Delayed recycle Axial Reactor xxx

Behrad Moadeli* Author Two†

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Abstract

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1 Introduction

Many chemical, petrochemical, and biochemical unit operation processes are modelled as distributed parameter systems (DPS). When these processes are described using first-principle modeling, they result in a class of partial differential equations (PDEs) to effectively capture diffusion, transport, and reaction phenomena, leading to infinite-dimensional state space representations.[1,2] This characteristic presents significant challenges, making the control and estimation of DPS inherently more complex than finite-dimensional systems. Two primary methods have emerged for addressing DPS control. One is early lumping, which approximates the infinite-dimensional system

*Ualberta, Address. Email: moadeli@ualberta.ca

†Affiliation, Address. Email: author2@example.com

with a finite-dimensional model.[3,4] While this method enables the use of standard regulator design techniques, mismatches between the dynamical properties of the original DPS and the approximate lumped parameter model can occur, negatively affecting the performance of the designed regulator.[5] The second method is late lumping, which directly tackles the infinite-dimensional system before applying numerical solutions. This approach introduces a challenging yet fertile direction of research, leading to many meaningful contributions that address various aspects of control and estimation of infinite-dimensional systems.

Among notable studies utilizing late lumping method for control of diffusion-convection-reaction systems resulting in parabolic PDEs, Christofides addressed order reduction methods for diffusion-convection-reaction type of reactors.[6] Dubljevic et al. utilized modal decomposition to capture dominant modes of a DPS to construct a reduced order finite dimensional system, which enables the design of a low dimensional controller for a diffusion-convection-reaction type reactor described by second order parabolic PDEs.[7] Ozorio Cassol et al. designed and compared the performance of a full-state and output feedback controller for a diffusion-convection heat exchanger system.[8] In Khatibi et al.'s work, an axial dispersion tubular reactor equipped with recycle stream is considered as a second order parabolic DPS, with a predictive controller being utilized to optimally control the reactor.[9] Although the presence of recycle is common in industrial reactor designs, this work is one of the few contributions in the literature that addresses a diffusion-convection-reaction system equipped with a recycle stream.

In addition, convection-reaction reactors that are generally modelled by first order hyperbolic PDEs are addressed in several contributions. The optimal control of systems governed by an example of first order hyperbolic PDE has been carried out by solving an operator Riccati equation (ORE).[10] The work has been further extended for time-varying PDEs of the same class.[11] Same approach has been used to come up with a full-state feedback[12] and output feedback[13] LQ optimal regulator for a boundary controlled convection-reaction system.

2 Methodology

3 Results

4 Conclusion

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