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Editorial: Design, simulation and optimization of hydraulic machinery, volume II

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Editorial on the Research Topic
Design, simulation and optimization of hydraulic machinery, volume II

Energy saving technology for hydraulic machinery and its systems can improve energy use efficiency, reduce operating costs, reduce environmental pollution, extend equipment life, and improve system reliability, which has important theoretical significance and practical value. The design simulation and optimization of hydraulic machinery is an important means of improving the performance of hydraulic machinery, reducing costs, and extending life, and is also a frontier subject in the development of hydraulic machinery science and technology. With the continuous progress of computer technology, numerical simulation technology and intelligent optimization technology, the design simulation and optimization methods of hydraulic machinery are being innovated and improved, providing strong support for the research and application of hydraulic machinery. An increasing number of papers are involved in the design as well as the optimization of hydraulic machinery. It is therefore important to collect up-to-date information on this subject.

Pumps are the most widely used and energy-consuming hydraulic machines in the production process. Firstly, Wei et al. investigates the unsteady characteristics of an ultra-low specific-speed centrifugal pump under turbine conditions using a numerical simulation method. The rotor-stator interaction between the impeller and the tongue makes the hydraulic performance and the internal flow field change periodically. The pressure fluctuation intensities at the tongue, blade inlet edge, and balance hole are large, and the total pressure fluctuation in the three areas is intense in space and time. This study provides a reference and guidance for the unsteady study of low specific-speed pump as turbine.

As one of the important equipment for pumping groundwater, deep well pumps are a research hotspot. Gao et al. studied the performance change law of high-speed deep well pumps under different space diffuser blade outlet setting angles. The hydraulic loss inside the space diffuser and the velocity moment at the outlet were quantitatively analyzed. The results showed that the outlet setting angle of 90° is a relatively optimal solution. This research can provide reference for the optimal design and application of high-speed deep well pumps.

Pump cavitation not only cracks surfaces but also reduces performance and is an important direction for pump optimization. Tan et al. applies three deep learning techniques to fault diagnosis of a mixed-flow pump under cavitation conditions. The paper uses vibration signals from experiments as inputs and classifies the operation status based on bubble density. The paper also uses FFT and dropout algorithms to improve accuracy. The paper finds that CNN has the highest accuracy among the three techniques, and can reach 87.2% with BN, MLP, and frequency domain data. The paper demonstrates the feasibility of CNN in mixed-flow pumps.

The study of pump station scheduling is also a major area of research in pump energy saving systems. Yi et al. presents a nonlinear model and a genetic algorithm to optimize the operation of urban tidal drainage pumping stations under heavy rainfall. The method considers the head-water level mismatch and the electricity price of each time period. The case study of Guazhou Pumping Station shows that the method can reduce the operation cost and benefit, and the water level variation of the river network, compared to the conventional operation. The method can balance the economic and safety aspects of drainage pumping station operation.

Reducing wear has a significant impact on the life and performance of machinery and equipment. The research work, including theory, experiment, and simulation, in this field carried out by various investigators are presented and discussed by Wang et al. The synergy of cavitation and sediment erosion is the most severe destruction in hydraulic machinery in sediment-laden rivers. The synergy effects of cavitation and sediment erosion not only reduce the efficiency and life of hydraulic machinery but also cause costs in operation and maintenance. Researchers have investigated the physical mechanisms involved in the synergy of cavitation and sediment erosion which is responsible for material damage. This would help to identify gaps for future studies. The environment in which turbines operate is often sandy.

Pan et al. studies the wear of runner blades of turbines with high head and high sediment content. The paper uses solid-liquid two-phase flow equation and turbulence model to simulate the internal water and sediment flow and obtains the sediment volume and velocity on the blade. The paper also designs and conducts a sediment wear test on the blade material and obtains the sediment wear curve. The paper applies the curve to numerical simulation and predicts the wear position and degree of the blade. The paper validates the simulation with inspection results. Similarly, hydraulic pump wear studies are important.

Liu et al. addresses the problem of data scarcity on the slipper wear of hydraulic pumps under high-speed, high-pressure conditions. The paper proposes an experimental design method that can simulate the friction state of the slipper pair based on the reprinting residual pressing force. The paper aims to facilitate the fault diagnosis and load-bearing design of the slipper pair and the development of high-speed and high-pressure piston pumps.

At last, Liu et al. investigated the effect of tooth head correction on the scroll expander performance in the ORC waste heat recovery system of vehicle engine. The paper establishes flow-thermal-solid coupling models based on different correction methods and analyzes the tooth head strength, stiffness, flow field and deformation. The paper finds that the EA-SAL correction improves the tooth head strength and stiffness and reduces the deformation under internal pressure. The paper also finds that reducing the correction angle can help reduce the deformation of the tooth head.

In summary, this Research Topic provides an overview of the design simulation and optimization of hydraulic machinery, such as pumps and turbines, and deepens our understanding of the role that energy-efficient technologies for hydraulic machinery will play in the future of carbon neutrality and environmental protection, which will help to reduce energy consumption and promote sustainable development. The content will be very useful for their research activities in the field of design simulation and optimization of hydraulic machinery.

Author contributions

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

Conflict of interest

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