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Laboratory report:

Research laboratory for Smart Control Valves at Zhejiang University

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1 Overview

The Research Laboratory for Smart Control Valves at Zhejiang University, China has, since its foundation in 2008, focused on developing novel valves for smart fluid control. It is based on the chemical process equipment subject area, which is the earliest national key discipline in this field, and was recognized as a Zhejiang Key Innovation Team in 2011. The laboratory also gets full support from the State Key Laboratory of Fluid Power and Mechatronic Systems, and the Engineering Research Center for High Pressure Process Equipment and Safety (Ministry of Education), Zhejiang University. The aim of the laboratory is to establish a cooperation platform between academics and industries, so as to improve the design and manufacturing technologies of valves. There are more than 1000 valve companies in Zhejiang Province and 6000 valve companies in China in total.

Currently, its focus is on the development of innovative valves for novel fluids, such as nanofluids, compressed hydrogen, and superheated steam. In particular, the laboratory is investigating multi-phase fluid control under working conditions of high velocity and high pressure.

2 Research staff

The laboratory is led by Professor Zhi-jiang JIN, a member of the Chinese Valve Standardization Technical Committee. Professor Li-long CHEN is the chief engineer of Hangzhou Worldwise Valve Co., Ltd., and has more than 30 years of manufacturing valve experience. Associate Professor Zhi-xin ZHANG mainly does research on noise and vibration reduction of valves. Associate Professor Bao-qing LIU mainly studies multi-phases flow through valves. Dr. Sun-ting YAN investigates the safety assessment technology of valves and pipelines. Dr. Jin-yuan QIAN mainly researches on fluid dynamics and heat transfer, and also on novel design of valves.

Currently, there are eight PhD students and 10 Mastership students in the laboratory.

3 Research directions

The research of the Smart Control Valve Laboratory can be divided into three main areas: (1) control valves: optimized design of valves with novel valve cores, valve bodies, and flow channels (Qian et al., 2014, 2016b, 2018; Chen et al., 2017; Hou et al., 2018); (2) smart control: control flow rate, pressure at target value of valves, and reduction of noise and vibration in piping systems (Qian et al., 2016a; Jin et al., 2018b); (3) smart valves: development of novel valves for novel fluids, such as nanofluids and pressurized hydrogen (Jin et al., 2018a; Qian et al., 2019). The relationships between three research directions are shown in Fig. 1.

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4 Facilities

The laboratory has 80 m^2 for small testing systems, equipped with three high performance computing terminals, a high precision flow rate sensor, etc. To meet the testing requests from numerous valve companies, and also for the model validation of novel valves, the laboratory has built more than five testing systems in joint research companies such as Hangzhou Worldwise Valve Co., Ltd., which can test the flow rate, pressure fluctuation, response time, and inner flow behavior of valves with DN of 5–1500, at pressures of 0.5–35 MPa and temperatures of 10–750 °C (Qian et al., 2017). Some typical laboratory facilities and testing systems are shown in Fig. 2.

5 International collaboration

The laboratory has built research partnerships with many research teams in the past years, including the Department of Energy Sciences of Lund University, Sweden, the Process Dynamics and Operations Group in Technische Universität Berlin, Germany, and the School of Mechanical Engineering in the

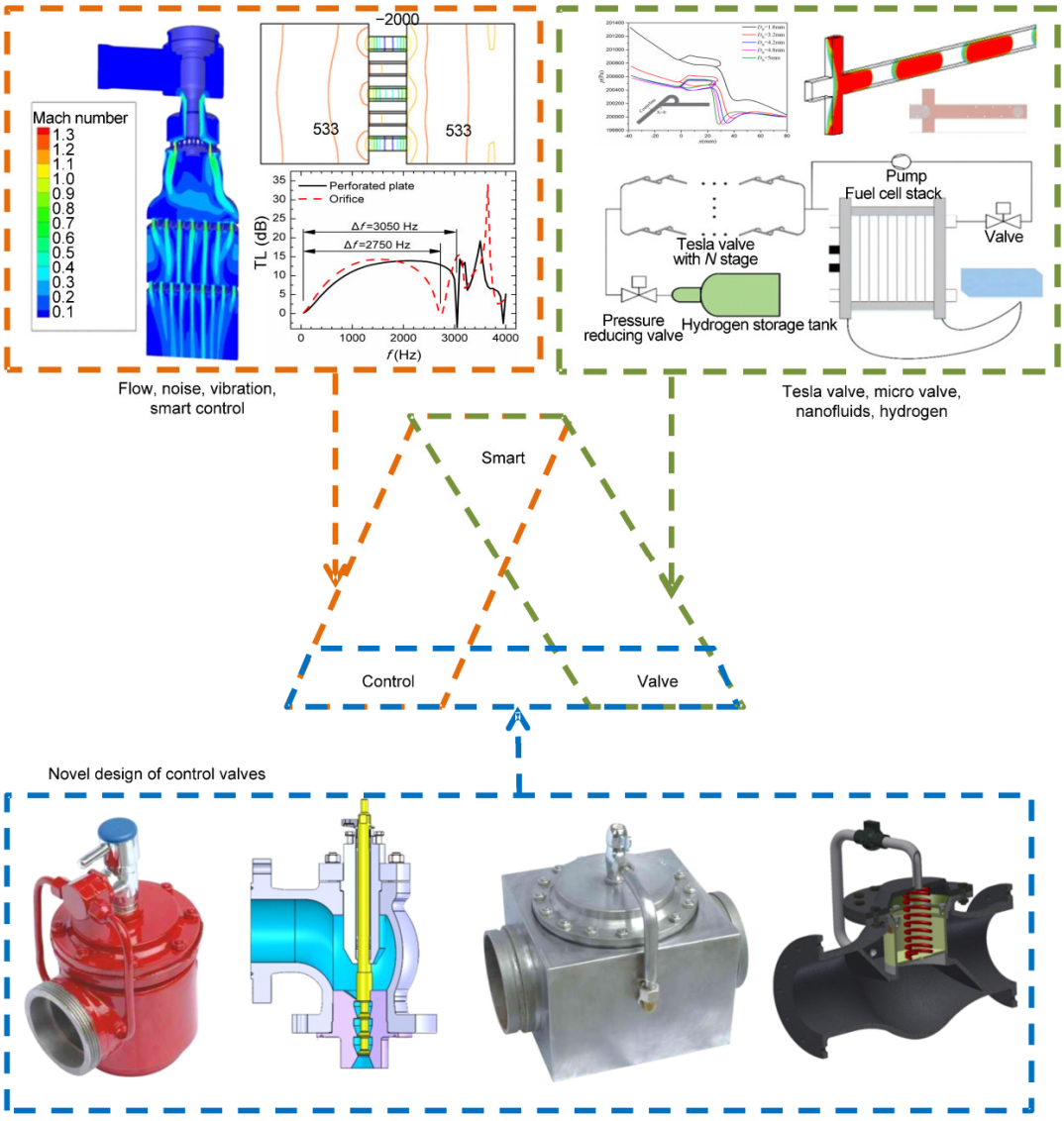

Fig. 1 Research directions of the laboratory

University of Leeds, UK. Every year there are exchange students and visiting scholars for international seminars or short- or long-term visits. The laboratory arranges for its members to participate frequently in international conferences, including the American Society of Mechanical Engineers (ASME)-Fluids Engineering Division Summer Meeting, International Heat Transfer Conferences, and International Fluid Power Conferences (Fig. 3).

6 Perspectives

Control valves have shown great improvement in the past decades. However, with the development of novel fluids and multiscale physics, conventional valves cannot meet the requirements of energy consumption and response time. To develop novel micro valves by deep study of the inner flow mechanism is necessary. With larger and larger equipment,

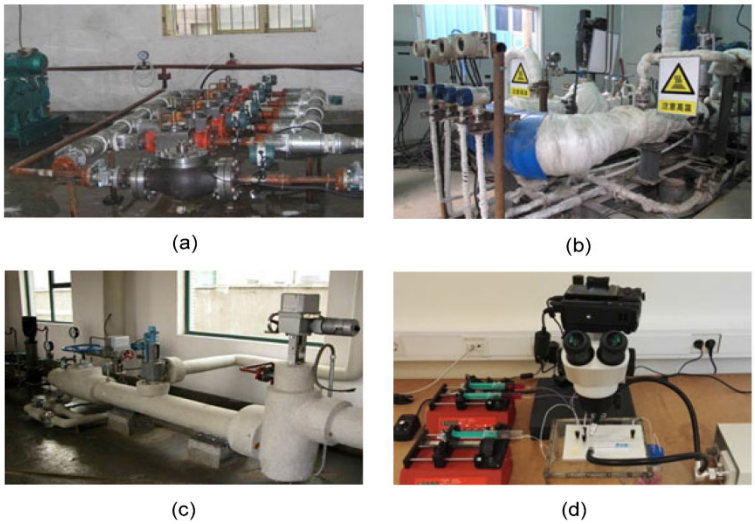

Fig. 2 Laboratory facilities and testing systems

(a) Dynamic response testing system for pilot-control globe valves; (b) Bypass flow rate testing system with pressure reducing valves; (c) High pressure safety valve testing system for steam pipelines; (d) Fluid dynamic investigation devices for microchannel valves

Fig. 3 International collaborations

(a) Visiting Air Liquide Co. Ltd.; (b) Attending ASME 2018 5th Joint US-European Fluids Engineering Division Summer Conference; (c) Professor Bengt SUNDEN (Lund University) visiting the laboratory and giving an academic talk; (d) Selected as the Best Paper Award in the 9th International Conference on Fluid Power Transmission and Control (ICFP 2017)

research on the precise intelligent control of valves for high pressure compressible fluids will also be attractive.

7 Recent events

The laboratory has set up cooperative programs with several famous valve companies, including Beijing Aerospace Petrochemical Technology and Equipment Engineering Co. Ltd., SUFA Technology Industry Co. Ltd., and Chongqing Chuanyi Control Valve Co. Ltd., to improve the control efficiency and life span of control valves in the petrochemical and nuclear industries.

Meanwhile, in order to improve artificial intelligence (AI) technology in the valve industries, with the help of Zhejiang Invention Association, the laboratory will build a branch named the Smart Valve Technical Committee, and a smart valve seminar will be held in June 2019. You are warmly welcomed to join us then.

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中文概要

题　目： 浙江大学特种控制阀研究室

目　的： 目前大中型控制阀大多存在结构复杂、驱动能耗大、反应时间慢、振动噪声大、稳定性差和使用寿命短等缺点。基于此，浙江大学相关研究人员组建了特种控制阀研究室，致力于提升控制阀的整体性能和设计水平。

研究点： 本研究室的主要方向为：1. 控制阀内部流动特性分析和新结构设计开发；2. 流体目标流量、温度、压力和振动噪声等的智能控制研究；3. 适应纳米流体、压缩氢气和高温高压过热蒸汽等新流体介质的智慧控制阀研究。

展　望： 特种控制阀作为超超临界火电机组、核电、石化高压反应和百万吨级乙烯工程等国家重大重点工程的关键零部件之一，将会在内流动机理、新结构开发、新流体介质和智能控制等研究领域得到广泛关注和长足发展。

关键词： 控制阀；智能控制；流动控制；流动特性