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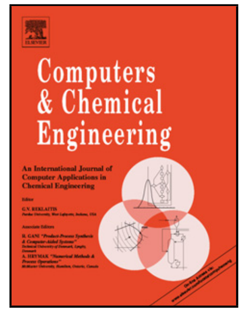

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Analysis of the multiplicity of steady-state profiles of two tubular reactor models

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Abstract

This paper deals with the analysis of two tubular reactor models, the non isothermal tubular reactor model and a biochemical reactor model. It is mathematically shown in particular that multiple equilibrium profiles can be exhibited if the diffusion coefficients are large enough by considering regular perturbation arguments.

Keywords: Reaction systems, multiple equilibrium profiles, tubular reactor, exothermic reaction, biochemical reaction

1. Introduction

The dynamics of reaction systems is usually described by nonlinear models that most of the time exhibit multiple equilibrium points. The development of such models have indeed largely been motivated by practical issues and the need to emphasize phenomena encountered in the real life. The exothermic CSTR (continuous stirred tank reactor) model (e.g. [27]) has been developed to address the issue of the presence of unstable steady-states in industrial chemical reactors, and in particular in the polymer industry, involving exothermic reactions also known as runaway reactions that require the careful design and application of appropriate feedback control laws in order to maintain the process in stable conditions. The use of the Haldane function for the specific growth rate, a non-monotonic function of the limiting substrate concentration, has been considered by [2] to emphasize overloading effects in biochemical processes like the anaerobic digestion where the accumulation of volatile fatty acids may lead to the wash-out of the process, i.e. the disappearance of the active micro-organisms. In ecology, Vito Volterra was motivated to develop a model, the predator-prey model, to address the periodic behaviour of the predators and the preys, an issue that had been raised by his future son-in-law Umberto D'Ancona, a marine biologist, who was puzzled by the behaviour of Selachians in the upper Adriatic sea [21]. All these models are indeed very simple (only two differential equations), simply based on mass (and energy for the CSTR) balance considerations, yet very rich in terms of the dynamical properties. The multiplicity of the equilibrium points and their stability have been largely analyzed and explained