中文摘要

本研究乃設計一組火花放電式常壓電漿燃料轉換器，針對氫氣產出特性進行實驗研究。研究方法係利用火花放電所產生之高壓電弧對碳氫燃料與空氣混合物產生離子化交互作用，藉由其能量來破壞碳氫燃料之鍵結，後端再配合觸媒催化來重組產出富氫氣體。本論文主要分爲兩大部份，包括不同設定參數對於常壓電漿燃料轉換器產氫之特性比較，以及不同操作條件下對於重組性能提昇之差異。
其中第一部份乃探討多種碳氫燃料於不同 O2/C(氧/碳莫耳數)比、燃料進料流率、空間速度以及重組氣體溫度下對整體重組性能的影響比較。經實驗證實，以甲烷爲重組燃料可獲得較佳之重組效能，並與其他低碳燃料相較，在相同燃料轉化效率之下，氫氣產率也較佳，且於較低重組氣體溫度即可獲得較佳之氫氣選擇性。而第二部份乃探討不同觸媒規格、添加水汽與節能方式(熱回收及熱絕緣)對產出富氫氣體的影響，並利用 SEM 來瞭解觸媒積碳特性。最後再搭配電漿重組參數組合(PRP)，來探討整體重組性能之關係。經實驗證實，觸媒於較高 Pt/Rh 比例、被覆量與較多觸媒孔數確實可以有效增加氫氣之選擇性。且採用節能方式的確可以有效增加甲烷轉化效率，並藉以提高氫氣及一氧化碳的產出濃度。其中熱回收方式以較低甲烷進料率會有較佳的甲烷轉化效率，最多可提昇 8.7 %左右，但隨著甲烷進料率的增加其提昇量越有限。此外在相同的操作參數下，添加水汽證實可以有效增加氫氣產率，但會使甲烷的選擇性較高。整體而言，本系統最佳參數爲甲烷進料流率 10 L/min、O2/C 比 0.8，其整體熱效率可高達 77.77 %；若再配合加入適量水汽 S/C(水/碳莫耳數)比爲 0.5 時，可使氫氣產率(Yield)高達 86.26 %，換算氫氣產出流率約爲 17.25 L/min。並利用 HSC 商用軟體來計算理論平衡產出，其值與實驗結果也相當吻合。

英文摘要

This study was to investigate a spark discharge plasma fuel converter for hydrogen production under atmospheric pressure. A spark discharge was used to ionize the hydrocarbon fuel and air mixture, and the catalyst was combined to enhance the hydrogen production. The thesis covers two subjects, including various setting parameters and different operating conditions for plasma fuel converter on the enhancement of reforming performance. The first subject was to investigate O2/C ratio, fuel feeding rate, space velocity and reformate gas temperature on the reforming performance for various hydrocarbon fuels. The experimental results demonstrated that the better performance could be obtained by methane reforming. Comparing with other low carbon fuels, the better hydrogen production was achieved under the same fuel conversion efficiency. Furthermore, the better hydrogen selectivity was got even at the lower reformate gas temperature. The second subject was to investigate the effects of catalyst, water addition and energy saving (heat recycling and heat insulation) on hydrogen-rich gas production. In addition, SEM photos were used investigate the carbon deposition on the catalyst. Finally, the plasma reforming parameter (PRP) with the reforming performance was investigated. The results showed that the better hydrogen selectivity could be obtained with high Pt/Rh ratio、loading amount and cell number. The concentrations of hydrogen and carbon monoxide could be improved due to the increase in the methane conversion efficiency by using the energy saving system. Under the condition of lower methane feeding rate, 8.7 % improvement in the methane conversion efficiency could be achieved by the energy saving system. However, the improvement was not apparent with higher methane feeding rate. In addition, the hydrogen production increased obviously with the water gas shifting reaction under the same operation parameters but a high methane selectivity. As a whole, the total thermal efficiency of 77.77 % could be achieved under the combination of 10L/min methane feeding rate and 0.8 O2/C ratio. 86.26 % hydrogen yield, being equivalent to 17.25 L/min hydrogen production rate could be obtained if the water gas shifting (S/C ratio= 0.5) was performed. Simultaneously, a commercialized program, HSC software was used to calculate the equilibrium production. It showed that the coincidence between the experimental and the calculated results.