



News, September 2015

Joint project "Heat utilisation with solid sorption technology" Dr. Bruno Michel

Events

Poster presentation at the workshop "Advanced sorption technologies and their applications", Empa, Dübendorf, 18 – 19 May, 2015

Hierarchically porous adsorbents for adsorption heat exchangers

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Motivation

Working fluid	Name	Formula	Freezing point [°C]	Boiling point [°C]	Latent heat [kJ/kg]	Latent heat density [kJ/m ³]
Water	H ₂ O		0	100	2 258	2 163
Methanol	CH ₃ OH		-98	65	908	872
Ammonia	NH ₃		-78	-34	1 358	832
Sulphur dioxide	SO ₂		-72	-10	605	534

- In adsorption heat pumps, the dynamic performance of an adsorber heat exchanger is governed by the choice of adsorbent material and working fluid as well as heat and mass transport
- Foam-type adsorber heat exchangers offer attractive volume utilization and mass transport, but require a metallic support structure
- The present work investigates the production of adsorbent-only foams as a means to improve mass transport while maintaining sufficient thermal transport

Templating Methods

Emulsion templating

- Oil droplets in a slurry act as the sacrificial template for pores

Foaming

- The pores are introduced by foaming of the particle suspension

Characterization strategy

Sorption properties

Characteristic sorption curve

$$\Delta F = RT \ln \left[\frac{p}{p_{sat}(T)} \right]$$

Thermal transport

Thermal diffusivity and conductivity

$$\lambda = \alpha \rho c_p$$

Cooling performance

Temperature-swing sorption

Mass Transport

Mass diffusivity by pressure swing-sorption

$$\frac{m_L}{m_\infty} = 1 - \frac{6}{\pi^2} \sum_{n=1}^{\infty} \frac{1}{n^2} e^{-\frac{n^2 \pi^2 D_{eff} t}{L^2}}$$

Results

- Self-supporting adsorbent foams were achieved using SAPO-34

- First results: Specific cooling power improvement

$P_{cool} = 27 \text{ mbar}$
 $\Delta T = 40-50^\circ\text{C}$

a) Templated sample #1

Thickness = 1.4 mm
Mass = 0.303 g
Density = 0.75 g/cm³

b) Templated sample #2

Thickness = 5.15 mm
Mass = 0.288 g
Density = 0.20 g/cm³

c) Conventional coating

Thickness = 1.5 mm
Mass = 0.872 g
Density = 1.4 g/cm³

Conclusions and outlook

- Novel approach for adsorbent assembly in adsorption heat pumps
- Separation of thermal and mass transport contributions to the rate of sorption
- Detailed study of the effect of porosity on sorption rate

Acknowledgments

Thermally driven adsorption heat pumps for substitution of electricity and fossil fuels

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Publications

Full-page article about THRIVE published in TagesAnzeiger, July 26, 2015:

<http://www.tagesanzeiger.ch/wissen/technik/das-grosse-potenzial-der-abwaerme/story/14629189>

Varia

Creation of a a YouTube video and Flickr gallery explaining the THRIVE project for a broader public. The video has – in September 2015 - more than 10'000 clicks:

<https://www.youtube.com/watch?v=6kuFYcbnTeg>

https://www.flickr.com/photos/ibm_research_zurich/sets/72157651308697141/

Project announcement was covered on various important platforms:

<http://ibmresearchnews.blogspot.ch/2015/07/crazy-science-easing-strain-on-energy.html>

<http://www.empa.ch/plugin/template/empa/3/160016/---/1=2>

<http://www.engadget.com/2015/07/27/ibm-wants-to-cool-data-centers-with-their-own-waste-heat>