

**REFORMING OF NATURAL GAS USING
AN ALTERNATING CURRENT GLIDING ARC SYSTEM**



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นงคณูช เรื่องจิตต์ : การเปลี่ยนรูปของก๊าซธรรมชาติโดยใช้ระบบประกายไฟฟ้าร้อนแบบกระแสสลับ (Reforming of Natural Gas Using an Alternating Current Gliding Arc System) อ. ที่ปริกษา : รศ. ดร. สุเมธ ชวเดช และ รศ. ดร. ฮิเดโตะชิ เซคิกุจิ 126 หน้า

ในงานวิจัยนี้ การเปลี่ยนรูปของก๊าซธรรมชาติได้ถูกดำเนินการโดยใช้ระบบประกายไฟฟ้าร้อนแบบกระแสสลับ ภายใต้สภาวะบรรยากาศ โดยได้มีการศึกษาผลกระทบต่าง ๆ ได้แก่ องค์ประกอบของก๊าซไฮโดรคาร์บอนอื่น ๆ และก๊าซคาร์บอนไดออกไซด์ ที่มีอยู่ในก๊าซธรรมชาติ, ปัจจัยที่เกี่ยวข้องกับกระบวนการ และการเติมก๊าซออกซิเจน โดยพบว่า ก๊าซอีเทน, ก๊าซโพรเพน และก๊าซคาร์บอนไดออกไซด์ที่มีอยู่ในก๊าซธรรมชาติมีส่วนในการช่วยเพิ่มประสิทธิภาพการเกิดปฏิกิริยาโดยรวมอย่างเด่นชัด โดยเฉพาะอย่างยิ่งก๊าซคาร์บอนไดออกไซด์ซึ่งมีคุณสมบัติในการเป็นก๊าซออกซิเดทีฟ ซึ่งแสดงผลเพิ่มอย่างชัดเจนต่อการเพิ่มค่าการเปลี่ยนแปลงก๊าซไฮโดรคาร์บอนทั้งหมดในก๊าซตั้งต้น โดยลดการเกิดโค้ก และลดพลังงานจำเพาะที่ต้องการ ผลของการทดลองแสดงให้เห็นว่า ทั้งความต่างศักย์ไฟฟ้าและความถี่กระแสไฟฟ้า ไม่เพียงแต่มีอิทธิพลเป็นอย่างมากต่อความเสถียรของพลาสมาเท่านั้น ยังมีผลต่อการกระตุ้นปฏิกิริยาของก๊าซธรรมชาติที่มีองค์ประกอบก๊าซคาร์บอนไดออกไซด์สูงด้วย ยิ่งไปกว่านั้นงานวิจัยนี้ได้ทำการทดลองผลของก๊าซออกซิเจนที่เติมในสารตั้งต้นด้วย โดยใช้ก๊าซออกซิเจนบริสุทธิ์หรืออากาศเป็นแหล่งออกซิเจนสำหรับปฏิกิริยาออกซิเดชันบางส่วน โดยสปีชีส์ออกซิเจนหรือสารว่องไวที่ก่อกำเนิดจากก๊าซออกซิเจนที่เติมในก๊าซธรรมชาติ มีบทบาทที่สำคัญในการช่วยลดการเกิดโค้กได้เป็นอย่างมาก นอกจากนี้ยังช่วยเพิ่มค่าการเปลี่ยนแปลงของก๊าซต่าง ๆ ในสารตั้งต้น ค่าผลผลิตของผลิตภัณฑ์และค่าการเลือกสรรในการเกิดผลิตภัณฑ์ รวมทั้งยังช่วยลดความต้องการพลังงานจำเพาะของระบบอีกด้วย โดยอากาศได้ถูกเลือกให้เป็นแหล่งออกซิเจนที่เหมาะสมสำหรับปฏิกิริยาเปลี่ยนรูปก๊าซธรรมชาติกับปฏิกิริยาออกซิเดชันบางส่วนนี้

แนวคิดใหม่ในการนำเทคโนโลยีของประกายไฟฟ้าร้อนอุณหภูมิต่ำร่วมกับเครื่องปฏิกรณ์ขนาดจ๋ว มีข้อดีอยู่หลายประการด้วยกัน เช่น ปฏิกิริยาเกิดได้ที่อุณหภูมิต่ำ เครื่องปฏิกรณ์มีการถ่ายเทและการกระจายความร้อนที่ดี และเวลาในการเกิดปฏิกิริยาสั้น เป็นต้น ดังนั้นงานวิจัยนี้จึงได้นำแนวคิดนี้มาประยุกต์ใช้กับเครื่องปฏิกรณ์ประกายไฟฟ้าร้อน ซึ่งเครื่องปฏิกรณ์ประกายไฟฟ้าร้อนขนาดจ๋วได้ถูกออกแบบเป็นครั้งแรกเพื่อใช้ศึกษาปฏิกิริยาเปลี่ยนรูปก๊าซธรรมชาติแทนเครื่องปฏิกรณ์ประกายไฟฟ้าร้อนแบบดั้งเดิม โดยในการศึกษาเบื้องต้นนี้ ก๊าซมีเทนซึ่งเป็น

องค์ประกอบหลักของก๊าซธรรมชาติได้ถูกใช้แทนก๊าซธรรมชาติ ทั้งนี้เพื่อลดความซับซ้อนของสารตั้งต้น ปฏิริยาเปลี่ยนรูปก๊าซมีเทนนี้ได้ถูกดำเนินการทดลองในเครื่องปฏิกรณ์ประกายไฟฟ้าร้อนขนาดจิ๋ว ทั้งในกรณีมีและไม่มีตัวเร่งปฏิริยา โดยในระบบที่ใช้ประกายไฟฟ้าร้อนอย่างเดียวนั้น ปัจจัยต่าง ๆ ของกระบวนการมีผลกระทบต่อ การเปลี่ยนแปลงก๊าซมีเทนและการเลือกสรรการเกิดผลิตภัณฑ์ ส่วนในระบบที่ใช้ประกายไฟฟ้าร้อนกับตัวเร่งปฏิริยาพบว่า การกระจายตัวของอนุภาคน้ำมันในเครื่องปฏิกรณ์ประกายไฟฟ้าร้อนขนาดจิ๋วมีบทบาทเป็นอย่างมากในการปรับปรุงประสิทธิภาพโดยรวมของปฏิริยา

ABSTRACT

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In this work, the reforming of simulated natural gas was conducted under the alternating current gliding arc system at ambient conditions. The effects of all gaseous hydrocarbons and CO₂ present in the natural gas, process parameters, and O₂ added were investigated. The presence of other gas components (C₂H₆, C₃H₈ and CO₂) in natural gas was found to contribute prominently to the synergistic effects on the overall plasma reaction performance. Especially, CO₂, an oxidative gas, exhibited pronounced effects by enhancing the conversions of all hydrocarbons in the feed, by reducing coke formation, and by lowering specific energy consumption. The results showed that not only did the effects of applied voltage and input frequency strongly influence the stability of the gliding arc discharge, they affect the chemical activation of simulated CO₂-containing natural gas reforming as well. Furthermore, the effect of added oxygen in the feed was tested with using pure oxygen or air as an oxygen source for partial oxidation. The oxygen species derived from the addition of oxygen to the simulated natural gas play an active role in significantly minimizing carbon formation; moreover, they provided improvement in the reactant conversions, product yields, and product selectivities, as well as the decrease in specific energy consumption. Air was best suited for use as the oxygen source in the combined CO₂-containing natural gas reforming and partial oxidation.

The innovative concept of integrating non-thermal plasma and microreactor technology offers several advantages, e.g. low reaction temperature, good heat

transfer and heat distribution, and short reaction time. Based on this concept, the gliding arc microreactor was first designed to investigate the reforming reaction of natural gas instead of using the conventional gliding arc reactor. For this preliminary study, methane, a major constituent of natural gas, was used instead of the simulated natural gas in order to reduce the complexity of feed composition. The reforming of methane was conducted under the gliding arc microreactor, with and without catalyst. In the sole plasma system, all operational parameters affected both methane conversion and product selectivities. In the plasma and catalytic system, the temperature distribution within the plasma microreactor has a significant role in improving the reaction performance.

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





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