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Review article

Review on methanation – From fundamentals to current projects

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HIGHLIGHTS

- Comprehensive overview of CO and CO_2 methanation technology.
- Survey of methanation fundamentals, catalysts, and mechanisms.
- Up-to-date overview of methanation research and projects.

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ABSTRACT

Methane production from syngas goes back to more than 100 years of research and process development. Early developments (1970–1980) using syngas from coal gasification plants primarily focused on fixed-bed and fluidized-bed methanation technologies. Temperature control and catalyst deactivation, e.g. caused by fouling and mechanical stress, were key issues of investigation.

Due to the debate about a sustainable energy supply, research on methanation has been intensified during the last ten years. Novel reactor developments comprise e.g. micro reactors and three-phase reactors aiming at an advanced temperature control and a reduced complexity of future methanation plants. The developments are supported by detailed modeling and simulation work to optimize the design and dynamic behavior.

To accompany and facilitate new methanation developments, the present work is aimed at giving researchers a comprehensive overview of methanation research conducted during the last century. On one hand, application-orientated research focusing on reactor developments, reactor modeling, and pilot plant investigation is reviewed. On the other hand, fundamentals such as reaction mechanisms and catalyst deactivation are presented.

Contents

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1. Introduction

Methane is an energy carrier of significant importance to the industry, energy, and transportation sectors worldwide. Its existing distribution infrastructure in many countries makes it is a constitutive element of modern economies. The major share of industrially used methane comes from fossil natural gas resources. However, the debate of the finiteness of fossil resources and climate change caused the research expenditures relating to catalytic and biological methane production from carbon oxide-rich gases (methanation) to increase over the last years. Biological methanation proceeds at low temperatures (<70 °C) in stirred tank reactors or trickle-bed reactors (e.g. [1–4]). In contrast, catalytic methanation is operated at temperatures above 250 °C, predominantly in fixed-bed reactors. Research into catalytic methanation processes focus on two options, CO methanation and CO_2 methanation.

- CO methanation (Eq. (1)) is an exothermic process using carbon monoxide and hydrogen as educts for the catalytic production of methane and water [5]. Educt gases mainly come from coal or biomass gasification at synthetic fuel production plants (Fig. 1) [6–8].

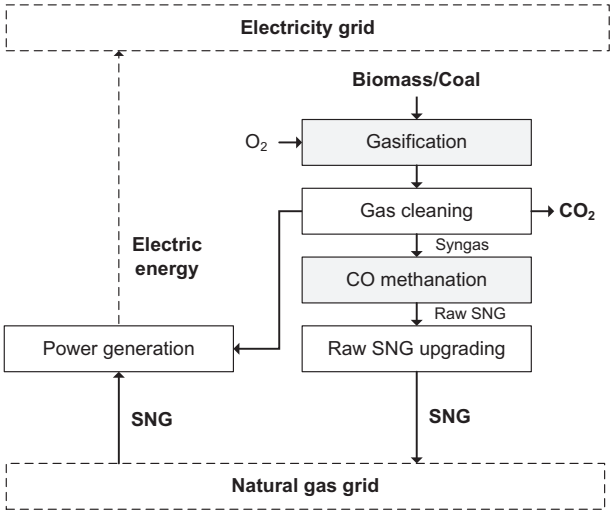

Fig. 1. Exemplary biomass/coal-to-SNG plant setup with CO methanation.

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