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Editorial: Optimal design and efficiency improvement of fluid machinery and systems: volume III

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Editorial on the Research Topic
Optimal design and efficiency improvement of fluid machinery and systems: volume III

Introduction

Fluid machinery plays a pivotal role in energy and industrial systems, where performance, efficiency, and reliability drive technological advancements. The complexity of fluid dynamics, coupled with increasing demands for sustainability and efficiency, underscores the need for innovative research to tackle design and operational challenges. This Research Topic, Optimal Design and Efficiency Improvement of Fluid Machinery and Systems: Volume III, features six cutting-edge studies that address these challenges through two key themes: performance optimization and efficiency enhancement, and the analysis of flow dynamics and operational transitions.

Performance analysis and efficiency enhancement

Efficient operation is essential for enhancing the performance and reliability of fluid machinery, particularly in hydraulic and hydrogen-based systems. Optimizing volumetric efficiency, minimizing leakage, and validating performance parameters through rigorous testing are pivotal to achieving these goals. This section synthesizes findings from three studies, offering significant insights into the advancement of fluid machinery technologies.

Yang et al. explored the efficiency performance of a large vertical submersible mixed-flow pump using model and prototype tests, reporting a maximum efficiency of 77.8% and a conversion efficiency of 80.33%, respectively. The study underscored the complementary

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roles of these testing methods, demonstrating that prototype tests provide critical validation under diverse operating conditions. Similarly, Zhai et al.; Zhai et al. investigated the leakage characteristics and volumetric efficiency of hydrogen circulation pumps (HCPs) employed in fuel cell systems. By introducing a refined leakage flow calculation formula, the authors reduced the average error to 3.82%, significantly improving prediction accuracy compared to traditional methods. Furthermore, the development of a three-blade elliptical conjugate rotor design revealed that radial clearance leakage exceeds axial clearance leakage, providing practical design insights for minimizing internal leakage and enhancing the efficiency of hydrogen recovery systems.

These studies collectively highlight the importance of integrating experimental validation, advanced simulation techniques, and innovative design strategies in addressing complex challenges in fluid machinery. Their findings contribute to the development of high-performance systems, supporting the transition to more efficient and sustainable energy solutions.

Flow dynamics and operational transitions

Understanding flow dynamics is crucial for ensuring the stability, efficiency, and operational flexibility of fluid systems. By investigating pressure pulsations, energy losses, and operational transitions, recent studies provide actionable insights to enhance system responsiveness and reliability under varying conditions.

Lu et al. analyzed pressure pulsation characteristics in the vaneless region of a pump-turbine operating in turbine mode under different head conditions. Their unsteady numerical simulations identified significant pressure fluctuations caused by rotor-stator interaction (RSI), with dominant frequencies at half the blade passing frequency (BPF). Wang et al. employed entropy generation theory to explore energy loss distributions in a guide vane centrifugal pump operating as a turbine. They highlighted the critical role of impeller-guide vane interactions in energy losses, especially under off-design conditions, offering strategies for optimizing internal flow. Man et al. investigated the transition process of pump turbines switching from pump to turbine mode without the use of a ball valve. Through torque balance equations and entropy production theory, they revealed distinct transition stages characterized by sharp fluctuations in pressure, torque, and axial force, providing insights to improve operational flexibility and enable rapid, stable transitions during emergency scenarios.

These studies underscore the importance of integrating experimental, theoretical, and computational methodologies to tackle the dynamic challenges of fluid machinery systems. Their findings contribute to optimizing performance, mitigating instability, and ensuring adaptability in complex operational environments.

Broader implications and summary

Together, the articles in this Research Topic advance fluid machinery research by addressing critical challenges in performance optimization, leakage reduction, energy loss analysis, and operational flexibility. By integrating experimental validation with advanced numerical simulations, the studies collectively highlight practical pathways for improving system performance and design. Moreover, they contribute to a broader understanding of fluid machinery's role in achieving sustainable and efficient operations.

The editors extend their gratitude to the authors for their significant contributions, to the reviewers for their constructive feedback, and to the editorial board for their unwavering support. These collective efforts have enriched the discourse on fluid machinery, fostering innovation and progress in the field.

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Conflict of interest

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