

Effect of Blade number on the Energy Dissipation and Centrifugal Pump Performance Based on the Entropy Generation Theory and Fluid–Structure Interaction

Abstract

Fluid–structure interactions may impact the precision and reliability of the unsteady flow and rotor deflection investigation in the centrifugal pump. The energy transfer between fluid and solid could be disregarded due to ignorance of fluid–structure interaction. This study numerically examines a centrifugal pump's unsteady flow and structural characteristics under varied blade numbers. The entropy generation is computed and simulated numerically, considering the distributions of energy loss in the flow field. ANSYS Fluent and Workbench were employed to simulate the centrifugal pump. The elastic structural dynamic equation is used to predict the structure reaction. The shear stress transport $k-\omega$ turbulence model was conducted to simulate the fluid domain. The findings indicated that the head and shaft power increased with the increasing blade numbers at the hydraulic performance. The impeller with seven blades reached the maximum efficiency (78.7%), with an increase of 0.27% relative to the original model. Increasing the number of blades reduces pressure fluctuations at the pump output, and the impeller with nine blades shows a minimum value in pressure amplitude (4960.79 Pa). However, it increases the entropy generation (1.42 W/K) of the centrifugal pump. Variations in blade number affect the distribution and the fluctuation of the equivalent stress and the total deformation. The model with a nine blade exhibited minimum values of equivalent stress and total deformation with 5.74 MPa and 0.046 mm, respectively. This work may improve centrifugal pump operating stability by understanding how blade number affects pump flow and structural behavior and visualizing internal energy loss.

Keywords

Blade numbers; Centrifugal pump; Entropy generation theory; Fluid–structure interaction