

ABSTRACT

Cleaning the glass on high-rise buildings presents significant safety and efficiency challenges. To address this issue, this research designed a prototype of a glass-cleaning robot with a thrust-suction-based adhesion mechanism using an Electric Ducted Fan (EDF) motor. This system utilizes a combination of thrust and negative pressure to maintain the robot's position on a vertical surface. The adhesion force is regulated in real-time using a PID controller based on the ESP32-WROOM-32 and a PZEM-017 current sensor as the primary feedback. The robot's mobility is supported by a track wheel system that allows for movement on vertical glass surfaces.

The test results show that the system was able to achieve stable adhesion, successfully supporting a maximum vertical load of 2700 grams. The PID control system demonstrated an average rise time of < 4 seconds but produced a significant overshoot of up to 17.34% at a high current setpoint (45 A), indicating the presence of non-linear characteristics. In terms of efficiency, the system with PID control was proven to operate 5.7°C cooler (57.0°C vs 62.7°C) compared to manual control when sustaining the maximum load, indicating a 9% improvement in thermal efficiency.

Keywords: *Glass-Cleaning Robot, Thrust-Suction, EDF Motor, PID Control, High-Rise Building.*