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Development of a Microcontroller-Based Intelligent Combustion Control System for Reformers in Industrial Applications

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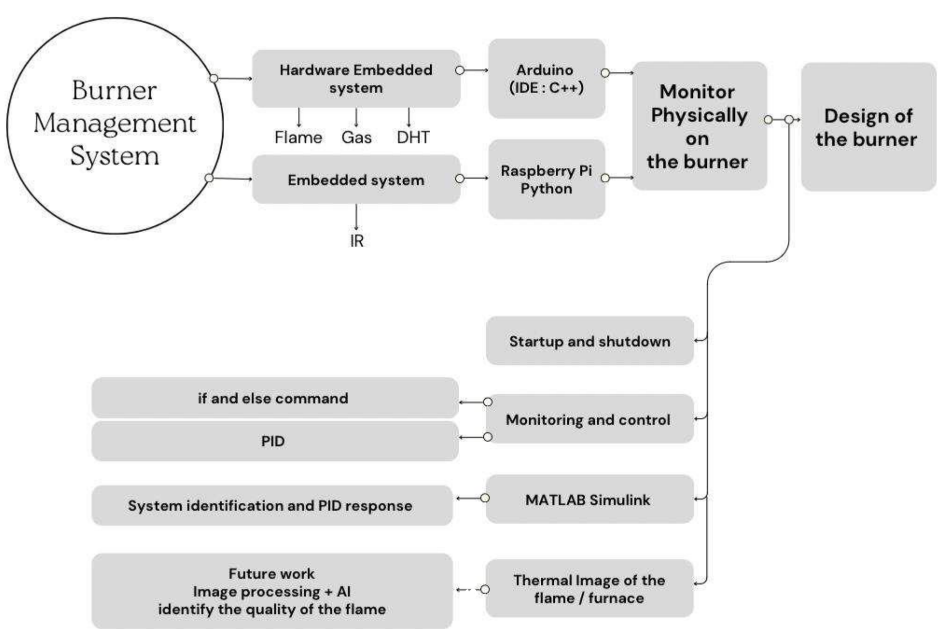
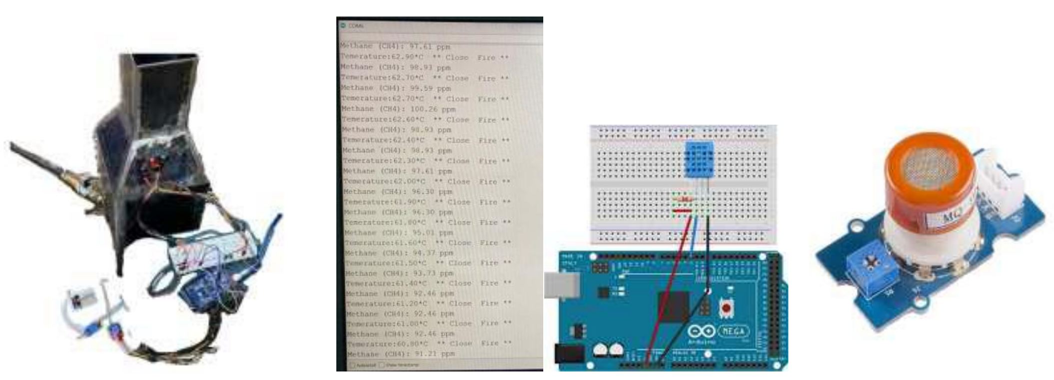
INTRODUCTION & AIM

Industrial reformers require high heat, but manual startup is a risk. The Automated Thermal Management System utilizes sensors and thermal imaging to control ignition, monitor flames, and adjust fuel–air ratios, thereby improving safety, efficiency, and diagnostics through automatic shutdowns and IoT-based data monitoring, leveraging Raspberry Pi and thermal imaging cameras.



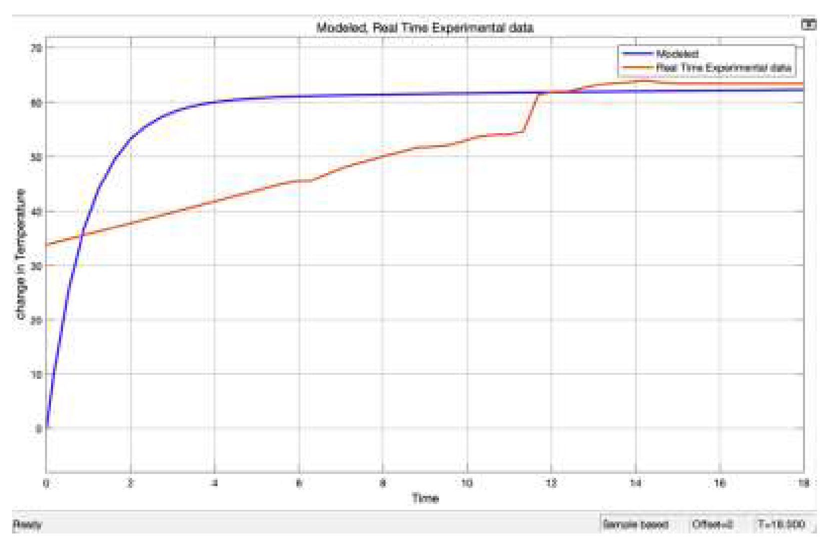
METHOD

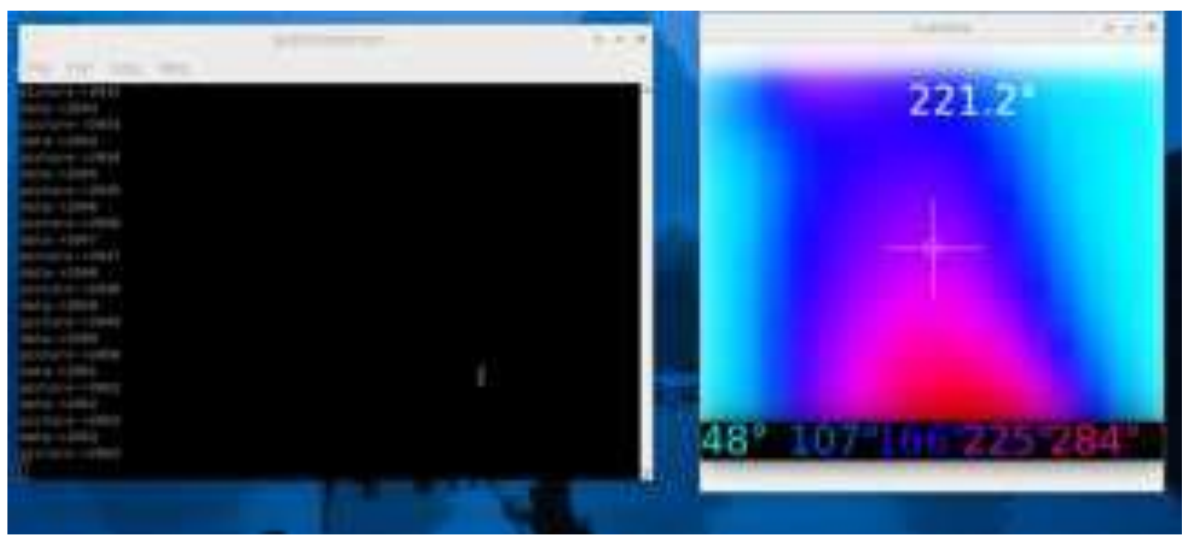
By utilizing real-time data from flame (MLX90641 IR), temperature (DHT11), and pressure sensors to automate start-up, monitoring, and shutdown routines, the system improves safety. Additionally, it provides operational data for better process decisions and increases combustion efficiency by precisely controlling fuel flow and air intake (MQ7). The Arduino IDE is used to program an embedded system that uses conditional logic to control system states. To make sure the chamber is clear of flammable gases and leaks, the system conducts necessary purging and leakage tests during startup. Following safety verification, the system provides the appropriate gas-air mixture, triggers ignition, confirms the presence of a flame, and restarts safety checks if ignition fails.



RESULTS & DISCUSSION

Optimized PI controller parameters were implemented to ensure the burner follows a safe and stable startup sequence. Using data-driven tuning, the PID strategy improved the burner's response by reducing overshoot and achieving a faster rise time. These improvements minimized operation in non-ideal conditions, resulting in a safer, smoother, and more efficient startup process. Real-time thermal monitoring of the burner was made possible by the integration of an infrared camera. Heat distribution, flame presence, and temperature variations were all visible in thermal photos. Continuous sensor output from the serial monitors supported safety compliance and enabled the Arduino control logic to respond quickly with conditional actions for effective, safe operation.





CONCLUSION

This project developed a comprehensive automated system for a specific reformer, ensuring safe and efficient operation through automatic startup, monitoring, and shutdown. Using real-time sensor data (temperature, flame presence) and an Arduino microcontroller with control logic, the system automates reformer operation and triggers safety shutdowns. An optimized PI control strategy improved startup response, reducing overshoot and reaching the desired temperature faster, while the serial monitor provides real-time operational insights.