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MULTIPLE EQUILBRIUM PROFILES FOR NONISOTHERMAL TUBULAR REACTOR NONLINEAR MODELS

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Abstract. The multiplicity of the equilibrium profiles is shown for axial dispersion nonisothermal tubular reactors described by Arrhenius type nonlinear models. It is proved that there is at least one steady state among the physically feasible states for such models. Moreover physically meaningful conditions which ensure the multiplicity of equilibrium profiles are given.

Keywords. Tubular Reactor, Equilibrium profiles, Compact C_0-semigroup, Nonlinear Operators, Fixed points, Ordered Banach space.
AMS (MOS) subject classification: 80A30, 93C20, 34G20.

1 Introduction

The dynamics of nonisothermal tubular reactors are described by nonlinear partial differential equations. The main source of nonlinearities in such dynamics is concentrated in the kinetics terms of the model equations. It is well known that the existence of Arrhenius type nonlinearities in the kinetics can generate multiple steady states, i.e. equilibrium profiles, either stable or unstable, and that in practical applications, the unstable steady states may correspond to the operating points of interest. The study of the steady state multiplicity and stability has been the object of intensive research activity in the sixties and seventies: most of the results are gathered in the book chapter written by Varma and Aris [15]. Multiple steady states have been observed experimentally, e.g. in stirred tank reactors [9, 16]. If the steady state multiplicity and stability of stirred tank reactors is now well understood, the tubular reactor case is still the object of research works. As a matter of example, Varma and Aris [15] emphasize sufficient conditions for the uniqueness of steady states for adiabatic reactors (i.e. when there is no heat exchange term) in the very particular case when the energy diffusion coefficient is equal to the mass diffusion coefficient. They also show that in the presence of multiple steady states for the above tubular reactor, these are alternatively stable and unstable. The case of unequal diffusion coefficients has been considered by Deimling [5] who showed the steady-state multiplicity, yet in unrealistic conditions, i.e. when the reactor temperature is lower than the inlet and cooling temperature in an exothermic reactor. Our objective is to emphasize the steady state multiplicity for nonisothermal reactor nonlinear models in more realistic conditions than those considered in [5].

In this paper, the multiplicity of the equilibrium profiles is shown for axial dispersion nonisothermal tubular reactors governed by Arrhenius type nonlinear models. It is essentially proved that there is at least one steady state among the physically feasible states for such models. In addition physically meaningful conditions are