FRAUNHOFER INSTITUTE FOR ENVIRONMENTAL, SAFETY, AND ENERGY TECHNOLOGY UMSICHT

CATALYTIC CONVERSION OF OXYGEN TRACES IN COKE OVEN GAS

M. Sc. Thomas Wiesmann*, Dr. Christian Hamel, Dr. Stefan Kaluza
Fraunhofer Institute for Environmental, Safety, and Energy Technology UMSICHT, Osterfelder Strasse 3, 46047 Oberhausen, Germany
Phone* +49 208 8598-1527, E-mail* thomas.wiesmann@umsicht.fraunhofer.de, www.umsicht.fraunhofer.de

INTRODUCTION

In the processes of steel production, large quantities of process gases are generated. Due to the substantial quantities of process gases generated, sector interconnection between steelmaking and the chemical industry offers an effective way to improve the sustainability of this important industry.

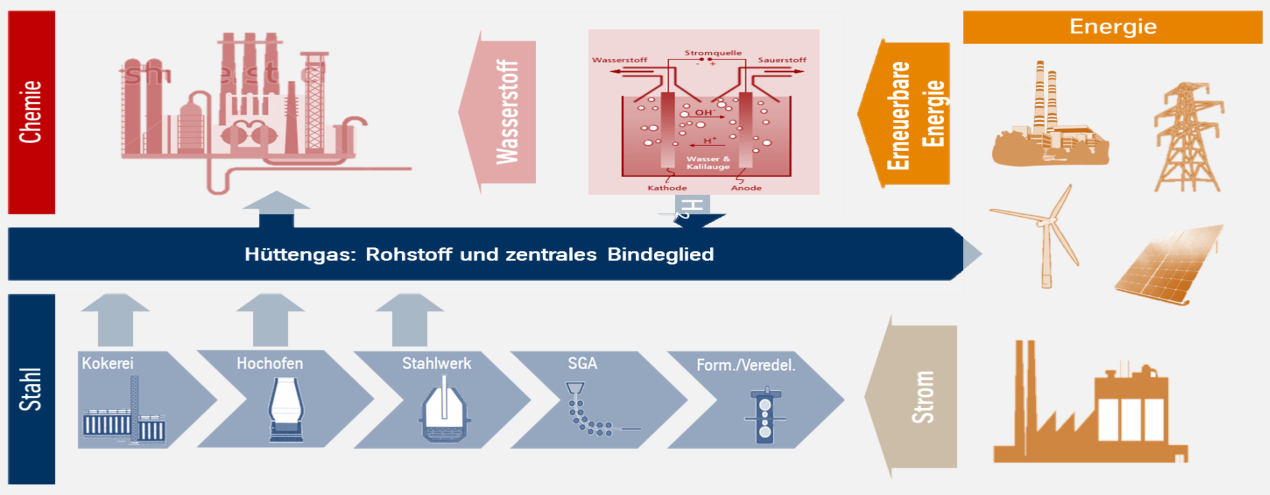

Figure 1: Gas from the processes of steel production for chemical synthesis

Energetically, coke oven gas is the most important one due to its high fraction of hydrogen (>60 %). A typical gas composition resembling coke oven gas is shown in Table 1.

In order to utilize the gas for downstream catalytic processes, oxygen traces (< 1 vol-%) have to be removed from the gas stream. Catalytic conversion provides a feasible solution to this issue. As trace oxygen removal is not a widely studied field, it was included in the framework of the Carbon2Chem® research project. The aim of Carbon2Chem® is to utilize available process gases from the steel making process for the synthesis of platform chemicals.

Table 1: Gas composition of coke oven gas

Component	Concentration [vol%]
H_2	55 – 60
CH_4	23 - 27
CO	5 - 8
CO_2	< 2
N_2	3 - 5
H_2O (vapor)	4
O_2	< 1
unsaturated hydrocarbons, sulfur compounds, ammonia	traces

TEST SYSTEM

- Suited for creating complex gas mixtures
  - Eight separate gas lines
  - Three separate evaporators (two liquid and one melting evaporator)
- Two different reactor types
  - Up to 500 °C at 60 bar
  - Up to 1000 °C at 1 bar
- sulfinert coating of the test system
- continuous gas analysis
  - online quadrupole mass spectrometer
  - and FTIR spectrometer

TESTING CONDITIONS

- First tests were performed using a supported Pt catalyst, supplied by project partner Clariant.
- Space velocity (GHSV) was set to 10000 h^{-1}.
- Temperature was varied between 50 °C and 280 °C.
- The pressure was set to 1 bar
- Only main gas components were tested (without water)

PRELIMINARY RESULTS

- Highest conversion of oxygen was achieved with hydrogen in the reaction gas.
- Influence of methane and carbon dioxide was relatively low.
- The addition of carbon monoxide at low temperatures led to a drastic decrease of conversion. This decrease is attributable to the adsorption of carbon monoxide on the catalyst surface.
- An increase of temperature led to increased desorption of carbon monoxide and, in turn, led to an increase in conversion again.

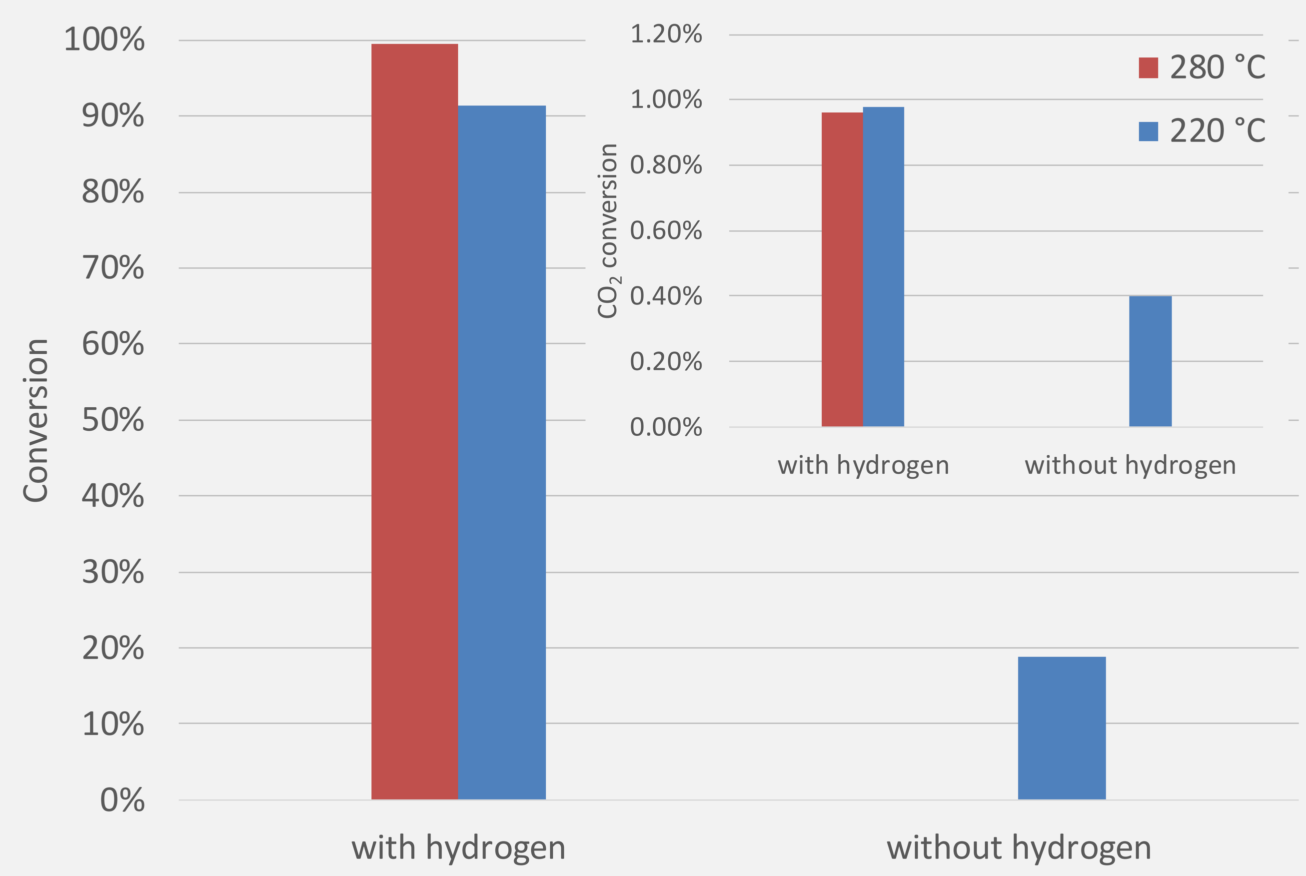

Figure 2: O_2 conversion in a gas composition with 0,8 vol-% O_2, 5.3 vol-% CO and optional 60 vol-% H_2, the concentration of CO_2 formed during the reaction is given in the inset

OUTLOOK

- Focus on different compositions of the main gas components in the temperature range between 150 and 250 °C.
- Besides platinum based catalysts, non precious metal catalysts based e.g. on nickel-molybdenum and cobalt-molybdenum will be investigated.
- The reaction pressure will be varied between 1 and 15 bar.
- Furthermore, the gas complexity will be gradually increased by adding different contaminants typical for coke oven gas, e.g. H_2S. The influence of these interfering components will be investigated.

ACKNOWLEDGMENTS

Carbon2Chem® is funded by the Federal Ministry of Education and Research (Bundesministerium für Bildung und Forschung, BMWF). Support code: 03EK3039D.

SPONSORED BY THE
Federal Ministry of Education and Research