Energy-environment-economy(3E) assessment of a novel low-carbon emission process integrating coal-to-methanol with green hydrogen

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Abstract

Methanol is an alternative fuel that offers convenient storage, transport and utilization, hence has attracted many attentions recently. Coal-to-methanol (CTM) is a mature, inexpensive industrial process for methanol production, yet accompanied with large CO2 emissions and low C conversion rate due to the mismatch of H/C ratio between feedstock and product. In this study, a novel low carbon process of the CTM coupled with green hydrogen is proposed, in which the water gas shift (WGS) sector is replaced by water electrolysis based on solar power for adjusting the hydrogen carbon ratio. Additional methanol production could be achieved from the hydrogenation of CO2 absorbed by rectisol, hence further increasing the C conversion rate and decreasing CO2 emissions. Sensitivity analysis is conducted with regard to the key parameters such as synthetic pressure and temperature, and the comprehensive performance of the new process system is compared with the conventional CTM from the perspective of energy-environment-economy (3E), using exergy efficiency, total annual cost (TAC) and equivalent CO2 emissions as evaluation indicators. In addition, a quantitative sustainability evaluation method is introduced, in which a dynamic econometric model considering volatility of product/raw material price, electricity price and carbon tax is established. The results reveal that the system is operated successfully under the optimum settings, increasing methanol output with lower carbon emission. The goal of green and efficient production is achieved economically, showing the perspective of CTM integration with renewable energy sources.

Keywords: *Coal-to-methanol, green hydrogen, 3E assessment, economic uncertainty*

Short biography

Dr.Yang works as a faculty staff at Xi'an Jiaotong University since he got the PhD degree from the University on 2010. He once conducted studies abroad at the University of Queensland (2009.1-2010.1) and Tokyo University of Science, Noda (2011.6-2012.6). He is now the head of Department of Process Equipment and Control Engineering, Xi'an Jiaotong University. His present research interests include efficient storage and utilization of hydrogen energy, industrial energy saving technology, process modeling and optimization based on historical data. He has published tens of peer-reviewed journal papers in the field of energy and chemical engineering, and was granted multiple Chinese patents. Some representative publications are listed below.

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