Adsorption Performance of Sliding Wall-Climbing Robot

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Abstract: Sliding wall-climbing robot (SWCR) is applied worldwide for its continuous motion, however, considerable air leakage causes two problems: great power consumption and big noise, and they constraint the robot's comprehensive performance. So far, effective theoretical model is still lacked to solve the problems. The concept of SWCR's adsorption performance is presented, and the techniques of improving utilization rate of given adsorption force and utilization rate of power are studied respectively to improve SWCR's adsorption performance. The effect of locomotion mechanism selection and seal's pressure allocation upon utilization rate of given adsorption force is discussed, and the theoretical way for relevant parameters optimization are provided. The directions for improving utilization rate of power are pointed out based on the detail analysis results of suction system's thermodynamics and hydrodynamics. On this condition, a design method for SWCR-specific impeller is presented, which shows how the impeller's key parameters impact its aerodynamic performance with the aid of computational fluid dynamics (CFD) simulations. The robot prototype, BIT Climber, is developed, and its functions such as mobility, adaptability on wall surface, payload, obstacle ability and wall surface inspection are tested. Through the experiments for the adhesion performance of the robot adsorption system on the normal wall surface, at the impeller's rated rotating speed, the total adsorption force can reach 237.2 N, the average effective negative pressure is 3.02 KPa and the design error is 3.8% only, which indicates a high efficiency. Furthermore, it is found that the robot suction system's static pressure efficiency reaches 84% and utilization rate of adsorption force 81% by the experiment. This thermodynamics model and SWCR-specific impeller design method can effectively improve SWCR's adsorption performance and expand this robot applicability on the various walls. A sliding wall-climbing robot with high adhesion efficiency is developed, and this robot has the features of light body in weight, small size in structure and good capability in payload.

Key words: wall-climbing robot, adsorption performance, centrifugal impeller, CFD simulation

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