#33626

Dynamic System Identification of Industrial Coffee Roasters: A Case Study

Sebastian Tück (s.tueck@probat.com), Dennis Pierl, Noah Flüthmann, Thomas Koziorowski, Kai Velten, Bernd Lindemann

Introduction

- Coffee roasters exhibit complex dynamic behavior due to actuator interactions.
- Accurate modeling is key for process optimization and energy efficiency.
- Grey-Box modeling approach used to predict flow rates and pressures.
- Goal: Improve control strategies for industrial roasting processes.

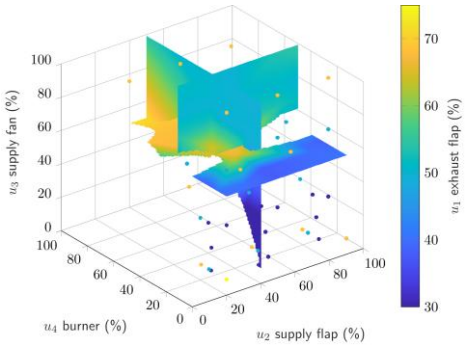

Figure 1: Identified Design Space of a PROBAT RT3 SY

Figure 2: Communication between roaster and MATLAB

Materials/Methods

- Identified machine design space via OPC UA and actuator variation.
- Applied Amplitude Modulated Pseudo-Random Binary Sequence (APRBS).
- Recorded pressures and temperatures online during excitation.
- Measured flow rates offline using log-linear method.
- Built Grey-Box model in MATLAB/Simulink with Simscape.
- Estimated parameters using Trust-Region Algorithm.
- Validated model with experimental data subsets.

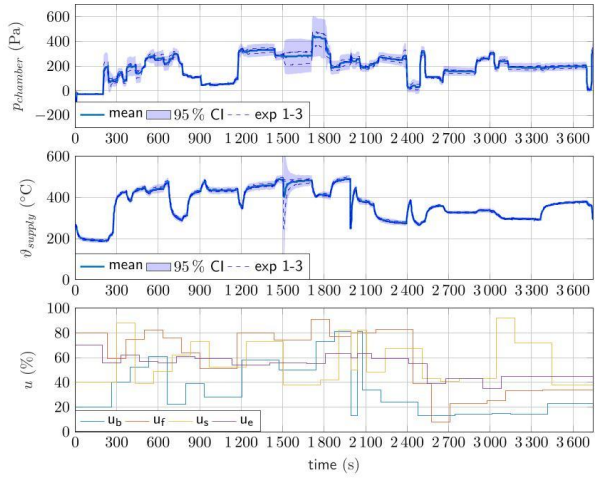

Figure 3: APRBS sequence with measurement results

Results/Discussion

- Flow rate prediction error: 7.2% (within measurement error).
- Roasting chamber pressure modeled with 0.67% mean error.
- Supply gas temperature showed larger deviations.
- Model validated for both online and offline datasets.

Conclusion/Perspectives

- Grey-Box model effectively captures roaster dynamics.
- Enables accurate prediction of flow rates and pressures.
- Useful for process optimization and control improvements.
- Future work: refine design space identification and heat transfer modeling.
- Explore model applicability to other roaster types.

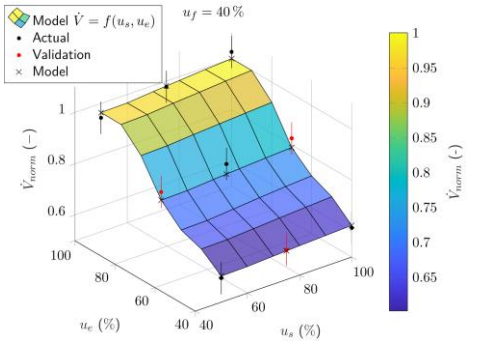

Figure 4: Model result of a PROBAT RT3 SY

References:
[1] Kowalczyk, M. (2018) – Online methods for combustion engine modeling.
[2] Nelles, O. (2020) – Nonlinear System Identification
[3] Velten, K. et al. (2024) – Mathematical modeling and simulation.