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Model Based Control of Resonating Processes

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Introduction

A resonating process is a special class of system which displays oscillatory dynamics around the operating point. Various engineering systems fall under this category. Very common examples of resonating systems are power electronic devices, mechanical spring-mass-damping systems, electro-mechanical systems and chemical reactors. In general the electrical and/or mechanical systems are either linear or mildly nonlinear, whereas the chemical reactors are highly nonlinear in nature. Modeling and/or control of resonating systems needs a special theoretical background, especially Model Based Control (hereafter abbreviated as MBC) happens to be the main target. Although the traditional PI or PID controller is very popular and well established control algorithm, its design procedure is not very clear for resonating systems and hence MBC of resonating systems is a prominent issue in control engineering literature. Very few researchers have made attempts to address the difficulties involved in modeling and control the resonating processes [1-3].

MBC, as the name sounds needs an accurate model of the process under consideration to develop e cient control algorithms. Orthogonal Basis Functions (hereafter abbreviated as OBF) are popular in representing many linear/nonlinear processes. Lagurre functions are the simplest form of OBFs, which can be parameterized with single real valued pole. It has so far enjoyed significant contributions in the eld of process model development [4], but the applicability of this modeling technique to resonating processes is limited as the resonating system's dynamic characteristics are decided by pairs of complex conjugate poles.

On the other hand, Kautz functions which are defined by complex conjugate pole parameters are left unexplored for almost few decades in the context of process identification and control. Hence the study of Kautz functions and resonating processes can be extended to build a theoretical linkage between them. Da Rosa et al. [1] developed a Kautz-Volterra Wiener model to capture the nonlinear resonating dynamics and the Kautz lters parameters are optimally selected. An explicit linear Model Predictive Controller (here after abbreviated as MPC) for controlling the resonating systems is formulated by Reddy & Saha [3]. In this explicit MPC the incremental control action is calculated as the weighted sum of the recursive Kautz states, the stability of the proposed linear MPC in presence of input constraints has been derived by adopting well known Lyapunov theory.

Reddy & Saha [5] have extended the linear state space Kautz model to formulate a newer kind of Wiener model, called Kautz-Wiener model. In the developed Kautz-Wiener model the linear dynamic part is represented by Kautz functions while the static nonlinear mapping has been described by means of either of wavelet network and Least Square Support Vector Machine. As an extension, the Kautz-Wiener models developed by Reddy & Saha [5] are utilized by Reddy & Saha [4] to develop MBC algorithms. Two types of MBC strategies are adopted viz. nonlinear MPC and nonlinear internal model control (hereafter abbreviated as IMC). In case of nonlinear IMC, the problem of model inversion has been addressed, rest of its kind in approach, through tactful modification of Wiener model coupled with optimization technique. Deletion of positive zeros from orthogonal basis lters while modifying Wiener model is the uniqueness of this technique and it ensures stability of the controller as observed in their closed-loop control performance through simulation case studies involving highly nonlinear continuous stirred tank reactors.

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