COMBINED REFORMING AND PARTIAL OXIDATION OF CO_2-CONTAINING NATURAL GAS USING LOW-TEMPERATURE GLIDING ARC DISCHARGE: EFFECT OF STAGE NUMBER OF PLASMA REACTORS

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วริยา จิตเที่ยง : การรวมกระบวนการเปลี่ยนรูปและการออกซิเดชันบางส่วนของก๊าซธรรมชาติที่มีคาร์บอนไดออกไซด์เป็นองค์ประกอบในระบบพลาสมาประกายไฟฟ้าร่อนอุณหภูมิต่ำแบบหลายขั้นตอน: ผลกระทบของจำนวนเครื่องปฏิกรณ์ (Combined Reforming and Partial Oxidation of CO_2-Containing Natural Gas Using Low-Temperature Gliding Arc Discharge: Effect of Stage Number of Plasma Reactors) อ. ที่ปรึกษา : ดร.ธรรมนูญ ศรีทะวงศ์ และ รศ. ดร. สุเมธ ชวเดช, 93 หน้า

ระบบพลาสมาประกายไฟฟ้าร่อนอุณหภูมิต่ำแบบหลายขั้นตอนได้ถูกนำมาใช้ในการศึกษาผลกระทบของจำนวนเครื่องปฏิกรณ์ต่อการเกิดปฏิกิริยาของระบบการรวมการเปลี่ยนรูปและการออกซิเดชันบางส่วนของก๊าซธรรมชาติจำลองที่มีคาร์บอนไดออกไซด์เป็นองค์ประกอบ โดยมีอัตราส่วนโดยโมลของก๊าซมีเทน, ก๊าซอีเทน, ก๊าซโพรเพน, และก๊าซคาร์บอนไดออกไซด์เป็น 70:5:5:20 ในการศึกษาปฏิกิริยาออกซิเดชันแบบบางส่วน ออกซิเจนบริสุทธิ์และอากาศถูกนำมาใช้เป็นแหล่งของก๊าซออกซิเจนโดยมีอัตราส่วนระหว่างไฮโดรคาร์บอนต่อออกซิเจนเป็น 2/1 จากการศึกษาพบว่าในระบบที่ไม่มีการออกซิเดชันบางส่วนและมีอัตราการไหลของสารตั้งต้นคงที่ ค่าการเปลี่ยนแปลงของสารตั้งต้นทั้งหมดยกเว้นก๊าซคาร์บอนไดออกไซด์เพิ่มขึ้นเมื่อเพิ่มจำนวนเครื่องปฏิกรณ์เป็น 3 เครื่อง แต่ถ้าเพิ่มจำนวนเครื่องปฏิกรณ์มากกว่า 3 เครื่อง ค่าการเปลี่ยนแปลงของสารตั้งต้นจะไม่เปลี่ยนแปลงต่อไป สำหรับระบบที่มีการควบคุมให้มีเวลาในการเกิดปฏิกิริยาคงที่ มีเฉพาะค่าการเปลี่ยนแปลงของก๊าซโพรเพนเท่านั้นที่เพิ่มขึ้นเล็กน้อย ในขณะที่ค่าการเปลี่ยนแปลงของสารตั้งต้นตัวอื่นๆไม่เปลี่ยนแปลงมากนักเมื่อจำนวนของเครื่องปฏิกรณ์เพิ่มขึ้น เมื่อทำการเติมก๊าซออกซิเจนให้แก่ระบบพบว่าช่วยเพิ่มประสิทธิภาพในการเปลี่ยนรูปของก๊าซธรรมชาติเป็นอย่างมาก ซึ่งการใช้อากาศเป็นแหล่งของก๊าซออกซิเจนส่งผลดีต่อประสิทธิภาพของระบบมากกว่าการใช้ออกซิเจนบริสุทธิ์ ทั้งในแง่ของค่าการเปลี่ยนแปลงของสารตั้งต้น ค่าผลได้ และค่าการเลือกเกิดของผลิตภัณฑ์ที่ต้องการ และค่าการใช้พลังงานไฟฟ้า โดยพบว่าค่าการใช้พลังงานไฟฟ้าที่เหมาะสมสำหรับการเปลี่ยนแปลงสารตั้งต้น คือ 3.21×10^{-18} วัตต์ วินาที ต่อโมเลกุลของสารตั้งต้นที่เปลี่ยนแปลงไปและ 2.57×10^{-18} วัตต์ วินาที ต่อโมเลกุลของก๊าซไฮโดรเจนที่ผลิตได้ ซึ่งได้จากระบบที่มีการใช้อากาศเป็นแหล่งของก๊าซออกซิเจนและใช้เครื่องปฏิกรณ์จำนวน 3 เครื่อง โดยควบคุมเวลาของการเกิดปฏิกิริยาให้คงที่ที่ 4.38 วินาที

ABSTRACT

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The effect of the stage number of a multistage AC gliding arc discharge system on the system performance of the combined reforming and partial oxidation of simulated CO_2-containing natural gas having a CH_4:C_2H_6:C_3H_8:CO_2 molar ratio of 70:5:5:20 was investigated. For the experiments with partial oxidation, either pure oxygen or air was used as an oxygen source, with a hydrocarbons-to-oxygen molar ratio of 2/1. Without partial oxidation at a fixed feed flow rate, all conversions of hydrocarbons, except CO_2, greatly increased with increasing number of stages from 1 to 3; but beyond 3 stages, the reactant conversions remained almost unchanged. However, for a fixed residence time, only C_3H_8 conversion gradually increased, whereas the conversions of other reactants remained almost unchanged with increasing number of stages. The addition of oxygen was found to significantly enhance the system performance of natural gas reforming. The utilization of air as an oxygen source showed a superior system performance to pure oxygen in terms of reactant conversions, desired product yields and selectivities, and power consumptions. The optimum power consumptions of 3.21×10^{-18} Ws per molecule of reactant converted and 2.57×10^{-18} Ws per molecule of hydrogen produced were obtained using air as an oxygen source and 3 stages of plasma reactors at a fixed residence time of 4.38 s.

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