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Numerical Investigations of the Impacts of Assembly Tolerance on the Performance of a Multistage Centrifugal Pump

Christophe Landry[1], Sébastien Houde[1]
[1]Department of Mechanical Engineering, Laval University, Quebec City, Canada

ABSTRACT

In the design of multistage centrifugal pumps, assembly tolerances play a critical role on the production costs, as tighter tolerances require more expensive manufacturing. Despite this, their impacts on key performance metrics (head, torque, efficiency) are rarely documented, although they can potentially lead to performance variability. This study addresses a performance variability issue apparently linked with tolerances on the relative positions of four impellers with respect to the diffusers encountered by a portable pump manufacturing company. This issue apparently arose when the company transitioned from metal to plastic components to reduce weight.

Following this redesign, specific pump models exhibited variable performance during testing associated to the torque level applied to the suction cover's screws, which influences the axial positioning of the diffuser in relation to the impellers. High torque levels applied to the main nut, which could lead to component misalignment, could result in performance variations at constant motor power, suggesting an impact on the pump efficiency. This observation highlights the complex interplay between assembly tolerances and fluid dynamics within the pump. To investigate these effects, a computational fluid dynamics (CFD) study was conducted to analyze flow characteristics, including leakage flow through the inter-component gaps. A simulation methodology was developed, and validated against experimental results, using a fixed operating condition and the nominal geometry. From this baseline case, additional simulations, containing axial misalignments and various geometric modifications were then conducted to study the effects of assembly tolerances. The study analyzes the influence of the component gap thickness on leakage flow rates and its impact on flow through the impellers and diffusers. The effects of axial offsets at the rotor-stator interface are also investigated.