Data-Driven Control of a Multivariable Vacuum Heating Furnace

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Résumé

This paper proposes a control strategy for an industrial heat treatment furnace, addressing challenges from its complex thermal dynamics and operational constraints. The furnace is a large-scale, multivariable system with around 100 radiant panel inputs and up to 50 thermocouple-based states, depending on load size. Uniform surface temperature is critical for limiting the occurrence of manufacturing defects while maintaining a sufficient heating rate. Traditional methods like PDE and LTI models are impractical due to high computational demands and nonlinearities. Instead, a Model-Free control approach is used, leveraging view factors for radiation estimation. The controller combines proportional and forwarding-based integral actions to stabilize the system and reduce temperature deviations. Validation on the digital twin of the industrial heat treatment furnace, shows improved temperature uniformity and cycle efficiency over the manufacturer's current proportional control. The results highlight Model-Free control as a viable solution for controlling nonlinear, multivariable industrial processes.

Mots-Clés: Model Free control, Multivariable system, Forwarding method, Industrial Heating Furnace

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