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NEW STREAMLINED CATALYTIC CARRIERS OF ENHANCED TRANSPORT PROPERTIES: EXPERIMENTS VS. CFD

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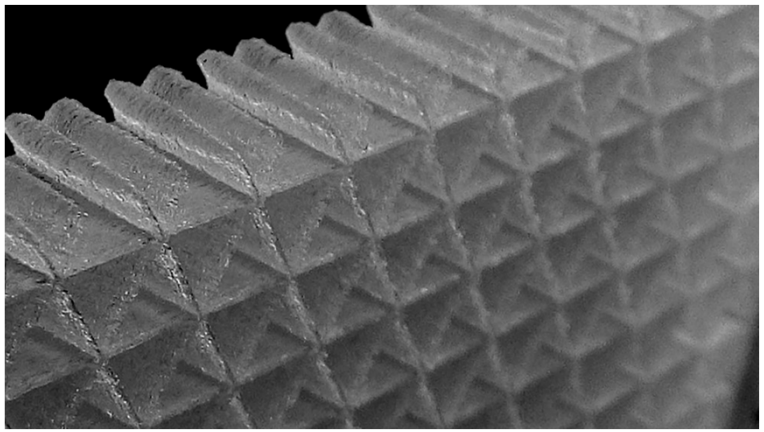

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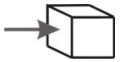
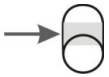
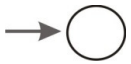
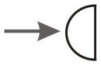
Aim: to study a new generation of structured reactor internals (catalyst carriers) called “streamlined" or "wing" structures. The structures are based on short-channel structures (short monoliths of diverse cross-sectional channel shape, for more details see references).

Innovation: channel wall cros-sectional shape is modelled like the aerofoil profile.

Type of geometry	*Drag coefficient* c_D
 cube	1.05
 cylinder	1
 sphere	0.47
 hemisphere	0.42
 tear	0.05
 aircraft wing profile	0.006

Kołodziej, A. and J. Lojewska, *Short-channel structured reactor for catalytic combustion: Design and evaluation.* Chemical Engineering and Processing, **2007**. 46(7): p. 637-648.
Schlichting, H., *Boundary-Layer Theory*. 7th edition ed. 1979, McGraw-Hill Book Company: New York.
Hoerner, S.F., *Fluid-dynamic drag; practical information on aerodynamic drag and hydrodynamic resistance*. 1958, Midland Park, N. J.

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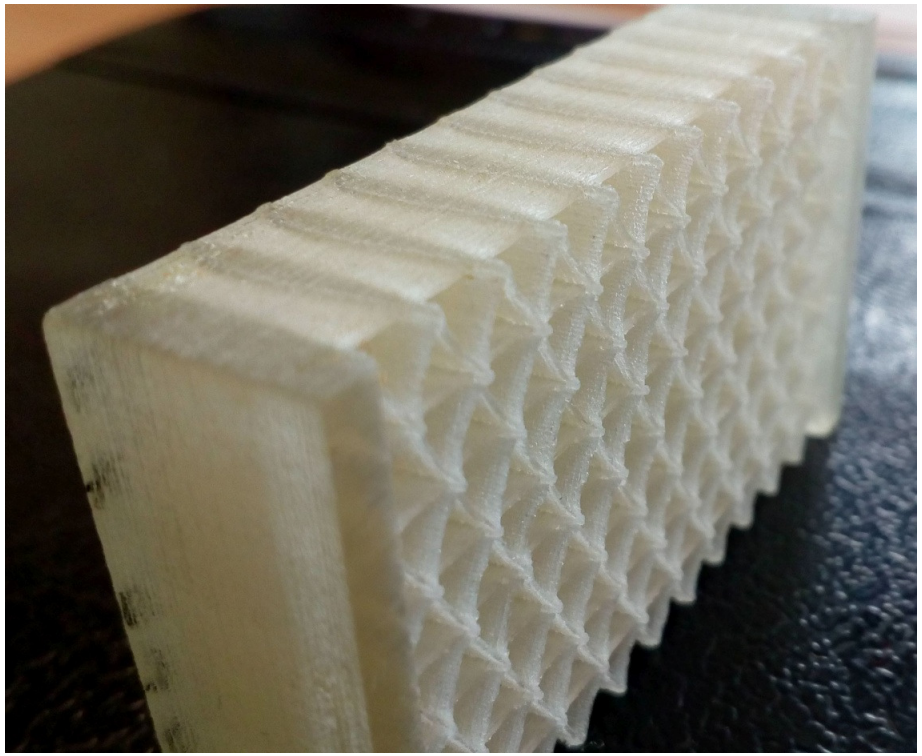
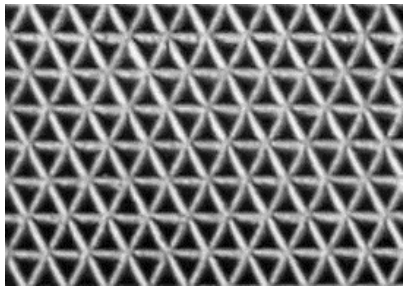
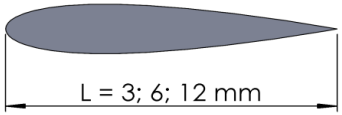


Materials: streamlined structures of triangular cross-section shape: 3, 6 and 12 mm long, created and analyzed with Ansys CFD (Computational Fluid Dynamics) software and 3D printed.



Structure	L, mm	S_v, m^2/m^3	ε	d_h, mm
No. 1	3	1591.26	0.34	0.86
No. 2	6	1289.62	0.40	1.23
No. 3	12	1180.98	0.35	1.20

Height of the repeating unit: 4 mm,
channel height at its narrowest point: ~2 mm,
channel height at its widest point: ~3 mm,
Structure test section: 45 x 30 mm.



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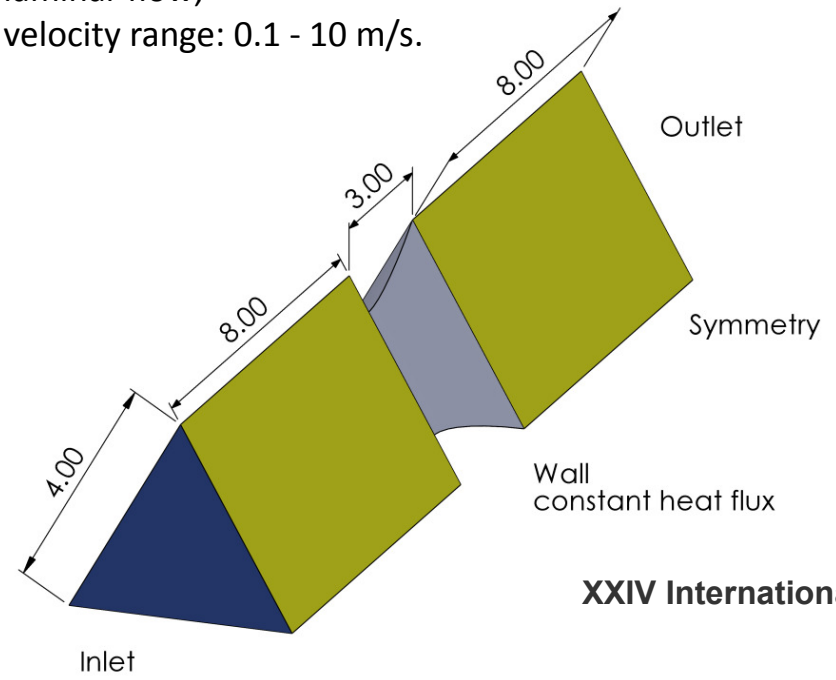
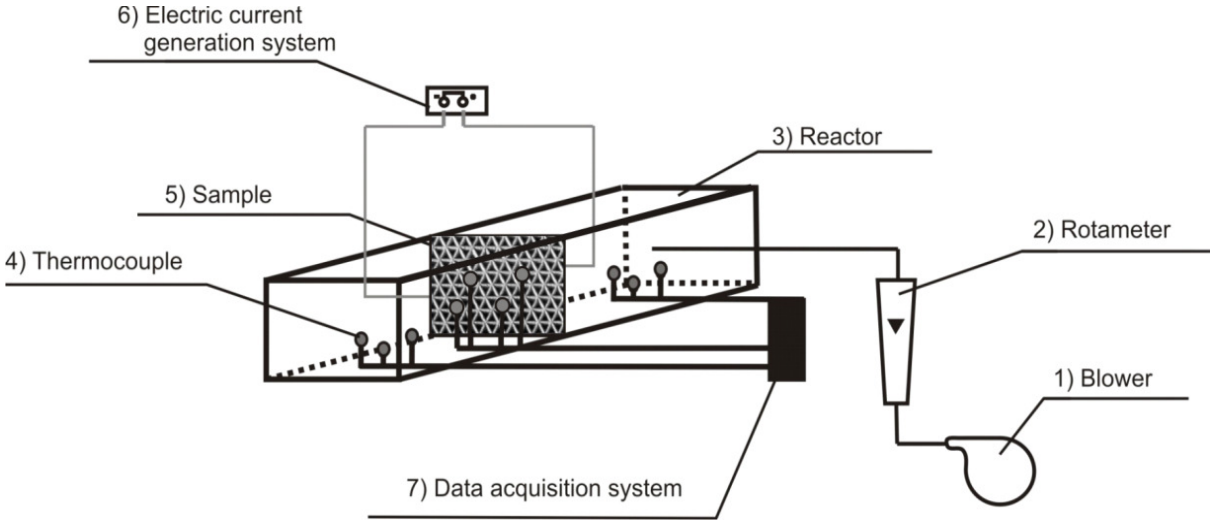
CFD – Computational Fluid Dynamics:

Single channel of 3/6/12 mm length was modeled;
boundary regions upstream and downstream of 8 mm introduced;
mesh type: polyhedral (no of elements ~1mln);
laminar flow;
velocity range: 0.1 - 10 m/s.



Experimental: investigation of heat transport and flow resistance

Single-phase gas (air) flow;
pressure measurement before and behind the structure;
structures heated by strong electric current (up to 300 A) flowing directly through them;
velocity range: 0.4 - 3 m/s (flow resistance); 0.2 - 7 m/s (heat transfer);



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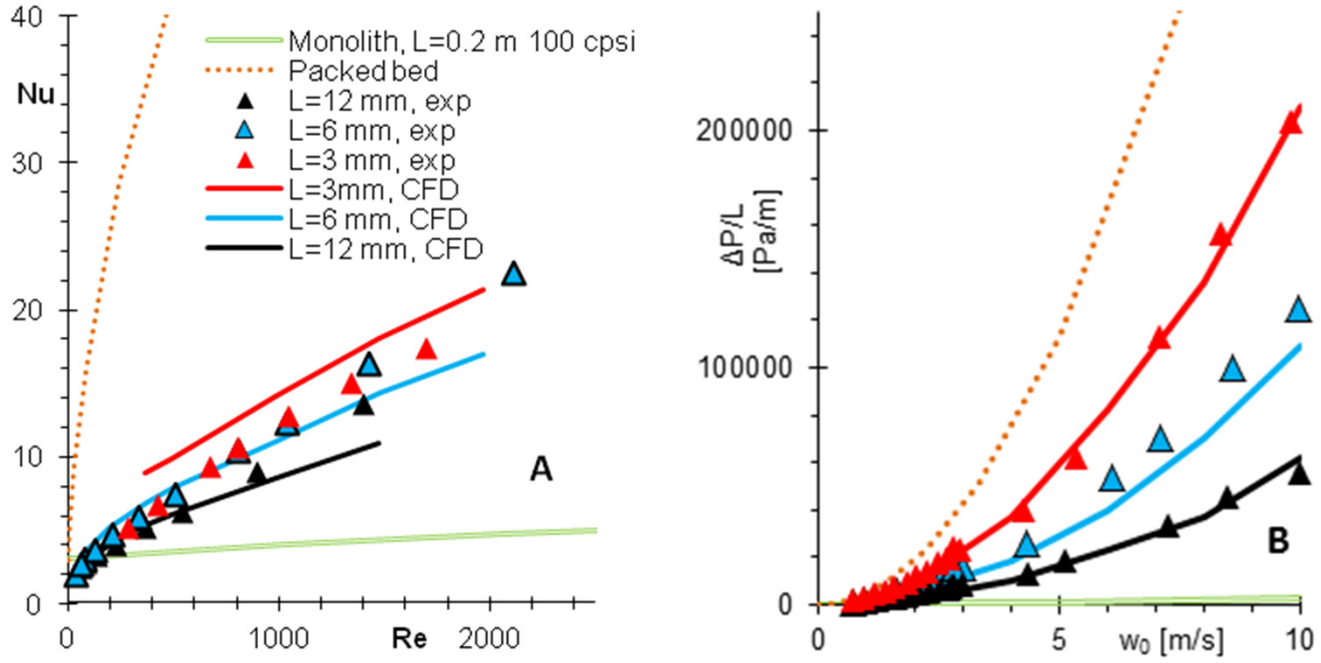
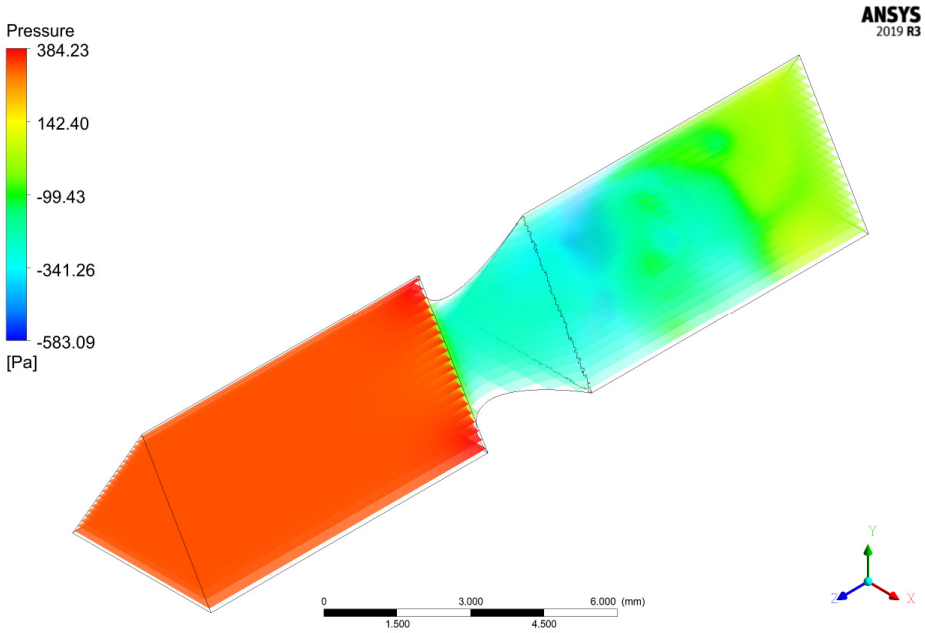
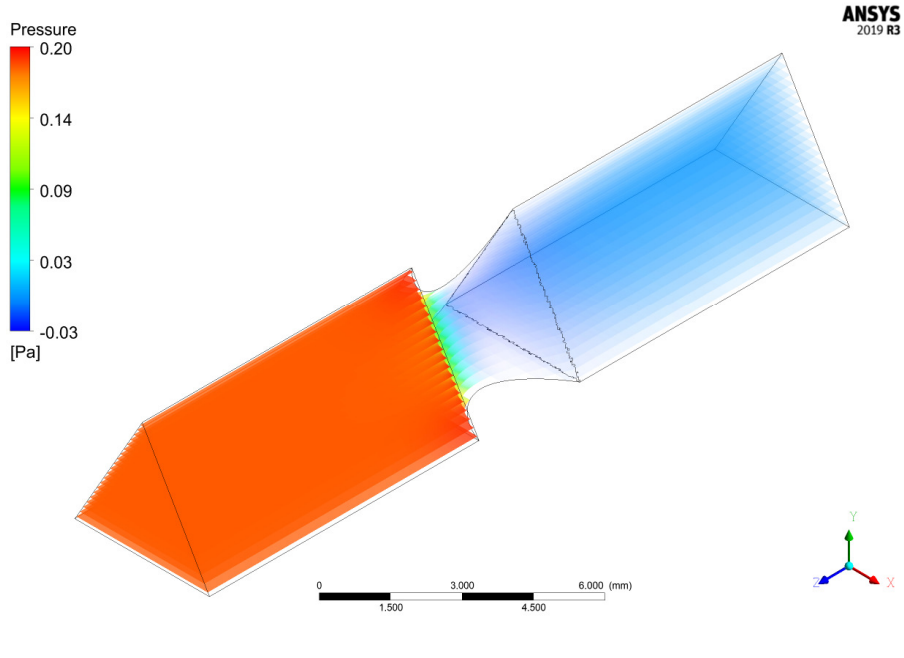


Transport - flow properties of streamlined catalytic carrier in comparison to packed bed and monolith: A - Nusselt number *Nu* vs. Reynolds number *Re,* B - ΔP/L pressure drop per unit of structure length vs. superficial fluid velocity $w_{0;}$ *dp* – grain diameter

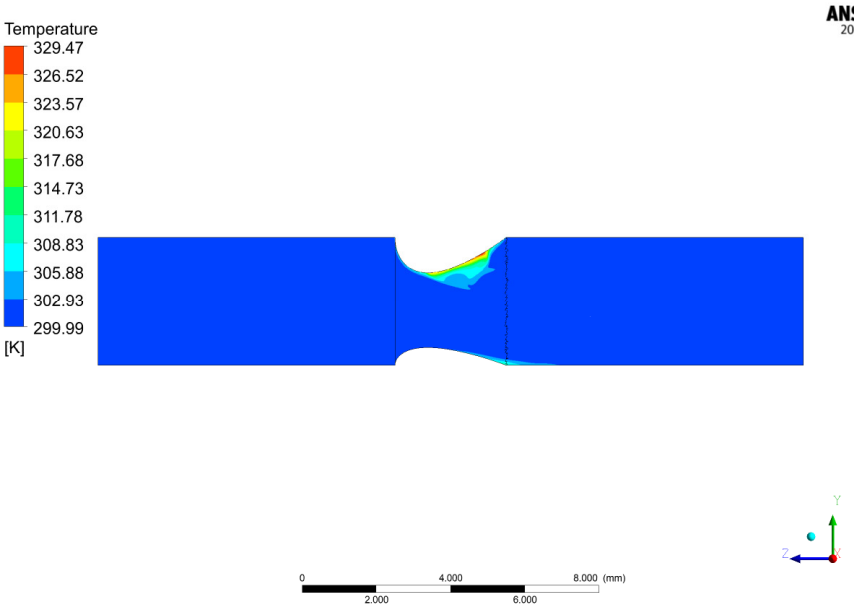
Wakao, N., S. Kaguei, and T. Funazkri, *Effect Of Fluid Dispersion Coefficients On Particle-To-Fluid Heat-Transfer Coefficients In Packed-Beds - Correlation Of Nusselt Numbers.* Chemical Engineering Science, **1979**. 34(3): p. 325-336.
Hawthorn, R.D., *Afterburner catalysis-effects of heat and mass transfer between gas and catalyst surface*, in *AIChE Symp. Ser.* **1974**. p. 428-438.



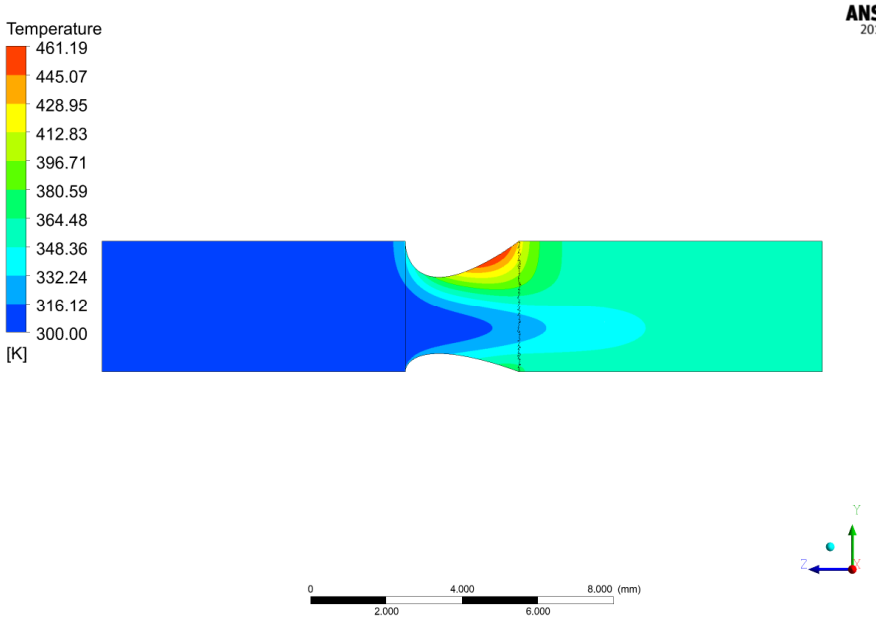
Pressure distribution, velocity: 10 m/s



Pressure distribution, velocity: 0.1 m/s



Temperature distribution, velocity: 10 m/s



Temperature distribution, velocity: 0.1 m/s

Conclusions:

- The novel structures display improved heat/mass transfer properties in comparison to monolith and beneficial pressure drop;
- The channel length *L* (within single structure) can be regulated to attain appropriate heat/mass transfer coefficients,
- The experimental results are in good agreement with CFD ones (maximum relative error does not exceed 26%).

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THANK YOU FOR YOUR TIME

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