INSTITUT NATIONAL DES SCIENCES APPLIQUÉES CENTRE VAL DE LOIRE

THÈSE
présentée à l'INSA Centre Val de Loire

POUR OBTENIR LE GRADE DE DOCTEUR
DE L'INSA CENTRE VAL DE LOIRE

PAR

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ÉCOLE DOCTORALE
MATHEMATIQUES, INFORMATIQUE, PHYSIQUE THEORIQUE ET INGENIERIE DES SYSTEMES

Discipline/ Spécialité : **Sciences et technologies industrielles / Automatique**

Boundary Observer-based 0utput Feedback Control of Coupled Parabolic PDEs

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Soutenue le : **17/12/2018 – 10h**
INSA Centre Val de Loire – Salle des Conseils
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Imprimé n°140 – 18/02/13 - DRV

RÉSUMÉ

This thesis aims to design a boundary observer-based output feedback controller for a class of systems modelled by linear coupled parabolic PDEs by using the backstepping method. Roughly speaking, the backstepping method for PDEs mainly consists of transforming some kinds of PDEs into some particular PDEs, that are easy to analyze and stabilize by using controllers or observers. This kind of particular PDEs will be called target systems. Firstly, it considers an easy case of coupled **reaction-diffusion equations with the same constant diffusion parameter**. For this case, it proposes a more relaxed stability condition for the target system of the backstepping transformation. Moreover, for the same case, it designs a backstepping boundary observer-based output feedback controller. Then, it takes an example to verify the proposed method. It also deals with a class of systems modelled by **reaction-advection-diffusion equations with the same constant diffusion parameter**, which are realized by proposing particular conditions on the target systems. Secondly, it deals with a kind of systems modelled by coupled **reaction-diffusion equations with different diffusions**. In a similar way, it designs a boundary observer for this kind of systems. However, due to the fact that the constant diffusions are not the same, it is more difficult to solve the kernel functions of the backstepping transformation than the same diffusion case. For this, an assumption on the kernel functions is made to enable us to solve the problem. Moreover, it also designs a backstepping boundary controller based on the proposed stability conditions. Those stability conditions are more relaxed than the conditions we can find in the literatures on this topic. Then, based on the Separation Principle, it designs an observer-based output feedback controller. It takes a simplified model of Chemical Tubular Reactor to highlight the proposed method. Thirdly, this thesis designs a boundary observer as a more general extension by studying a class of systems modelled by coupled **reaction-advection-diffusion equations with spatially-varying coefficients**, which is more challenged to solve kernel functions of the backstepping transformation. To achieve this, it transforms the parabolic kernel equations into a set of hyperbolic equations. Then, it proves the well-posedness by setting suitable boundary conditions for the kernel functions. Moreover, it also provides the stability conditions for the target systems. The performance of the proposed observer is illustrated by taking a numerical model. Fourthly, it extends the above backstepping observer-based output feedback controller to **fractional-order PDE systems**. Finally, conclusions are outlined with some perspectives.

Index Terms: Parabolic PDEs, Coupled system, Dirichlet-type boundary, Neumann-type boundary, Backstepping method, Boundary controller, Boundary observer, Output feedback control, Lyapunov stability, Fractional-order system.

Imprimé n°140 – 18/02/13 - DRV