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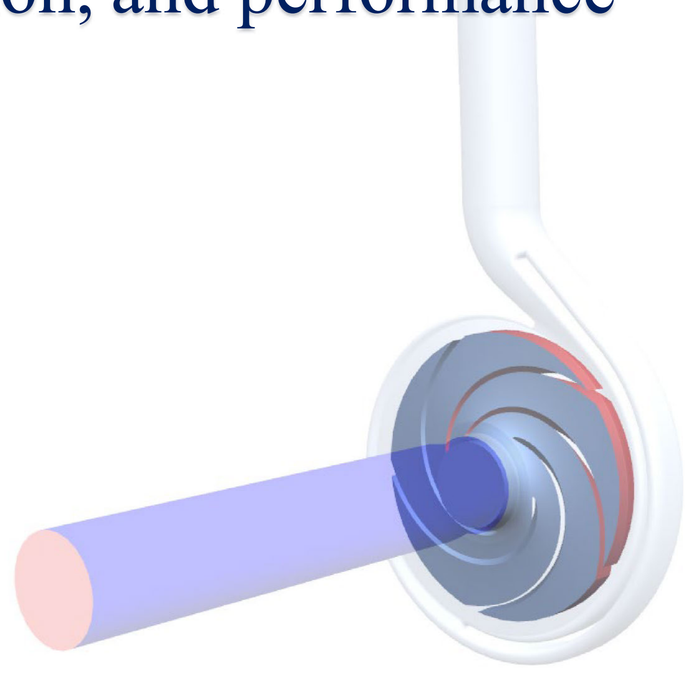
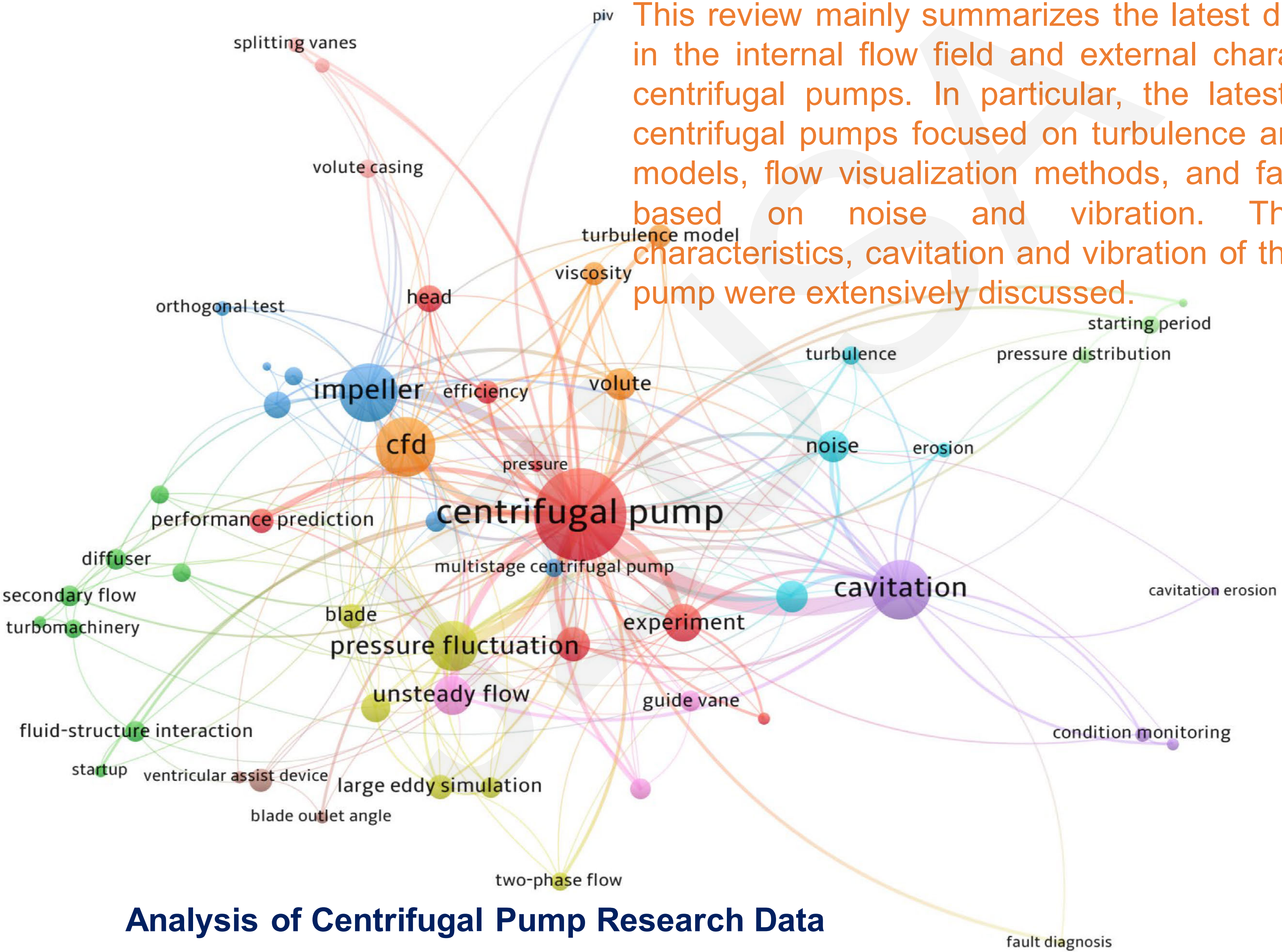
Internal flow structure, fault detection, and performance optimization of centrifugal pumps

Key words:
Centrifugal pump; Two-phase flow; Cavitation; Pressure pulsation; Multi-objective optimization



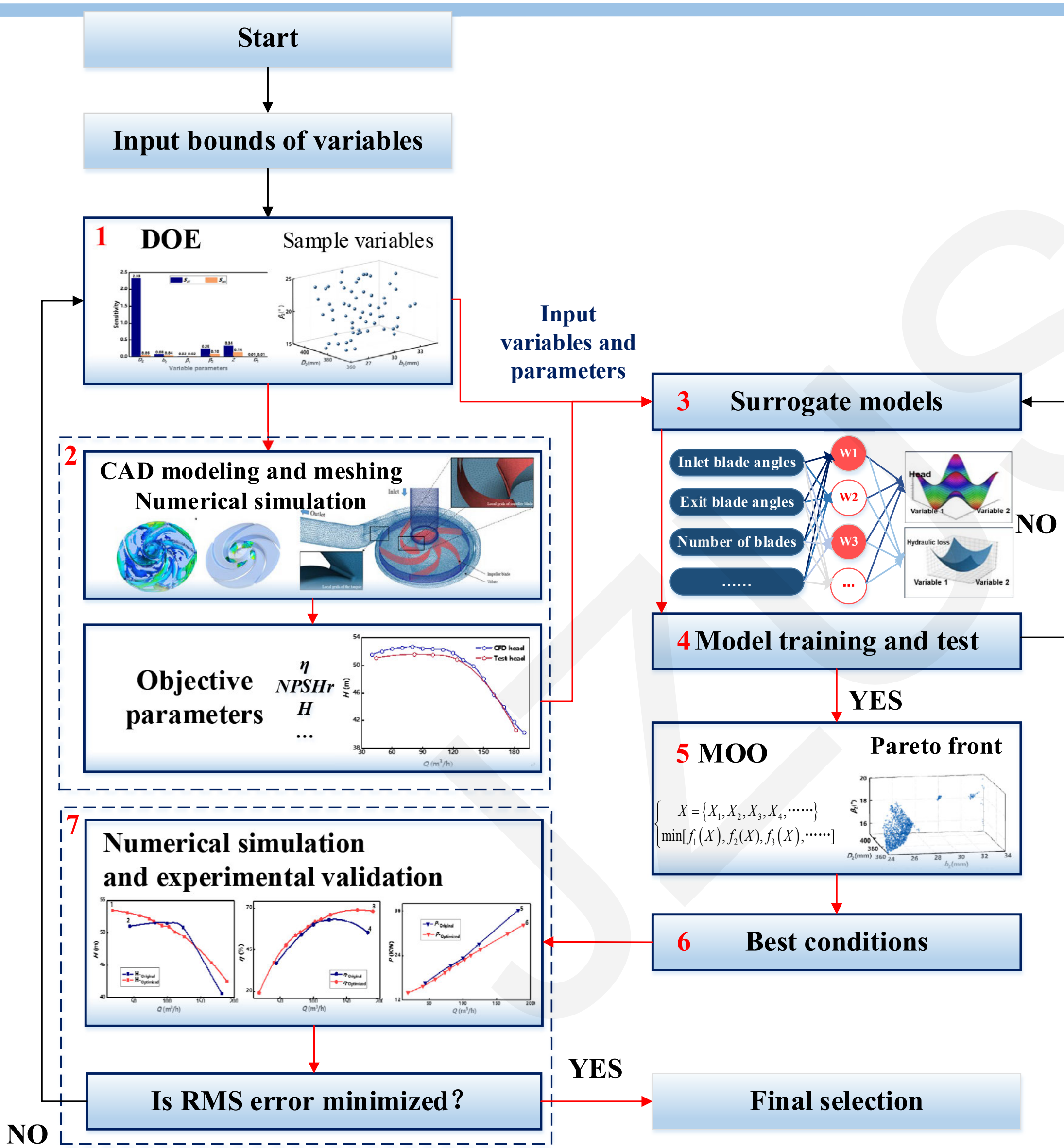
Framework of the article

This review mainly summarizes the latest developments in the internal flow field and external characteristics of centrifugal pumps. In particular, the latest findings of centrifugal pumps focused on turbulence and cavitation models, flow visualization methods, and fault detection based on noise and vibration. The external characteristics, cavitation and vibration of the centrifugal pump were extensively discussed.



Analysis of Centrifugal Pump Research Data

Performance optimization of centrifugal pumps

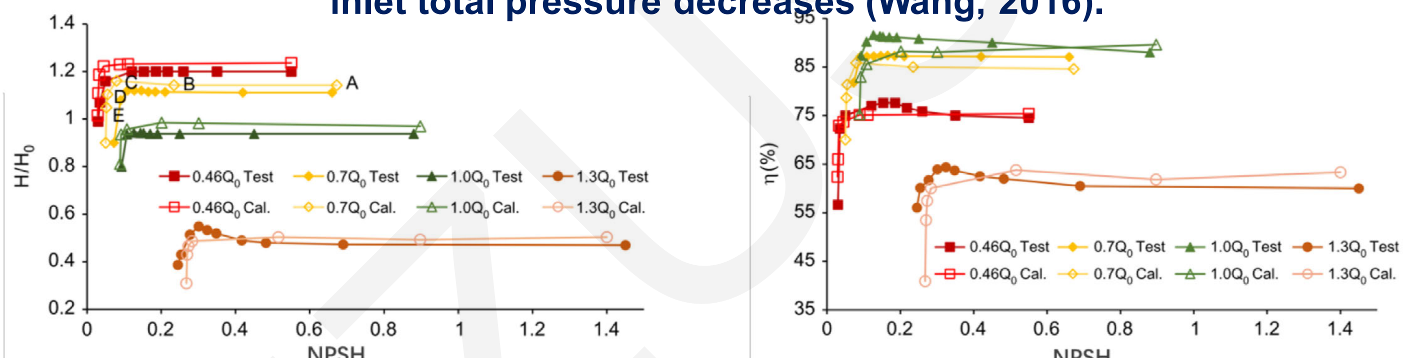


Optimization process

The various methods and measures for optimizing the performance of centrifugal pumps are described in detail. The latest overall process for multi-objective optimization of centrifugal pumps was reviewed. The applicability of various alternative models and multi-objective optimization methods to optimize the performance of centrifugal pumps was introduced and analyzed. A summary of the design variables and optimization parameters for multi-objective optimization of centrifugal pumps in recent years to further promote the optimization research of centrifugal pumps was provided.

External characteristics under off-design conditions

Vapor structures in the test pump at high flow conditions (120% of the optimal flow rate Q_0) as the inlet total pressure decreases (Wang, 2016).



a) the head-NPSH curves

b) efficiency-NPSH curves

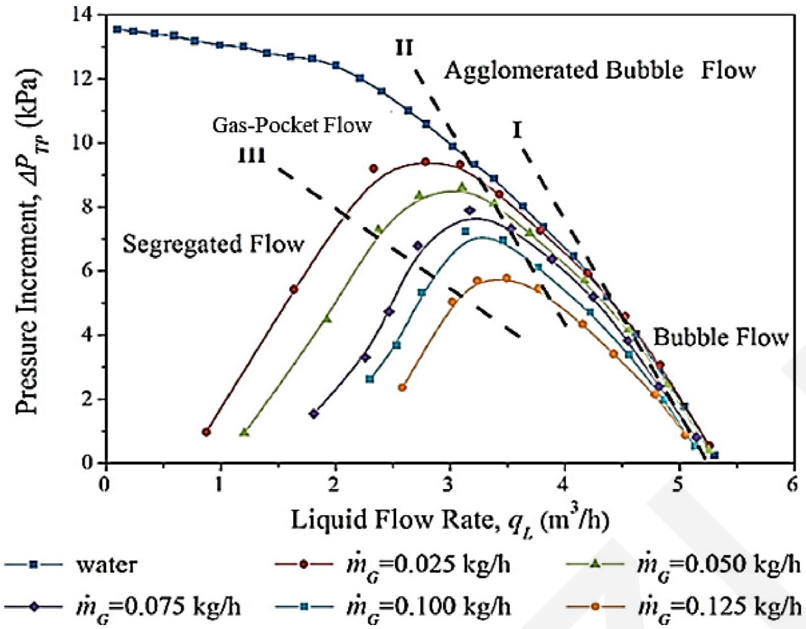
Under different flow rates. **Reprinted from ref. (Meng et al., 2016), Copyright 2016, with permission from Emerald Publishing Limited.**

the cavity mostly adheres to the suction side during the reduction of NPSHa and gradually blocks the entire blade passage. The vortex in the wake of the cavity is in the middle of the channel, and a high kinetic energy nucleus appears at the trailing edge of the suction blade near the tongue. The impeller cannot convert high kinetic energy into potential energy under vortex flow. Drop of pump head is inevitable.

Wang, W., 2016. Research on cavitation flow control of low specific speed centrifugal pump. Jiangsu University.

Tan, L., Zhu, B., Cao, S., et al., 2013. Cavitation flow simulation for a centrifugal pump at a low flow rate, Chinese Science Bulletin. 58(8):949-952.

Research status on gas-liquid two-phase flow



Relationship between the flow patterns and pump performance under differing gas flow rates.

Monte Verde et al. (Monte Verde, et al., 2017) correlated the topological distribution of each stage of the gas-liquid flow mode of the centrifugal pump impeller. Under the condition of a certain speed and inlet pressure, the performance of the pump when the mass flow rate of the gas is changed is shown. The changes of flow patterns were observed under the above conditions, and the distribution of the four flow patterns were divided. The pump performance curves are similar under different gas mass flow rates, and all begin to deteriorate with the appearance of gas-pocket flow patterns. The presence of segregated flow may cause the inability of the pump to generate pressure and cause serious damage.

Acknowledgements

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Monte Verde, W., Biazussi, J.L., Sassim, N.A., et al., 2017. Experimental study of gas-liquid two-phase flow patterns within centrifugal pumps impellers, Experimental Thermal and Fluid Science. 85:37-51. http://doi.org/10.1016/j.expthermflusci.2017.02.019