ID 1049

Steam Methane Reforming Enhanced by Oxygen for Hydrogen Production

Bellal Mohamed Nazim[1, 2*], Saouli Ouacil[1,2]

[1] department de Génie des Procédés Ecole Nationale Polytechnique de Constantine, Algerie

[2] Laboratoire de Génie des Procédés pour le Développement Durable et les Produits de Santé, Ecole Nationale Polytechnique de Constantine, Algerie

*Corresponding author's email: nazimnazim2@gmail.com

ABSTRACT

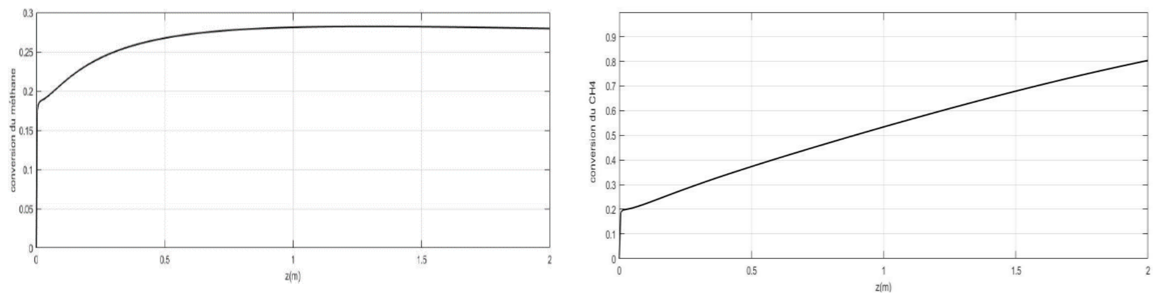
This research assesses the performance of fluidized bed reactors, one with a membrane and the other without, in conducting steam methane reforming (SMR) enhanced with Oxygen within a non-isothermal setting. We employed a well-known mathematical Model to simulate the process, utilizing MATLAB to execute the model computations. The model is built on a one-dimensional, dual-phase, incorporating both the emulsion and bubble phases. The findings from this comparative analysis underscore the primary benefit of utilizing fluidized-bed reactors: the dynamic solid particles within facilitate an even distribution of heat. Moreover, the study highlights the efficiency of this approach to SMR reaction in substantially lowering energy demands.

Keywords: fluidized bed reactor; heat exchange; steam methane reforming; hydrogen production

1. Introduction

The use of H2 permselective membranes in chemical reactors emerges as a technology for intensifying chemical processes by improving their performance compared to conventional processes (without membranes) [1]. A membrane reactor is a device that combines a chemical reactor and a permeable membrane into a single unit. Membranes are introduced to selectively add or remove chemical species. For example, chemical reactants can be added along the reactor to enhance selectivity towards a desired product, or reaction products can be selectively removed to favorably alter the equilibrium as indicated by Le Chatelier's principle [2]. The aim of this work is to study the steam reforming process, methane combustion in a fluidized bed membrane reactor operating at moderate temperatures and pressures through system modeling to improve its performance. Presenting the various results obtained from solving the ordinary differential equations that describe the mass and energy balance across a fluidized bed membrane reactor for hydrogen synthesis. These results include the temperature profile across the reactor, the methane conversion rate, and the hydrogen production rate. A comparative study between steam methane reforming (SMR) and autothermal reforming (ATR) processes was also conducted in both isothermal and non-isothermal systems.

2. Results and Discussions

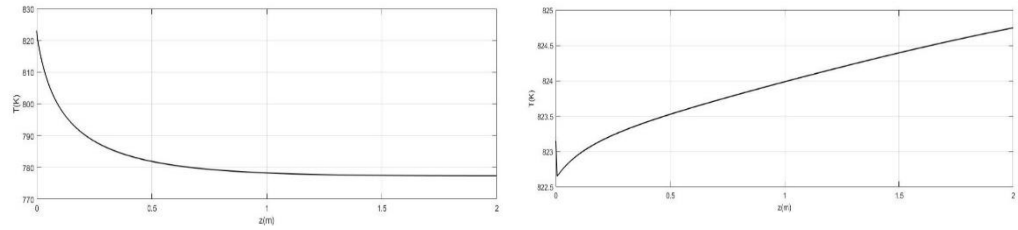


(A) (B)

Figure 1: (A) conversion Rate without ATR reaction (B) conversion rate with ATR reaction

Figure 1 represent the direct comparison between the reaction conversion rate of the steam methane reforming with and without ATR.

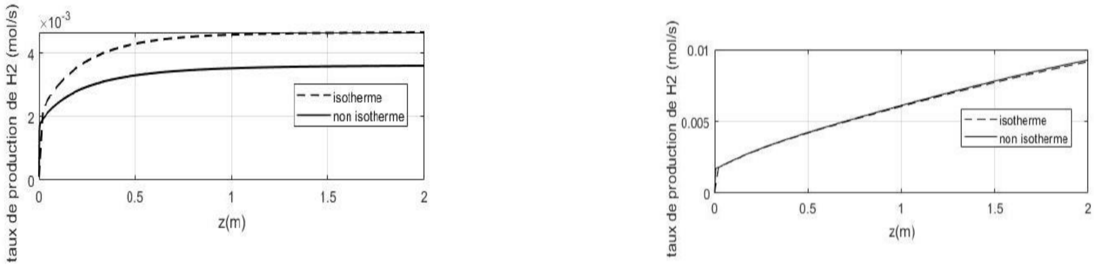
DOI: 10.21467/abstracts.169 ISBN: 978-81-970666-4-1 (eBook)



(A) (B)

Figure 2: (A) temperature profile without ATR reaction (B) temperature profile with ATR reaction [K]

Figure 2 shows the temperature profile of the steam methane reforming with and without ATR, it is clear the with the presence of oxygen in the system helps maintaining a more stable temperature.



(A)

(B)

Figure 3: (A) Hydrogen production rate without ATR (B) Hydrogen production rate with ATR [mol/s]

Figure 3 shows the impact of the operating system temperature on hydrogen production it is clear the ATR system helps at maintaining the isotherm condition of the system.

3. Conclusion

The results obtained confirm the advantages of using a fluidized bed membrane reactor in the autothermal reforming (ATR) process for hydrogen production, especially in terms of increased methane conversion rates and hydrogen production rates. The comparative study during the operation of the steam methane reforming (SMR) process in a fluidized bed, both in isothermal and non-isothermal systems, revealed that the endothermic effect of the reaction leads to a reduction in methane conversion rates and hydrogen production rates. In parallel, the comparative study of the autothermal reforming (ATR) process in the fluidized bed membrane reactor demonstrated that the system exhibited minimal temperature variation, only 2°C. This highlights one of the major advantages of fluidized beds over conventional beds, which is the ability of the moving solid particles to facilitate uniform heat distribution and minimize temperature variations across the bed.

References

[1] W. J. Sheu, Z. W. Hsu, W. H. Chen, and Y. C. Chen, "Investigation of steam methane reforming in a Pd–Ru membrane reactor with a counter-current configuration," *Int J Hydrogen Energy*, vol. 52, pp. 938–952, Jan. 2024, doi: 10.1016/j.ijhydene.2023.04.009.

[2] B. Hejazi, J. R. Grace, X. Bi, and A. Mahecha-Botero, "Kinetic Model of Steam Gasification of Biomass in a Bubbling Fluidized Bed Reactor," *Energy and Fuels*, vol. 31, no. 2, pp. 1702–1711, Feb. 2017, doi: 10.1021/acs.energyfuels.6b03161.

ISBN: 978-81-970666-4-1

Series: AIJR Abstracts

DOI: 10.21467/abstracts.169