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L-III | Design and Scaling of a Plasma Reactor for Oxygen Removal in Coke Oven Gas

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The removal of oxygen in coke oven gas is a novel non-thermal plasma application developed within the Carbon2Chem® Project. The general feasibility of the process could be already demonstrated with multiple plasma systems from Fraunhofer UMSICHT and Ruhr-University Bochum based on the dielectric barrier discharge (DBD) principle. The oxygen removal of higher volume flow rates can be realized by numbering-up of the plasma reactor system. Additionally, studies of the DBD upscaling are conducted to find potential measures for intensification and cost reduction of the industrial process.

Upscaling behaviour of the oxygen removal in a model coke oven gas

In previous works the feasibility of the plasmachemical oxygen removal was shown at flow rates of 0.1 Nm^3/h. The current research focus is the scale-up of the process. In general, it is observed that similar oxygen removal at various flows can be realized (Figure 1) by maintaining the the specific power input (power/volume flow rate).

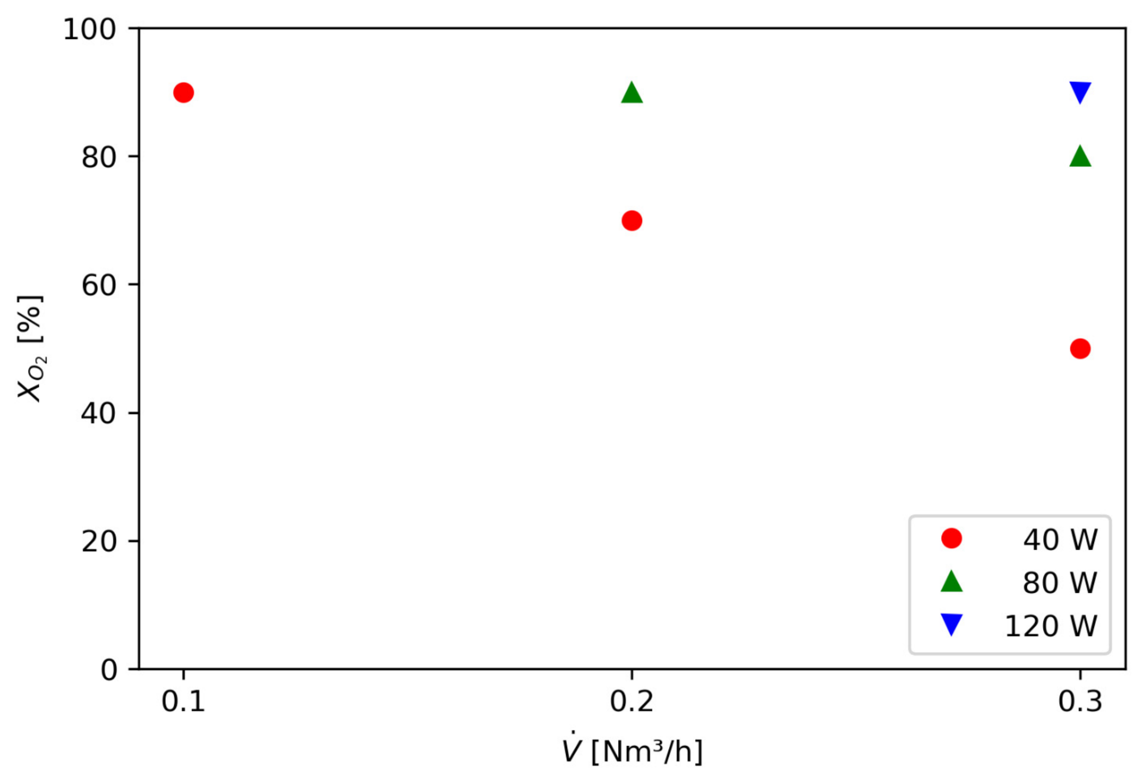

Figure 1: Influence of volume flow rate and power input on the conversion of 1,000 ppmV O_2 in a model coke oven gas with a volume DBD reactor (2 mm gap width, 80 mm inner reactor diameter, 2 mm dielectric thickness)

The presented volume flow rate variation study is tested together with similar inlet oxygen content variation studies for a variety of reactor setups. The experiments are conducted with a gap width (x_{Gap}) of 2 mm and fixed high-voltage generator parameters, which were already identified as efficient process conditions in previous works.
The tests showed that neither the reactor length (l_{Re}), the thickness of the dielectric (s_{Die}) nor the inner reactor diameter (d_{iR}) did increase the conversion significantly. However, the results suggest the usage of structured electrodes to achieve a high initial conversion ($X_{O2,max}$) and a low drop of the conversion (ΔX_{O2}) at increased volume flow rates or inlet oxygen contents without further power input (Figure 2).

Reactor design for the upscaling of the plasma-chemical oxygen removal at the steel mill

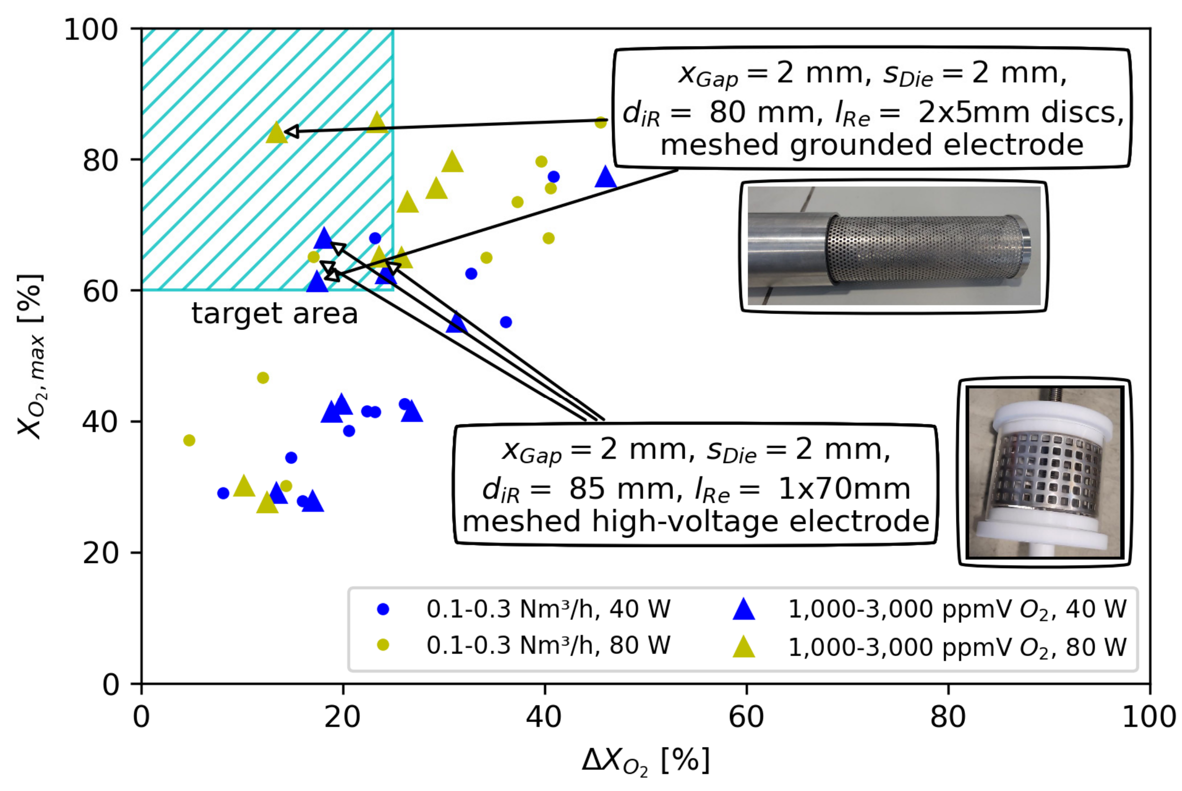

Figure 2: Scaling experiments with various volume-DBD setups and their influence on the initial conversion degree ($X_{O2,max}$) and the conversion drop (ΔX_{O2}) at rising volume flow rates or oxygen inlet concentrations

The results of these studies are the foundation for an upscaled volume DBD reactor (Figure 3), which is designed for volume flow rates up to 10 Nm^3/h. The reactor system combines scale-up and numbering-up approaches and will be tested with coke oven gas of the thyssenkrupp's steel mill in Duisburg.

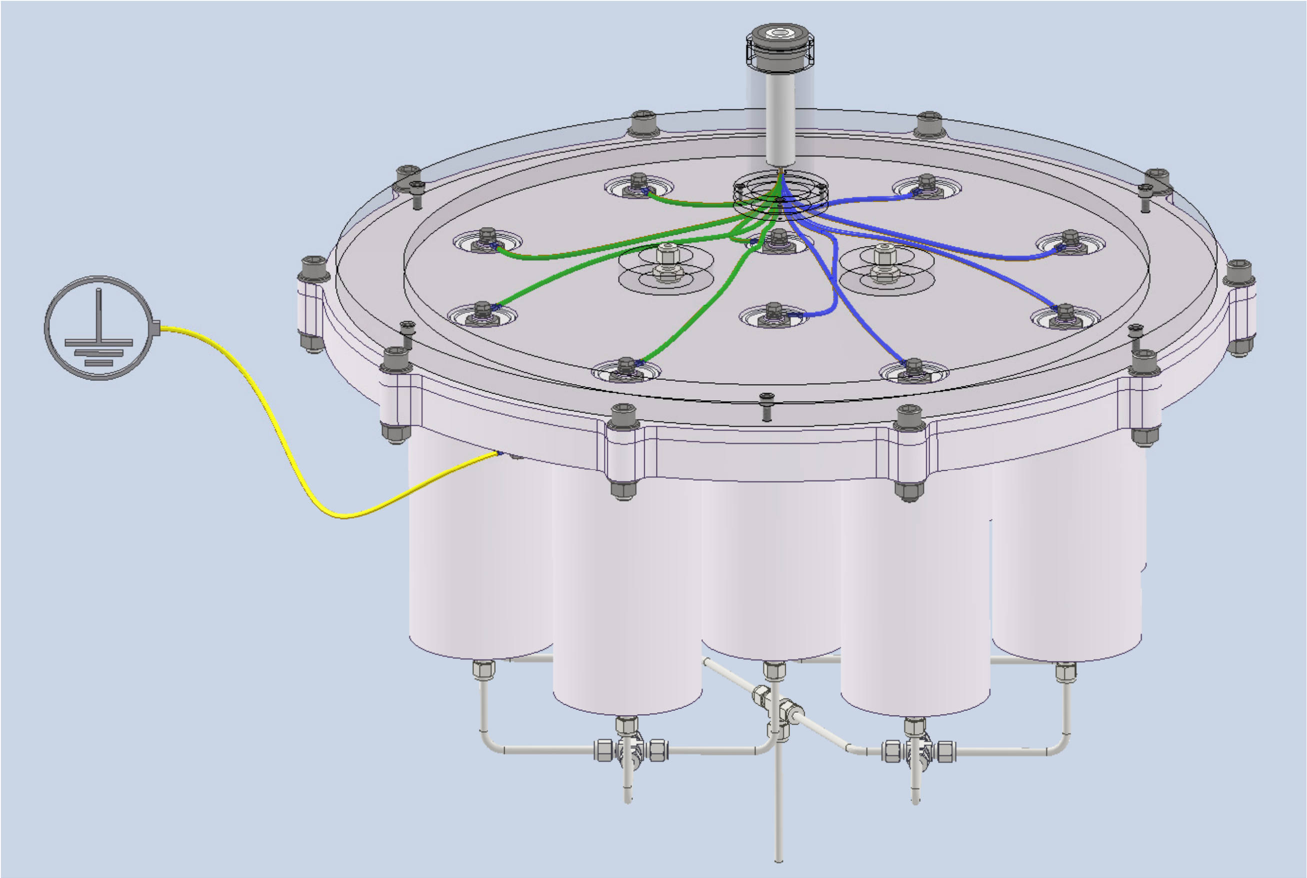

Figure 3: 3D draft of the planned upscaled volume DBD reactor

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