Institute of Chemical Engineering

Adres artykułu: http://sportal2.lo.pl/en/article/catalytic-carriers-inspired-by-the-shape-of-fish-gills

Catalytic carriers inspired by the shape of fish gills

Duration: 2024 - 2026
Description

PRELUDIUM-22 UMO-2023/49/N/ST8/00819

Every year, about 7 million people in the world die because of air pollution. Dangerous air pollutants, like NOx, SOx or volatile organic compounds (VOCs) emitted mainly by industry and transport, are responsible for such a situation. It is confirmed that the diesel exhaust causes cancers. Therefore, the tasks of air protection, purification and emissions reduction are important and urgent. Heterogeneous catalytic processes enable effective elimination of toxic emissions. However, they still need to be improved. A typical catalyst consists of a support (e.g. monolith, packed bed) and an active phase deposited on it. In order to obtain an efficient catalytic reactor, both the active phase and the support should be designed together. Achievements in this field are large, but the design of the catalytic supports commonly used in industry has not changed significantly (larger scale units are still dominated by packed bed reactors of large flow resistance). It is possible to create a new type of carrier whose geometry is based not on knowledge collected during decades of engineering experience, but on millions of years of evolution. Fish gills are a good example of such efficient, long-lasting and meticulously shaped heat and mass exchangers. The idea of the gill is about 400 million years old. Oxygen solubility in water is low and temperature-dependend, thus fish had to develop an efficient respiratory system. It has been experimentally proven that 80 – 90% of the heat released in the fish organism is exchanged as it passes through the gills. The aim of the project is to examine the possibility of improving the heat/mass transfer properties of catalysts by changing the geometry of the carrier to gill-like. The research hypotheses assumed in the Project are: • fish gills are efficient structures for heat and mass transfer; • the gill-like structures can be designed and studied using CFD (Computational Fluid Dynamics) and their heat transport capabilities can be tested with great accuracy; • the geometry of the catalyst carrier which idea bases on the fish gill structure can be modified to adjust it to the process or industry requirements and to intensify the heat and mass transport; • designed structures displaying the best parameters may be produced with high accuracy using the additive techniques; • the catalytic active phase can be effectively deposited on the metal support surface and the resulting reactor filling is expected to improve the efficiency of catalytic combustion of methane. In the first stage of the project, CFD simulations will be carried out to study the influence of the carriers geometry on their transport and flow properties. These carriers will have a shape inspired by the fish gills. Particular attention will be focused on gill parts such as filaments and lamellae. Due to the large number of possible variants, the structures will be first pre-selected based on CFD simulations. Preliminary research indicated a very high potential of carriers with a gill-like structures. These structures have a flow resistance slightly higher than the monolith, while at the same time much more intense heat transport, closer or even higher than a packed bed. This result is very promising. The selected structures of the most promising properties will be then manufactured from e.g. 316 steel using additive technique like SLM. This technique allows the execution of structures with high accuracy. The dimensions of the structure may be scaled to adjust it to the possibilities of the SLM. The manufactured structures will be tested experimentally. Their transport and flow characteristics will be determined. The results of the experimental tests will be summarized in the CFD simulation results. The layer of the catalytic active phase will be applied to the structure(s) with the most desired properties, and the resulting catalytic filling will be tested in the process of catalytic methane combustion. If the predictions will coincide with the experimental results, they might initiate a new generation of catalysts. The improvement may include more intense heat/mass transfer parameters.

Metryczka

Published by:	Artur Wojdyła
Published at:	29.07.2025 13:49
Last edited by:	Artur Wojdyła
Last edited at:	29.07.2025 14:04
Number of views:	9