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Editorial
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Practice of flow control and smart valves

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Introduction

The usual metaphors of "heart" and "throat" indicate the importance of pumps and valves in industrial systems including petroleum, chemical, metallurgy, aviation, and aerospace. With the continuous penetration of the industrial internet, the miniaturization, digitization, multi-functionalization, and systemization of valves have become very important (Si et al., 2020; Chang et al., 2021; Pang et al., 2021; Bonilla et al., 2022; Yuan et al., 2022; Zhao et al., 2022). Flow control, especially smart flow control, is one of the critical issues in the field of pump and valve research related to the process requirements of piping systems (Jin et al., 2020; Lyu LT et al., 2021; Fiderek et al., 2022; Zhang et al., 2022). The importance of smart flow control is greatly increased when valves operate at high temperatures and in high-pressure environments, or in novel fluids such as nanofluids, compressed hydrogen, and superheated steam (Qian et al., 2020a, 2020b; Ji et al., 2021; Lin et al., 2021; Lyu F et al., 2021). Online fault detection is an important means of intelligent operation and maintenance of pumps and valves; it not only ensures their performance requirements, but also prolongs their service life (di Capaci and Scali, 2018; Zhou et al., 2018; Tang et al., 2019; Yu et al., 2020; Vailati and Goldfarb, 2021; Pedersen et al., 2022; Peng et al., 2022). Therefore, it is urgent to develop intelligent valves with adjustment accuracy, fast response, accurate parameter feedback, convenient remote operation, instant online fault diagnosis, and fail-safe capability. As this field has attracted more and more attention in recent years, it has achieved remarkable development. However, it is worth noting that there is no dedicated publication or issue devoted to these aspects.

This special issue contains original and hitherto unpublished work on the practice of flow control and smart valves. Focal points of the issue include, but are not limited to, innovative applications of: (1) optimized design of novel valve cores, valve bodies, and flow channels; (2) improved precise control of flow, valve target pressure, and reduction of noise and vibration in piping systems; (3) development of novel fluid valves for use with nanofluids, superheated steam, pressurized hydrogen, and so on; (4) development of sensing systems for parameter feedback, remote operation, and fault diagnosis.

We have invited renowned scientists in the field to share their expertise and perspectives. These cover the various topics mentioned: (1) on-line fault diagnosis of pumps and valves; (2) on-line performance monitoring of pumps and valves; (3) improvement of pumps and valves under extreme conditions, in respect of dynamic performance, seal performance, and adjustment accuracy.

Lin et al. (2022) analyze the seal performance of hydrogenated nitrile butadiene rubber (HNBR) gaskets in a charge valve seal pair by finite element analysis. A nonlinear finite element analysis model is established

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to dynamically analyze the seal contact characteristics under different pre-compression amounts, seal widths, and hydrogen pressures. The contact pressure on the sealing surface increases with the increase in pre-compression. When the seal width increases, so does the contact pressure on the seal faces and the width of the separation area between the seal faces.

Shi et al. (2022) propose a heterogeneous sensor information fusion method to enhance the fault expression ability of the feature set, so that the diversification of fault types (electromagnetic faults and mechanical faults) can be characterized. The personalized weighting method (using the entropy weighting method and attention mechanism) used in the article enhances the effective signal and weakens the interference source. This method can achieve a higher fault diagnosis accuracy under severe working conditions.

Zhong et al. (2022) propose an on/off pilot technique using two independent high-speed on/off valves (HSVs) to replace conventional pilot-operated proportional valves. Through the fast-switching characteristics of HSV, the dead zone of the pilot stage is avoided, and the dynamic response performance of the main valve is improved. The feasibility of switching the pilot technology scheme is proved through theoretical analysis and experimental demonstration.

Kang et al. (2022) use a whole-valve transfer function model to analyze the mechanism and evaluation of the operating point drift when a thermal effect acts on the servo valve. The asymmetrical relationship of the armature-nozzle combination is an important reason for the thermal effect causing drift of the operating point. Differences in structural parameters and fluid medium properties at different temperatures lead to nonlinear changes in the operating point.

Sun et al. (2022) propose a fault diagnosis method based on mathematical model (MM) imputation and a modified deep residual shrinking network (MDRSN), which improves the accuracy in missing data estimation and fault diagnosis. Multiple fault time-series samples of the regulating valve at different opening degrees are collected. The MM imputation model is used to supplement the incomplete data set, and an improved residual shrinkage network is used to diagnose the faults of the control valve under different conditions.

Lu et al. (2022) analyze the statically indeterminate structure of an unloading valve and quantitatively calculate the amount of fretting wear of a valve in a gasoline direct injection high-pressure pump. A fretting wear test system is constructed, and the test data of ball valve fretting wear is obtained. Through theoretical derivation, a statically indeterminate force model of ball valve fretting wear is constructed, and the key fretting parameters required for simulation calculation are obtained. The wear formula suitable for finite element calculation is obtained by improving the Archard wear model, and a quantitative numerical calculation model of ball valve fretting wear is constructed by combining the iterative acceleration calculation method and grid adaptive technology.

Mao et al. (2022) propose a single-layer and stacked electrohydrodynamic (EHD) pump to improve the output pressure and flow of an electric hydraulic pump. The bendable and twistable electro-hydraulic pump is realized by digital manufacturing, and the designed and processed electro-hydraulic pump is used to drive the eccentric actuator. The output pressure and flow of the superimposed electric hydraulic pump are measured experimentally and compared with the output pressure and flow of a single-layer electric hydraulic pump.

We believe this special issue will provide a forum for researchers and engineers to present and discuss recent developments in the practice of flow control and smart valves. We expect the selected papers will stimulate discussion among scientific researchers, and we hope that they will bring new inspiration to readers of this journal.

Conflict of interest

Jin-yuan QIAN, Wei WU, Min CHENG, and Jun-hui ZHANG declare that they have no conflict of interest.

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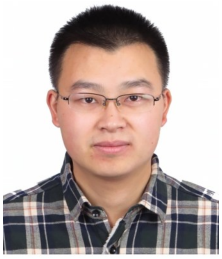

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