

Article

Evaluation and Investigation of Hydraulic Performance Characteristics in an Axial Pump Based on CFD and Acoustic Analysis

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Abstract: In this work, the internal flow behaviour and characteristic pressure fluctuations of an axial pump with varying water conditions are analysed. The impact of tip vortex flow on the pattern of turbulent flow is simulated numerically by the application of the CFD technique and experimentally using an acoustics analysis method. The numerical CFD data are verified with an experimental test model for accuracy and reliability. Based on the results, the difference in pressure in the internal flow and at the surfaces of the blade can be impacted through tip leakage vortex regions, which leads to changes in internal flow. Subsequently, the flow in the clearance and tip leakage vortex regions is changed. Moreover, the results reveal that the suction wall upstream is more unsteady near the surface due to more mixing, secondary flow, and tip leakage vortices. Pressure fluctuation occurs near the tip of the blade, caused by the increasing vortex flow velocity and hence raising the turbulent kinetic energy (TKE). Using different monitoring points at the blade impeller reveals high values of the pulsation amplitude. Owing to the region of clearance backflow under low-water conditions, the axial pump displays larger fluctuations in pressure near the tip blade area. Because the leakage flow leaves the gap at a high flow rate, shear layers are formed quickly between the main flow and the leakage flow. Near the end wall, there is a negative-vorticity-induced vortex. Moreover, as the flow rate increases, the pump's amplitude decreases along with its main frequency. For the low-water flow, the results reveal that there is an important clearance backflow because the axial pump has large clearance.

Keywords: CFD; acoustics analysis; tip blade; tip vortex; axial pump; pressure pulsation



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1. Introduction

It is important to investigate the flow field in axial pumps [1,2]. The outflow quality control of circulation pumps is the main consideration in determining the technical details of a circulation flow system [3,4]. To investigate the characteristics of unsteady flow within pumps, it is necessary to conduct an effective analysis of the pumps' efficiency [4,5]. In the study of the pattern of internal flow in axial pumps through varying flow operations, common methods include complex 3D unsteady flows, frequently involving multifaceted flow fields and high levels of pulsation, pressure, acoustics, and noise [6,7]. To analyse the characteristics of the internal flow inside axial pumps under changing geometrical conditions and parameters, it is necessary to suppress the pressure pulsation, noise, and acoustic levels within the pumps [8]. Presently, numerical investigation using computational fluid dynamics (CFD) is a powerful technique used to study the structure of the flow field within pumps. In combination with experimental design techniques, it has been employed to analyse the multifaceted flow behaviour within axial pumps. Many researchers have conducted wide-ranging studies on the 3D flow patterns and pulsations in pressure within flow pumps. Wang et al. [9] performed both experimental verification and computational calculations to indicate the development of the characteristics of a skewed flow within an S-shaped system of fifteen degrees in an axial pump. Kim et al. [10] studied

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