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Numerical and Experimental Studies on a Novel Kind of Hydraulic Levitation Micropump for Liquid Cooling System

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Extended Abstract

Micropump is the driving source of the liquid cooling systems [1]. However, the bearing wear failure is inevitable in the running of mechanical micropumps and has been the major obstacle to the reliability. To break this bottleneck, a novel kind of hydraulic levitation micropump (HLMP) has been designed [2]. Owing to the coupling effect of electromagnetic force and hydraulic force, the rotor of HLMP can levitate in the working fluid in all directions, thus fundamentally eliminating the solid-solid contact. In this work, the mechanism of levitation is elucidated by numerical simulation and the hydrodynamic performance is investigated under various working conditions.

In order to investigation the fluid flow characteristics inside the entire micropump, computational fluid dynamics (CFD) is conducted. The turbulent model is in the k-ε format and the calculation solver is the pressure-based type. The Coupled algorithm is adopted for pressure–velocity coupling, Quick algorithm for momentum and volume fraction, Presto algorithm for pressure, and second order upwind for the remaining period. Also, 3-D electromagnetic simulation model is adopted with the consideration of axial offset of the rotor, which is in accord with the actual operation of HLMP. Consistent with the actual operation status, the currents in motor coils are controlled by the three-phase inverter circuit, which can alter the currents by the rotation angle of the rotor to maintain maximum driving torque anytime. Additionally, the trajectory measuring system is built to monitor the levitation process of the rotor in HLMP. The HLMP prototype is fabricated herein, whose overall size is only 34 mm×34 mm×31 mm, but can provide the maximum output performance of 3160 ml/min and 90.5 kPa. The variations of the radial levitation force and the axial levitation force with the rotor offset displacement are calculated respectively. Considering that the gravity of the rotor is only 0.16N, the levitation capacity of HLMP is sufficient. The horizontal motion trajectories of the rotor in real operation are measured. Results show that the rotor performs elliptic motion and the trajectory shrinks with the rotational speed increasing. The displacement of the rotor along the axial direction is also monitored. The axial clearance between the rotor and the stational wall is about 0.4 mm, and the fluctuation distance of the rotor falls into this scope. Therefore, in all cases, the rotor wouldn't collide with the stationary wall during operation, thus displaying excellent levitation performance of HLMP.

A novel kind of hydraulic levitation micropump is proposed and demonstrated in this study. The mechanism of the levitation is clarified with the consideration of the close coupling of the flow field and the electromagnetic field. High-precision displacement monitoring method is also designed for the high-speed rotor in HLMP. Results show that the HLMP has a good combination of high performance and high reliability and is a promising and powerful option for driving microfluidics systems.

<u>SCOPES:</u> **Computational Fluid Dynamics, Micro-pump, Hydro-dynamically levitation, Electronic cooling**

References

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