Development of Reactors for the Plasma-catalytic Removal of Oxygen Traces in Steel Mill Gases

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Abstract

The required process temperature of industrial chemical conversions can be reduced by using catalysts. Opportunities for further improvement of the reaction are the external excitation as of reactants or active centers of the catalyst with non-thermal plasma, which allows even further reduction of the reaction temperature in certain reaction setups. The potential of non-thermal plasma in combination with a catalyst is already intensively investigated for removal of trace components such as volatile organic compounds in air [1] and NOx in diesel exhaust gases [2]. Within the research project Carbon2Chem® the potential of plasma-catalysis shall be investigated for the treatment of off-gases from steel production. General feasibility of the process with respect to industrial scalability of plasma-catalytic reactor systems must be proven. The focus of the plasma-catalytic conversion in this project lies in the conversion of oxygen traces in steel mill gases.
A test rig for the plasma catalytic conversion has been designed and assembled. The test system provides gas mixtures for typical steel mill gas compositions (main components: H_2, CH_4, CO_2, CO, N_2; minor components: O_2). The used reactor is based on the dielectric barrier discharge (DBD) setup as packed-bed design [3]. The reactor allows conversions at residence times of 1-2 s (=GHSV of 1800-3600 h^{-1}) and the DBD discharge gap is varied from 2-4 mm.
The combination of non-thermal plasma with catalyst allows the conversion of oxygen traces in hydrogen rich (20-60 vol%) gas mixtures similar to coke oven gas mixtures. The investigated DeOxo-catalyst shows complete conversion of O_2 traces with hydrogen in the investigated GHSV range, but the catalyst is deactivated by CO. Non-thermal plasma allows partial O_2 conversion in presence of CO. Placement of catalyst granules in the discharge zone (in-plasma-catalysis) allows improvement of the oxygen conversion compared to the non-thermal plasma treatment. While the principle feasibility has been clearly demonstrated, the conversion rate has to be further optimized by geometrical adaption of the reactor setup to establish a homogeneous and better controllable plasma treatment. Afterwards the next scale-up step towards a pilot installation using real process gas streams can be taken. Detailed results will be presented at the congress.
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References

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