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Review article

Review on methanation – From fundamentals to current projects

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HIGHLIGHTS

- Comprehensive overview of CO and CO₂ 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.

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Contents

1. Introduction	00
2. Fundamentals	00
3. Methanation concepts	00
3.1. History	00
3.2. Established methanation concepts	00
3.2.1. Adiabatic fixed-bed methanation	00
3.2.2. Cooled fixed-bed methanation	00
3.2.3. Fluidized-bed methanation	00
3.2.4. Three-phase methanation	00
3.2.5. Market availability	00

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66	3.3.	Research activities	00
67	3.3.1.	Fixed-bed reactors	00
68	3.3.2.	Fluidized-bed reactors	00
69	3.3.3.	Three-phase reactors	00
70	3.4.	Comparison	00
71	4.	Demo projects and commercial plants	00
72	4.1.	CO methanation projects	00
73	4.2.	CO ₂ methanation projects	00
74	5.	Catalysts, activation, and deactivation	00
75	5.1.	Catalysts	00
76	5.1.1.	Active compound	00
77	5.1.2.	Support	00
78	5.1.3.	Promoters	00
79	5.2.	Reduction and activation	00
80	5.3.	Deactivation	00
81	5.3.1.	Poisoning	00
82	5.3.2.	Vapor–solid reactions	00
83	5.3.3.	Thermal degradation	00
84	5.3.4.	Fouling	00
85	5.3.5.	Attrition	00
86	5.3.6.	Crushing	00
87	6.	Mechanism	00
88	6.1.	CO methanation	00
89	6.2.	CO ₂ methanation	00
90	6.3.	A consistent mechanism for CO and CO ₂ methanation	00
91	7.	Modeling and simulation of methanation reactors	00
92	7.1.	Modeling and simulation scope	00
93	7.2.	Reactor modeling	00
94	7.2.1.	Time resolution	00
95	7.2.2.	Reactor dimensions	00
96	7.2.3.	Phase modeling	00
97	7.2.4.	Temperature characteristic	00
98	7.2.5.	Kinetics approach	00
99	7.2.6.	Software	00
100	7.3.	Plant modeling	00
101	8.	Summary	00
102	8.1.	Methanation concepts and research	00
103	8.2.	Catalysts	00
104	8.3.	Mechanism	00
105	8.4.	Modeling	00
106	9.	Abbreviations and symbols	00
107		References	00

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 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 CO₂ 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].

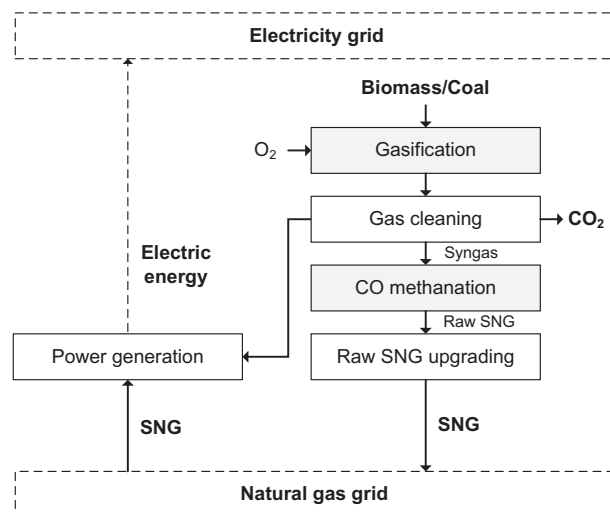


Fig. 1. Exemplary biomass/coal-to-SNG plant setup with CO methanation.

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