COMBINED STEAM REFORMING OF CO_2-CONTAINING NATURAL GAS AND PARTIAL OXIDATION IN A MULTISTAGE GLIDING ARC DISCHARGE SYSTEM

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ABSTRACT

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When commercially converting methane to synthesis gas, conventional catalytic processes require both high temperature and high pressure, resulting in high energy consumption and catalyst deactivation. Non-thermal plasma is considered a promising alternative technology for synthesis gas production because it can be operated in ambient conditions. In this research, the effect of stage number of multistage gliding arc discharge system on the process performance of combined steam reforming and partial oxidation of simulated natural gas was investigated. The simulated natural gas contained 70% methane, 5% ethane, 5% propane and 20% carbon dioxide. The experiments were carried out to investigate reactant conversions, product selectivities and yields, and power consumption by varying either residence time or stage number of plasma reactors, feed flow rate, hydrocarbons (HCs)/O_2 feed molar ratio and input voltage. An increase in stage number from 1 to 3 stages at a constant feed flow rate enhanced the reactant conversions, and H_2 yield with a reduction of energy consumption. The lowest energy consumption of 3.49×10^{-17} Ws per molecule of reactants converted or 2.04×10^{-17} Ws per molecule of hydrogen produced was obtained from 3 stages of plasma reactors at a residence time and feed flow rate of 4.11 s and 100 cm^3/min, respectively.

บทคัดย่อ

นริสรา อาทิเวช : การรวมกระบวนการเปลี่ยนรูปด้วยไอน้ำของก๊าซธรรมชาติที่มีคาร์บอนไดออกไซด์เป็นองค์ประกอบและการออกซิเดชันบางส่วนภายใต้ระบบพลาสมาประกายไฟฟ้าร่อนแบบหลายขั้นตอน (Combined Steam Reforming of CO_2-Containing Natural Gas and Partial Oxidation in a Multistage Gliding Arc Discharge System.) อ. ที่ปรึกษา : ศ. ดร. สุเมธ ชวเดช 67 หน้า

ในทางการค้าการเปลี่ยนรูปก๊าซมีเทนให้เป็นก๊าซสังเคราะห์จะใช้กระบวนการแบบดั้งเดิมที่มีตัวเร่งปฏิกิริยานั้น เป็นกระบวนการที่ต้องใช้ความร้อนและความดันสูง ส่งผลให้การใช้พลังงานไฟฟ้าสูงและเกิดการเสื่อมของตัวเร่งปฏิกิริยาเร็วขึ้น ระบบพลาสมาที่ไม่ใช้ความร้อนถือว่าเป็นเทคโนโลยีทางเลือกสำหรับการผลิตก๊าซสังเคราะห์ เพราะระบบนี้สามารถปฏิบัติได้ได้สภาวะบรรยากาศ ในงานวิจัยนี้ ระบบพลาสมาประกายไฟฟ้าร่อนแบบหลายขั้นตอนได้ถูกนำมาใช้ในการศึกษาผลกระทบของจำนวนเครื่องปฏิกรณ์ต่อการเกิดปฏิกิริยาของระบบการรวมกระบวนการเปลี่ยนรูปด้วยไอน้ำและการออกซิเดชันบางส่วนของก๊าซธรรมชาติจำลอง โดยที่ก๊าซธรรมชาติจำลองประกอบด้วย ก๊าซมีเทน 70%, ก๊าซอีเทน 5%, ก๊าซโพรเพน5%, และก๊าซคาร์บอนไดออกไซด์ 20% ในงานวิจัยนี้ได้ดำเนินการเพื่อทำการศึกษาผลกระทบของตัวแปรต่างๆ ได้แก่ การเปลี่ยนแปลงของสารตั้งต้น, การเลือกเกิดของผลิตภัณฑ์, ค่าผลได้ของผลิตภัณฑ์, และกำลังไฟฟ้าที่ใช้ โดยการเปลี่ยนค่าเวลาที่สารตั้งต้นอยู่ในเครื่องปฏิกรณ์ซึ่งสามารถควบคุมจากจำนวนเครื่องปฏิกรณ์และอัตราการไหลของสารตั้งต้น, ค่าอัตราส่วนระหว่างไฮโดรคาร์บอนต่อออกซิเจน, และค่าความต่างศักย์ เมื่อเพิ่มจำนวนเครื่องปฏิกรณ์จาก 1 เครื่อง ไปเป็น 3 เครื่อง สำหรับระบบที่มีการควบคุมอัตราการไหลให้มีค่าคงที่ซึ่งช่วยปรับปรุงค่าการเปลี่ยนแปลงของสารตั้งต้น, ค่าผลได้ของผลิตภัณฑ์ รวมทั้งการลดลงของพลังงานไฟฟ้าที่ใช้ด้วย พลังงานที่ใช้ต่ำที่สุดคือ 3.49×10^{-17} วัตต์วินาทีต่อโมเลกุลของสารตั้งต้นที่เปลี่ยนแปลงไป และ 2.04×10^{-17} วัตต์วินาทีต่อโมเลกุลของก๊าซไฮโดรเจนที่ผลิตได้ ซึ่งได้รับค่านี้จากการทดลองที่ใช้เครื่องปฏิกรณ์จำนวน 3 เครื่อง สำหรับระบบนี้ควบคุมเวลาที่สารตั้งต้นอยู่ในเครื่องปฏิกรณ์ 4.11 วินาที และอัตราการไหล 100 ลูกบาศก์เมตรต่อนาที

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