HEAT TRANSFER MODELLING OF STEAM METHANE REFORMING

E. Carcadea[1], M. Varlam[1], I. Stefanescu[1]

[1]National Research Institute for Isotopic & Cryogenic Technologies, Rm.Vâlcea, Romania

Abstract

Steam methane reforming is a widely studied process because of its importance for hydrogen production. A two-dimensional membrane-reactor model was developed to investigate the steam-methane reforming reactions. The use of membrane as membrane-reactor separator offer us few advantages because it help in continuously removing the hydrogen from the reaction zone, shifting the chemical equilibrium towards products and enabling operation at lower temperatures. It is well known that optimum conversions should be reached for a given combination of operating parameters (pressure, temperature, steam to methane feed flow rate). The paper reports the results of a heat transfer modeling of a membrane reactor for methane steam reforming, study developed in order to analyze the importance of temperature for methane conversion and hydrogen yield. COMSOL Multiphysics software was applied to analyze the steam methane reforming in the chemical reactor investigated. In our simulation two domains were taken into account (reforming and permeating) while the membrane was considered one dimensional. The model couples the Maxwell - Stefan Diffusion and Convection to the Darcy law and to Navier-Stokes equation for both reforming and permeation zone, to account for the variation in gas density which results from the extraction/permeation of H2. The flux of hydrogen through the membrane is proportional to the permeability of the membrane and inversely proportional to the membrane thickness. The driving force for the hydrogen flux is related to the hydrogen partial pressure or molar concentration (Sievert's law). The temperature difference between the reforming and the sweep gas area was analyzed in our study to give us an insight regarding the interaction between the flow, chemical reaction and temperature. The aim was to determine the maximum value of temperature in the sweep area of the porous membrane reactor, close to the inner permeation tubes, because the maximum values of temperature for long life and maximum performance of these tubes is close to 450 K. The simulation results show that in the sweep area an increase of temperature up to 617 K can be noticed on the external wall but in the middle on the sweep area where the inner permeation tubes are located the temperature is about 450 K, which is a proper temperature for maximum performance and long life. Also, it was found that an increase in the wall temperature of the reforming side has a positive effect in hydrogen production and permeation. Therefore, a two-dimensional axisymmetric CFD code (COMSOL Multiphysics) was applied to analyze the effect of external wall temperature on the reactor performance and some remarks have been made about its influence on hydrogen permeation.