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Evaluation of the economic and environmental impact of combining dry reforming with steam reforming of methane

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ABSTRACT

Lately, there has been considerable interest in the development of more efficient processes to generate syngas, an intermediate in the production of fuels and chemicals, including methanol, dimethyl ether, ethylene, propylene and Fischer–Tropsch fuels. Steam methane reforming (SMR) is the most widely applied method of producing syngas from natural gas. Dry reforming of methane (DRM) is a process that uses waste carbon dioxide to produce syngas from natural gas. Dry reforming alone has not yet been implemented commercially; however, a combination of steam methane reforming and dry reforming of methane (SMR + DRM) has been used in industry for several years.

The aim of this work was to simulate both the SMR and SMR + DRM processes and to conduct an economic and environmental analysis to determine whether the SMR + DRM process is competitive with the more popular SMR process. The results indicate that the SMR + DRM process has a lower carbon footprint. Further research on DRM catalysts could make this process economically competitive with steam methane reforming.

Keywords: Dry reforming; Syngas; Steam methane reforming; Global warming potential

1. Introduction

The efficient commercial production of syngas (a mixture of hydrogen and carbon monoxide) is gaining significant attention worldwide (Raju et al., 2009) as it is a versatile feedstock that can be used to produce a variety of fuels and chemicals, such as methanol, Fischer–Tropsch fuels, H_2, ethanol, and dimethyl ether (DME). Syngas can be produced from a variety of primary feedstock such as coal, petroleum coke, biomass, and natural gas. The lowest cost routes for syngas production, however, are based on natural gas (Spath and Dayton, 2003).

The primary feedstock and reaction routes of syngas production determine the H_2:CO molar ratio of the syngas (also called syngas ratio), which is important as different end products require different syngas ratios. In general, for DME production, a syngas ratio of 1 is needed, whereas in the case of Fischer–Tropsch synthesis, the required syngas ratio varies from 1 to 2.1 (Park et al., 2012) depending on the catalyst and pressure used.

Natural gas is the cleanest of all fossil fuels and steam methane reforming is a well established process for the production of syngas and hydrogen. Dry reforming uses waste CO_2 to generate syngas from methane. The dry reforming of methane with CO_2 has received special attention in recent years due to two main reasons: (i) it produces syngas with a H_2:CO molar ratio that is suitable for products including F–T fuels and DME and (ii) the reaction consumes two types of greenhouse gases, CO_2 and CH_4 (Pichasa et al., 2010). Although dry reforming alone has not found application commercially, combined CO_2 and steam reforming systems have been operational in the industry for a number of years. In this paper, the focus is on producing syngas from natural gas by means of both steam methane reforming and a combination of dry reforming and steam methane reforming. These processes are simulated using Aspen Plus, a process simulation software, and the results provide the basis for their comparison in terms of economics and global warming potential.

2. Syngas from natural gas

There are six (Liu, 2006) basic types of reforming processes available for the production of syngas and hydrogen from natural gas, whose major component is methane. These are:

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