

Institute of Chemical Engineering

Adres artykułu: <https://iich.gliwice.pl/en/article/optimization-of-the-geometry-and-morphology-of-the-periodic-open-cell-structures-in-terms-of-their-use-as-catalyst-carriers>

Optimization of the geometry and morphology of the periodic open cell structures in terms of their use as catalyst carriers

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Description

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Open cell solid foams are widely studied for a long time as a promising packings of a structured catalytic reactor used for the combustion of volatile organic compounds or for the selective reduction of nitrogen oxides with ammonia. They provide a slight pressure drop despite a significant development of the geometric surface essential for the fluid-solid phase contact. Their stochastic structure ensures intensive mixing, which improves the heat and mass transfer coefficients. The morphology is individual for each foam and depends on many factors, such as the diameters of struts, windows and cells. Moreover, solid foams have different shapes of struts: round, triangular, in the shape of a Steiner's hypocycloid (deltoid) (triangular with concave sides). However, the irregular geometry of foams is a problem in modeling them with CAD (Computer Aided Design) and CFD (Computational Fluid Dynamics) programs. Therefore, the structure of foams, for the purposes of modeling or mathematical description, was often approximated by spatial cellular structures (POCS - Periodic Open Cellular Structures), e.g. based on a cube or a truncated octahedron (Kelvin cell). The idea of cell structures is to replace the cell in the foam with a regular representative unit cell (RUC - Representative Unit Cell) mapping the foam cell, and then create a cell structure by duplicating the representative cell in all directions in space. The resulting structure is much easier to design and modify, and most importantly, its geometric and morphological parameters can be easily determined. Moreover, the geometry of the cellular structure ensures intensive mixing and a favorable ratio of heat/mass transport to flow resistance. The development of additive manufacturing methods (3D printing) initiated a new research trend that approximates the structure of foams using POCS modeling. In addition to the RUC geometry itself, the struts shape should also be taken into account, as it depends on the porosity of the structure. However, it should

be noted that the surface of the modeled geometry is smooth, while the surfaces of printed structures are characterized by a certain roughness, which may improve the adhesion of the catalyst and, at the same time, cause some inconsistency between the experimental and modeled results. Therefore, the modeling results should be verified by experimental studies. A review of the literature revealed a lack of experimental work on the influence of strut shape on the transport and flow properties of POCS. Only purely theoretical works are available. Therefore, the main element of the scientific work will be the experimental studies of heat transport and flow resistance conducted on cellular structures placed in a flow reactor (owned by the team). These structures will differ in the shapes and diameters of the struts and the diameters of the cells, so the influence of geometry and morphology on transport and hydrodynamic coefficients will be investigated. The aim of the project is to determine the optimal shape and diameter of the struts and the diameter of the representative cells of the modeled cellular structure in order to intensify heat/mass transport with a slight increase in overall flow resistance. These structures will measure 30x45x30 mm and will consist of identical cubes. They will be modeled in CAD+CFD software (owned by the team) and then printed using SLM (Selective Laser Melting) from AISI 316 steel (a material commonly used for 3D printing). CAD+CFD modeling of cellular structures is currently being carried out on a single cubic cell. Various cross-sectional variants of struts (circle, square, inverted square, hexagon, triangle, Reuleaux triangle - "convex triangle", Steiner's hypocycloid - "concave triangle", star), different strut diameters (0.5-1 mm) and cell diameters (5-10 mm). The acquisition of the project will enable the production of real cellular structures using 3D printing and the conduction of experimental research on heat transfer and flow resistance in order to verify the results of CFD modeling. Among the tested structures, the three structures with the most favorable properties will be selected for production. In order to check the influence of morphological parameters (diameter and shape of struts, cell diameter), each selected structure will be printed in three different variants (a total of nine structures). Thanks to the use of computed tomography, it will be possible to accurately determine the geometric and morphological dimensions of the structures. These dimensions will be compared with the results of CAD modeling and are necessary for the accurate calculation of transport and flow coefficients obtained from experiments.

Metryczka

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