INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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SHORT ABSTRACT

Resonating processes are a special class of systems which display oscillatory dynamics around the operating point. 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 in nature, whereas the chemical reactors are highly nonlinear in nature. Hence control of resonating nonlinear chemical processes is always a challenging problem for control researchers community. Although the traditional PI(D) controller is very popular and well established control algorithm, its design procedure is not very clear for resonating systems. Hence Model Based Control (hereafter referred to as MBC) is a preferred candidate for controlling such systems. However not much has been addressed so far on this issue in the control engineering literature.

Model Predictive Control (hereafter referred to as MPC) and Internal Model Control (hereafter referred to as IMC) are the two important branches of MBC theory and are effective approaches for controlling constrained processes. As the name sounds, MBC design needs an explicit model of the process while computing the optimal control input. An efficient model and the closed-loop stability are the two major issues in this controller design procedure. The scope of this thesis broadly spans two areas: firstly the system identification of resonating systems and secondly the design of stable MBC of such resonating systems. In system identification, *Kautz model* and its nonlinear version in *Wiener* structure have been developed, which are novel in their kind. Kautz functions are derived in a standard state space form in order to approximate the behavior of linear/mildly nonlinear resonating systems. In its nonlinear version (a.k.a *Kautz-Wiener model*) the linear dynamic part is formed by the Kautz filters while the static nonlinear mapping is described via two independent means, *viz*, wavelet decomposition and least squares support vector machine (hereafter referred to as LSSVM). The performance of the developed models are

compared with that of similar models of the same class through suitable examples of case studies comprising of continuous stirred tank reactor (a.k.a CSTR) which is a reasonably nonlinear resonating system. Degree of nonlinearity as well as resonance was enhanced with series-connected CSTRs.

Kautz functions are formulated in a recursive fashion in order to compute the future incremental control effort of MPC. Use of Kautz functions in the optimization procedure leads to parsimonious representation. The efficacy of the proposed Kautz-MPC is tested on two case studies, *viz*. linear highly oscillatory mechanical system and mildly nonlinear magnetic ball suspension system. Performance of Kautz-MPC is compared against already published literature on Laguerre model based MPC. Stability of the Kautz-MPC is established through Lyapunov criteria.

On the other hand nonlinear Kautz-Wiener models have further been employed in the present thesis for developing nonlinear MBC strategies and their closed-loop control performance have been evaluated through simulation case studies involving CSTRs. Two types of model based control strategies are adopted *viz.* nonlinear MPC and nonlinear IMC. In case of nonlinear IMC, the problem of model inversion has been addressed, first of its kind in approach, through tactful modification of Wiener model coupled with optimization technique. Deletion of positive zeros from orthogonal basis filters while modifying Wiener model is the uniqueness of this thesis and it ensures stability of the controller.