Lecture on latent storage components

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Agenda

- Impact SCCER on Competence Center Thermal Energy Storage
- Motivation
- Insight on projects
- Outlook
Competence Center Thermal Energy Storage
Our Team 2013

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Competence Center Thermal Energy Storage
Analytical Laboratory

- Beckmann-Coulter
- Easy Max
- Differential Scanning Calorimetry (DSC)
- Thermogravimetric analysis (TGA)
- Transient-Hot-Bridge (THB)
- Gas chromatograph
- Gas-sorption analyzer
- Dynamic Mechanical Analyzer (DMA)
- Infrared spectroscopy (FTIR)
- LUMISizer
Competence Center Thermal Energy Storage
Computed Tomography
Group Latent Storage
Facts and Figures: both SCCER periods

26 projects

25 peer reviewed publications

2 Spin-Offs

5 phd collaboration:
EPFL, INSA Lyon, TU Vienna, Uni Edinburgh, Uni Padova
Our Motivation
Thermal Storage

Energy consumption worldwide for heating and cooling

Energy Consumption for Heating & Cooling

50%

Source: windeurope.org

Thermal storage can be:

- Cost-effective
- Environmentally-friendly
- Simple

→ Interest to use thermal storage when heat and cold are consumed
Our motivation
Characteristics & Advantages of latent storage

Characteristics

• Heat or cold storage in a *melting / solidification* process
• **Phase Change Material (PCM)** as storage medium

Comparison with sensible storage:

✔ 2-8 times higher energy density than water
✔ Steady $T_{\text{output}}$
✗ Low heat transfer coefficient
✗ Higher cost
Our motivation
High power latent heat storage

Need for **compact** energy storage technologies to store and deliver **high thermal power** in a flexible and efficient manner.
Competence Center Thermal Energy Storage
Our research

Material characterization and optimization

Pilot plants and fundamental research

System modelling and optimization of components
Development & Characterization of Materials:
Which are the most interesting PCM?

**Motivation:** Need for environmentally friendly, cost-effective, compact and stable PCM for sustainable future

**Approach:**
- Novel salt/water-based PCM for compact and cost-effective storage
- Esters for bio-sourced and biodegradable latent storage

**Key Result:**
- 3 new salt-water based PCM have been developed for at 15°C, 32°C and 58°C
- 55 esters have been synthesized and analyzed so far
- Internal database with >300 PCM developed

High power latent heat storage

Which is the most promising technology?

**Approach:**
- Method developed to compare performance in terms of high power capability, compactness and cost
- Most promising technologies investigated experimentally

**Key Result:**
- Clear trade-off between heat transfer rate and energy density
- Hollow fiber and automotive heat exchangers → most promising technologies

Higher power latent storage
Technologies investigated

Market Readiness

- HEX immersed in PCM
- Macro Encapsulated PCM
- Phase Change Dispersions
- Direct Contact

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Optimal design?

Motivation:
• Further development and optimization of existing latent storage based on finned tube heat exchangers

Approach:
• Optimization of existing design for domestic hot water applications
• Extension of technology to refrigeration applications

Key Results:
• A fast model has been developed, validated and used as design tool
• A compact alternative to water-glycol storages for refrigeration applications has been developed

Higher power latent storage

Technologies investigated

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Macro-encapsulated latent storage
Optimal capsule shape and size?

Motivation:
• Flexible, modular and cost-effective technology for high-power applications

Approach:
• Power profile, energy density and cost depend on capsule design
• A computational model is developed combining a detailed 3-D model of a single capsule and a 1-D model of the entire storage

Key Results:
• Fast model developed and validated to be used as a design tool
• A more in-depth research is conducted in common phd with EPFL
• Spin-off COWA

Key Applications:
• Domestic Hot Water: More compact storage solutions (HP-Boiler)
• HP Buffer storage: More capacity for self-consumption of PV
Higher power latent storage

Technologies investigated

- HEX immersed in PCM
- Macro Encapsulated PCM
- Phase Change Dispersions
- Direct Contact
Phase Change Dispersion
Advanced heat transfer fluids

Motivation:
• Liquid-liquid heat transfer → better performance than conventional PCM storage
• Very high cooling capacity in very narrow T range

Approach:
• Various mixtures of PCM, surfactants, additives and production methods tested
• Characterized in terms of heat capacity, viscosity, stability

Key Results:
• Stable phase change dispersion produced for machinery cooling
• More than double cooling capacity than water between 22 and 25°C

Higher power latent storage
Technologies investigated

Market Readiness

- HEX immersed in PCM
- Macro Encapsulated PCM
- Phase Change Dispersions
- Direct Contact

Research
Direct contact latent storage

Feasibility of stable, high-power operation

**Motivation**:  
- No heat exchanger:  
  - Higher energy density  
  - Lower cost  
  - Lower environmental impact

**Approach**:  
- Material compatibility investigations (2 L setup)  
- Nozzle geometry investigations (40 L setup)

**Key Results**:  
- Fast charging/discharging can be achieved  
- Stable temperature output  
- Material interaction is the limiting step
Summary and conclusion

Developed high power thermal storage technologies at different TRLs

- Compact, high power thermal solutions, exist for many important applications
- Many promising low TRL technologies will continue to be developed
Thank you for your attention!