize the design of various components of compressors such as impellers and diffusers. Recently, experimental and numerical studies were conducted on the energy loss reduction through internal flow treatment in return systems that divert flow to the next stage of pressure increase. Rube et al. reported that 5-10% reduction in the entire stage efficiency is due to flow losses in the return system [1]. Rossbach et al. revealed that the secondary flow that is generated in the vaned passage by the strong inward swirl at high flow rates induces large-scale flow separation and the high mixing losses at the exit of the return guide vanes [2]. In addition, Traficante et al. attempted the active flow control of an axial compressor-stator cascade using plasma actuators, continuous and synthetic jets, and found that the internal flow could be improved [3]. However, the obtained results are limited and insufficient to determine the optimum feeding position and flow rate of these jets.

Therefore, in this study, systematic investigations of the effects of jet and suction flow feed position and feeding flow rate on the improvement of the internal flow was conducted both experimentally and numerically. Specifically, computational fluid dynamics (CFD) utilizing Reynolds-averaged Navier-Stokes (RANS) equation with k-ωSST turbulence model was conducted, which was validated by comparing the static pressure on the suction surface obtained experimentally and by CFD. We discuss the relationship between the internal flow fields and the energy loss flowing over the vaned passage obtained from the numeric distributions such as the total and static pressure and residual angular momentum. The obtained CFD results show that the optimum slot-installation position and feeding flow rate differ for jet and suction flow, respectively. Furthermore, the flow separation region in the vaned passage is reduced by suppressing the development of the secondary flow. These results indicate that the proposed return guide vane using jet and suction flow reduces the total energy loss by improving the internal flow between the return vanes.

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