THERMODYNAMIC ANALYSIS OF HYDROGEN PRODUCTION FROM GLYCEROL AT ENERGY SELF-SUFFICIENCY CONDITIONS

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Summary

A thermodynamic analysis based on the principle of minimizing the Gibbs free energy is performed on the hydrogen production from glycerol. It was demonstrated that when the operating parameters such as water/glycerol ratio (WGR), oxygen/glycerol ratio (OGR) and operating temperature are carefully chosen, the energy self-sufficiency conditions can be achieved. Two levels of energy self-sufficiency, i) within the reformer and ii) within the overall system, are considered and the obtained hydrogen production is compared. Unlike the former system, the latter system represents a more realistic operation in which some energy is required for heating up the feeds to a desired operating temperature. It was clearly shown that much less hydrogen production is achieved when the system is operated without relying on external heat sources. Finally, the maximum hydrogen production achievable for each system is determined and its corresponding operating condition is reported.

Keywords

Hydrogen production, glycerol, thermodynamic analysis

Introduction

Glycerol ($C_3H_8O_3$) is a major byproduct from biodiesel production. An excessive glycerol is expected due to the large increase in biodiesel production. Many researchers have been looking for potential applications of glycerol. Hydrogen production from glycerol has attracted a number of researchers as hydrogen is a main fuel in most fuel cell applications. The synthesis can be carried out via different reactions such as gasification, steam reforming (SR) [1], aqueous-phase reforming (APR) and autothermal Reforming (ATR) [2].

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In this work, the hydrogen production from glycerol was investigated based on thermodynamic analysis. Particular interest was on the conditions which offer energy self-sufficiency and the corresponding hydrogen yield was revealed at two different levels of sufficiency (i.e., reactor and system levels).

Results and discussion

Fig. 1 shows the effects of WGR and OGR on net heat (Q_{net}) of the reformer and the system at T = 940 K. There are some conditions at which the reformer or the system can be operated at their energy self-sufficiency (Q_{net} = 0). It should be noted that the condition can be achieved by appropriate adjustment of three variables including WGR, OGR, and temperature. However, only two variables can be specified and there is only one possible condition for the other variable to satisfy the energy self-sufficiency condition.

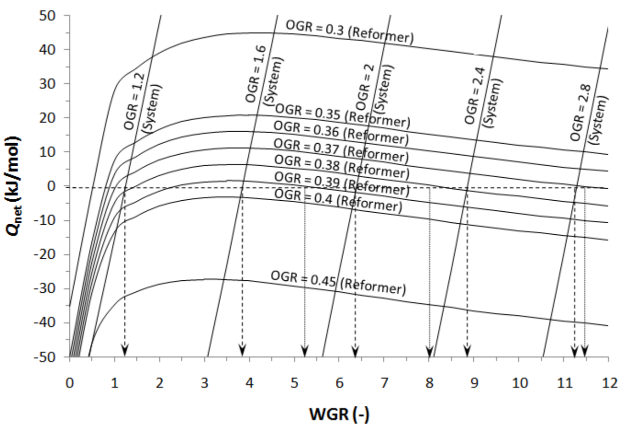

Fig. 1. Net heat energy (Q_{net}) of reformer and system as different WGR and OGR (T = 940 K).

The maximum hydrogen production for each value of WGR can be determined by searching for an optimum value of OGR which offers the highest hydrogen production. Fig. 2. shows the maximum hydrogen production achievable for different values of WGR and their corresponding values of OGR and T while Fig. 3 shows the obtained product distributions. It is obvious that when the hydrogen production achieved from the reformer energy self-sufficiency is much less than that from the system energy self-sufficiency. However, the latter is a more practical consideration as the operation requires no external energy.

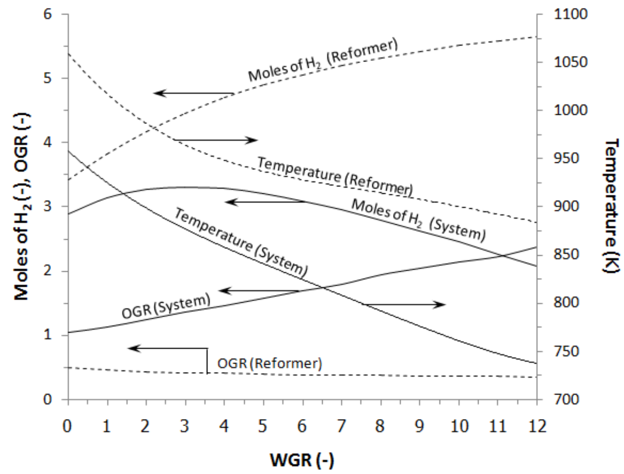

Fig. 2. Maximum of H_2 production at different values of WGR and their corresponding values of OGR and T.

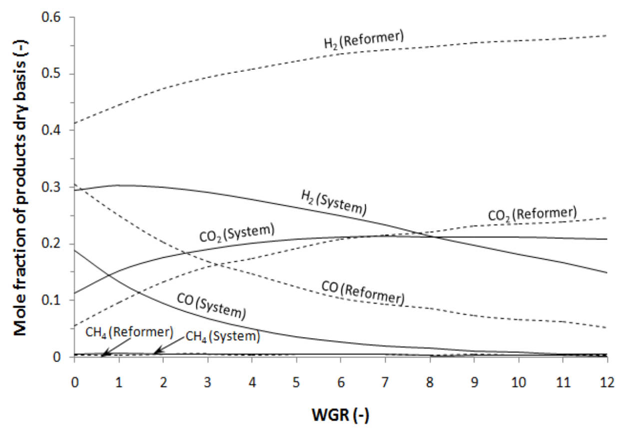

Fig. 3. Mole fraction of products.

The obtained results were further discussed in term of later applications of the obtained products as feeds for solid oxide fuel cell (SOFC), proton exchange membrane fuel cell (PEM) and chemical production via synthesis gas.

References

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