Temperature Control of an Industrial Process Using Advanced Control Techniques

Problem Statement

In industrial automation systems, maintaining accurate and stable temperature is critical for product quality, safety, and energy efficiency. Conventional controllers such as ON–OFF and PID controllers often suffer from overshoot, slow response, and poor performance under disturbances and sensor noise. Additionally, temperature sensors may provide noisy or inaccurate measurements, leading to inefficient control actions. Therefore, there is a need for an intelligent control strategy that can accurately estimate process temperature and predict future behavior to achieve precise and reliable temperature control in industrial environments.

Objectives

To develop a mathematical model of an industrial temperature control process.

To estimate accurate temperature values using **Moving Horizon Estimation (MHE).**

To design and implement **Model Predictive Control (MPC)** for precise temperature regulation.

To compare the performance of MPC with conventional PID control methods.

Approach/Methodology

- **Mathematical Modeling:** Develop a first-principles or data-driven mathematical model of the industrial temperature control process, capturing its dynamic behavior and key parameters.
- **Moving Horizon Estimation (MHE):** Implement an MHE algorithm to provide robust and accurate real-time estimation of the process temperature, effectively handling sensor noise and unmeasured disturbances.
- **Model Predictive Control (MPC):** Design an MPC strategy that utilizes the developed model and MHE estimates to predict future system states and optimize control actions, ensuring precise temperature regulation and constraint satisfaction.
- **Comparative Analysis:** Evaluate the performance of the proposed MPC system against traditional PID controllers through simulations and experimental validation, focusing on control accuracy, disturbance rejection, and energy efficiency.