CHAPTER 11

Catalytic Reactors: Power Generation and Fuel Processing

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The large surface-to-volume ratios of microreactors favor the use of catalytic reactions as opposed to volumetric gas-phase reactions. Latest designs of efficient catalytic microreactors for portable power generation and for on-board fuel reforming are outlined. The underlying physicochemical processes are presented and state-of-the-art numerical models for catalytic microreactors are reviewed. The key mechanisms affecting the thermal management of catalytic microreactors are elaborated and, finally, numerical and experimental investigations of steady and transient operation of catalytic microreactors and microreformers are presented.

11.1 INTRODUCTION TO CATALYTIC COMBUSTION

Complete or partial catalytic oxidation of low hydrocarbons over catalytically active surfaces is used in many technical processes, such as chemical synthesis, exhaust gas treatment, fuel reforming, fuel cells, microreactors, and gas turbines for power generation. These processes have been the subject of many research and development efforts over the last years. Heterogeneous (catalytic) combustion has been intensively investigated for gas turbines of power generation systems since the early 1970s, aiming at a significant reduction of NO_x emissions and improved combustion stability.

Initially, the catalytically stabilized thermal combustion (CST) concept was developed [1]. In the CST methodology, part of the fuel is converted heterogeneously in one or more sequential catalytic reactor modules, while the remaining fuel is combusted homogeneously in a post-catalyst flame. Since heterogeneous combustion is a flameless process and does not contribute to NO_x formation, CST provides an ultralow NO_x combustion technology with demonstrated NO_x emissions less than 3 ppm under turbine-relevant conditions [2, 3]. Compared to NO_x after-treatment techniques, this technology can lead to a significant cost reduction and offers a possibility to meet the stringent NO_x emission regulations in Europe and the United States. Furthermore, CST improves the flame stability and reduces combustion-induced pressure pulsations when compared to the conventional lean-premixed combustion approaches. By using