

Fethi Belkhir

Soft-sensor design and dynamic model development for a biomass combustion power plant

**Soft-sensor design and dynamic model
development for a biomass combustion
power plant**

**Soft-sensor Entwurf und Entwicklung
mathematischer Modelle eines Biomasse-
verbrennungskraftwerks**

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This thesis is dedicated to my parents Bouzid Belkhir & Souad Haouam for their endless love, support and encouragement. To all great spirits who despite the adversities thrown their way decided not to give up on their definite chief aim.

“Resolve says, ‘I will’. The man says, ‘I will climb this mountain. They told me it is too high, too far, too steep, too rocky and too difficult. But it’s my mountain. I will climb it. You will soon see me waving from the top or dead on the side from trying.’”

Jim Rohn

Abstract

English: From a system theory perspective, a biomass power plant is a nonlinear, coupled multivariate system with multiple inputs (fuel feed, air supply, grate speed) and multiple outputs (gas temperature, oxygen concentration, steam generated), where the different process input-output relationships are difficult to understand due to the large disturbances acting on the combustion process, which emanate mainly from the varying calorific value of fuel delivered to the furnace. Hence, any attempt to maintain stable operating conditions and to design or improve the control strategy being employed will lead to suboptimal solutions, which may jeopardize the commercial character of the combustion site. One possible way to handle such a situation is by improving the combustion performance using advanced model-based control strategies for this aim to further ameliorate the economical aspect of the power plant, while adhering to stringent emission standards. These control techniques explicitly incorporate the available process knowledge, which is represented in terms of an available mathematical model, used by the controller to compute the best control actions to fulfill the multiple conflicting goals in the plant. Therefore, mathematical modeling will be carried out to derive a suitable dynamic model of the power plant. The model is extended by designing a soft-sensor which estimates the energy content of fuel mix.

German: Aus systemtheoretischer Perspektive ist ein Biomassekraftwerk ein nicht-lineares, verkoppeltes Mehrgrößensystem mit mehreren Eingängen (Brennstoffzufuhr, Luftzufuhr, Rostgeschwindigkeit) und mehreren Ausgängen (Gastemperatur, Sauerstoffkonzentration, erzeugter Dampfmenge). Dabei werden die unterschiedlichen Beziehungen zwischen Prozesseingängen und -ausgängen von großen Störungen überlagert, die hauptsächlich vom variierenden Heizwert der in den Ofen gelieferten Biomasse herrühren. Deshalb wird jeder Versuch, stabile Betriebsbedingungen aufrechtzuerhalten und die eingesetzte Regelstrategie zu verbessern, zu suboptimalen Lösungen führen, die den kommerziellen Nutzen des Kraftwerks gefährden können. Eine Lösungsmöglichkeit ist die Verbesserung der Verbrennungsleistung unter Verwendung höherer modellbasierter Regelungsstrategien, um den wirtschaftlichen Aspekt des Kraftwerks unter Einhaltung strikter Emissionsnormen weiter zu verbessern. Diese Strategien integrieren explizit das verfügbare Prozesswissen, das durch ein verfügbares mathematisches Modell repräsentiert wird, das vom Regler verwendet wird, um die besten Steuerungsaktionen zu berechnen, die die vielfältigen konkurrierenden Ziele in der Anlage erfüllen. Daher wird eine mathematische Modellierung durchgeführt, um ein geeignetes dynamisches Modell des Kraftwerks abzuleiten. Das Modell wird um einen Softsensor erweitert, der den Energiegehalt des Brennstoffs schätzt.

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