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# IMPROVEMENT OF THE HEAT TRANSFER IN CATALYTIC FIXED BED REACTORS BY MEANS OF STRUCTURED PACKINGS

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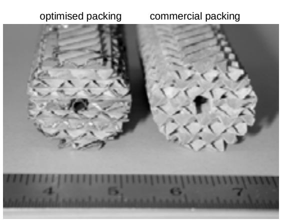
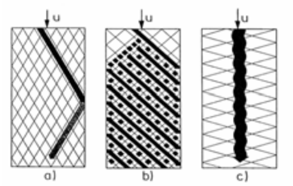
## Overview

A novel type of structured catalyst support for heterogeneous catalysis in industrial tube-bundle reactors has been developed. Compared to conventional fixed beds, it shows a lower pressure drop but an increased heat transfer through the reactor wall. This can improve the performance of reactors used for strongly endo- or exothermic reactions by decreasing the development of cold or hot spots and lowering the risk of thermal run-aways in the latter case. These improvements have been shown by flow visualization and in heat transfer experiments and validated in experiments under dehydrogenation reaction conditions combined with a reactor simulation.



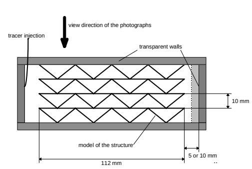




(figure from Disseration Gerd Gaiser, Univ. Stuttgart, 1990)

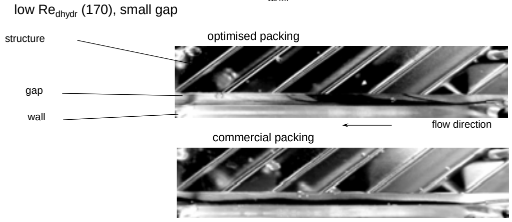
## Introduction

Conventional open cross flow structures show three main fluid paths:
The first follows the orientation of the "valleys" in the corrugated sheets, which alternately transport the fluid from one reactor wall through the structure to the opposite reactor wall in one layer, where the heat transfer occurs, and from left to the right in the neighbouring layers (case a) in the right figure).
The second main fluid path stays always inside the packing, winding itself around the crosspoints of the sheet's corrugations and ensuring the good mixing behaviour and the heat and mass transfer between fluid flow and structure surface (case c) in the right figure).
The third fluid path, not shown in the figure, is the by-passing flow in the gap between structure and reactor wall.
To increase the poor heat transfer to the reactor wall, the second main fluid path is closed in the improved structured packings developed in this work, by flat sheets between the corrugated layers as seen in the left figure. This forces the whole fluid flow to contact the reactor wall where the heat transfer is improved.

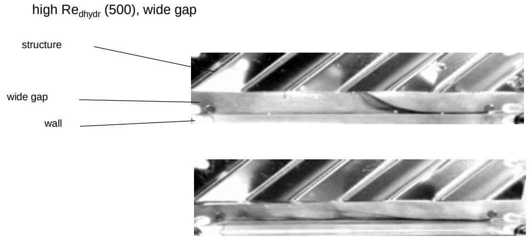
## Flow visualization




low $Re_{dhydr}$ (170), small gap

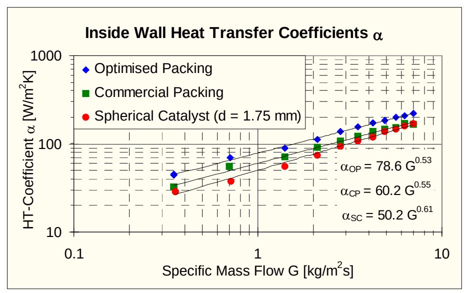


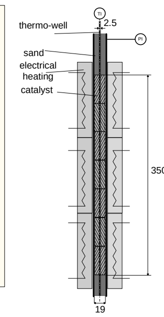

high $Re_{dhydr}$ (500), wide gap




## Heat transfer experiments

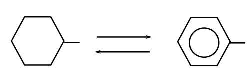
(radial gradients in the structures neglected, Nu-Pr-Re-analogies describing heat transfer behaviour obtained)



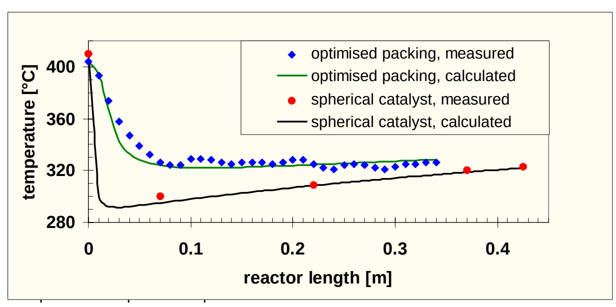




## Polytropic experiments in pilot scale plant

- Endothermic Dehydrogenation of **Methylcyclohexan** as example reaction ($\Delta H_r^{298K}$ = 205 kJ/mol):




- structure (optimized packing) coated with $Pt/Al_2O_3$-catalyst
- compared to commercially available spherical $Pt/Al_2O_3$-catalyst
- pseudohomogeneous first order model including found heat transfer characteristics, heat transfer by radiation and mass transfer limitation due to film diffusion




## Conclusions and Outlook

Optimised structured catalyst supports improve the heat transfer in tube-bundle fixed bed reactors by 25 - 30% without higher pressure drop.

The validity of the Nu-Re-Pr-analogy under reaction conditions could be shown by comparison of polytropic experiments with reactor simulation.

The use of optimised packing may decrease operating costs and permits higher space-time-yields both for endo- and exothermic reactions.

## Acknowledgments

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