Proceedings of the 9th World Congress on Mechanical, Chemical, and Material Engineering (MCM'23)
Brunel University, London, United Kingdom –August 06-08, 2023
Paper No. HTFF 167 (The number assigned by the OpenConf System)
DOI: 10.11159/htff23.167

Investigation of Bubble Behaviour and Heat Transfer in The Cooling-Circuit Of The PEM-Electrolysis

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Extended Abstract

Climate change, carbon neutrality and the future of mankind became part of the daily news feed. This led to an urgent need for the decarbonization of the economy. The production of hydrogen based on green electricity through upscaling of electrolysis systems is a very promising strategy to reach this goal in a cost-effective manner. The Polymer-Electrolyte-Membrane (PEM)-electrolysis is considered as one of the promising technologies thanks to its advantageous load charge behavior. Therefore, it can be easily combined with highly fluctuating power from wind and solar energy [1].

The mechanism of PEM-electrolysis produces oxygen at the anode side according to the following chemical reaction $2H_20 \rightarrow O_2 + 4H^+ + 4e^-$ [1]. The water streaming in the anode cycle is supersaturated, because the oxygen concentration in water exceeds its solubility. In the cooling circuit, the water flow experiences an ongoing bubble evolution due to many factors like the pressure or temperature change. In the cooling circuit a gas separation through a gas-liquid separator is realized. Thereafter, the flow enters the heat exchanger. At this stage the bubble behavior and its influence on the heat transfer gained great scientific interest.

The scope of this research is to understand and investigate the bubble evolution in the cooling-circuit of the PEM-Electrolysis and to estimate the resulting effect on the heat transfer. Inside the heat exchanger several bubble phenomena occur such as nucleation, rise in the flow and coalescence. This poses the question if the bubbles will reach the surface of the heat exchanger and result in influencing the heat transfer. Moreover, we aim to study this effect depending on the type of prevailing regime [2]. To address this challenge two approaches are targeted. The first approach is to develop an empirical cell model for bubbly and stratified flow in a horizontal pipe. The model estimates the pressure drop and heat transfer. The second approach is a CFD investigation which can capture the phenomena cited above. The advantage of the first approach is a quick prediction compared to the numerically expensive CFD approach. The CFD approach will help investigate the evolution of bubbles in the pipe flow. In a further step, the results achieved will be validated experimentally. The experimental plant is already designed and it is currently under construction. It will enable the investigation of bubble evolution in pipe and rectangular flow channels. The two channels are made transparent to make the bubble evolution observable with a high-speed camera. Furthermore, heat transfer will be also experimentally studied.

The main objective of this scientific work is to create an empirical and a CFD model that can predict the effect of oxygen gas in water on the heat transfer and give further details about the behavior of bubbles. This will help in the design and the improvement of the performance of heat exchanger for electrolysis plants.

Keywords: two phase flow, heat transfer, numerical modeling, electrolysis

Acknowledgments

The present work was sponsored by the German Federal Ministry of Education and Research (BMBF) within the framework of the project SINEWAVE (project number 03HY123D).

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