DTU Library

Long-term PCM heat storage for a solar space heating and domestic hot water combisystem

Fan, Jianhua; Furbo, Simon; Wang, Zhifeng; Englmair, Gerald

Publication date:
2017

Document Version
Publisher's PDF, also known as Version of record

Citation (APA):
Fan, J., Furbo, S., Wang, Z., & Englmair, G. (2017). *Long-term PCM heat storage for a solar space heating and domestic hot water combisystem*. Poster session presented at Workshop on System Integration of Renewables and the Future Grid , Beijing, China.

Sustainable Energy Systems

Technical University of Denmark
Department of Civil Engineering
Section for Building Energy
Ass. Prof. Jianhua Fan jif@byg.dtu.dk
Ass. Prof. Simon Furbo

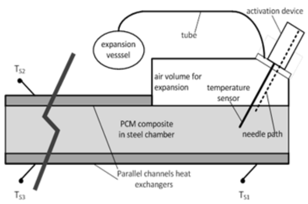
Chinese Academy of Sciences
Institute of Electrical Engineering
Solar Energy Laboratory
Prof. Zhifeng Wang

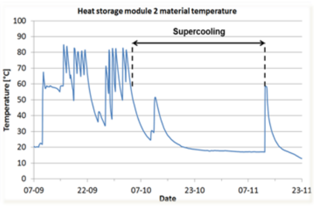
Gerald Englmair, MSc.
Start of PhD-study: 01.05.2015
gereng@byg.dtu.dk
www.byg.dtu.dk

Long-term PCM heat storage for a solar space heating and domestic hot water combisystem

Background: Due to the mismatch of solar energy resources and the demand of thermal household services, long-term storage of heat is essential for an innovative solar heating system that covers the heat demand with a high solar fraction in the range of 80%-100%. Therefore a concept for a novel compact seasonal heat store based on stable supercooling of a phase change material (PCM) has been defined in previous research activities at DTU [1].

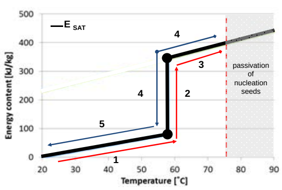
Material: Sodium Acetate Trihydrate (SAT) is a salt hydrate with a melting point of 58 °C and a relatively high latent heat of fusion (264 kJ kg^{-1}). It can be used as PCM in heat storage applications. Additives are used to stabilize the SAT, optimize or enhance the material properties and ensure cycling stability [2]. SAT can be used for long term heat storage by utilizing its ability to supercool stable to ambient temperature while heat of fusion is preserved.





Heat storage units: Flat units were constructed by the Danish company Nilan A/S with an internal height of 5 cm, resulting in a 150 l enclosed material chamber (left figure). Laboratory test were conducted by Dannemand et al. [3]. During tests with a solar collector field as heat source [4] modules were frequently heated up to a temperature above 77°C, afterwards stable supercooling was achieved for several months before solidification was initiated by seed crystal injection (right figure).

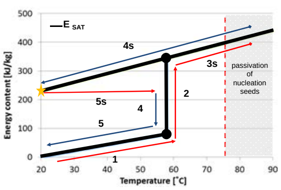
Functionality: With SAT composites three different storage principles (a-c) can be utilized for combined short-term and long-term storage of heat:



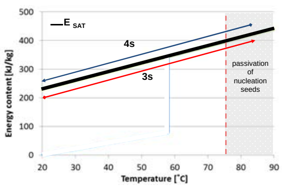
a) Heat of fusion and sensible heat capacity without supercooling

Heat storage operation states with SAT:

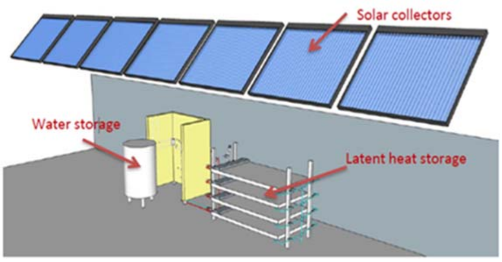
1	Charge of solid material
2	Melting
3	Charge of liquid material, nucleation seeds remain
3s	Charge of liquid material, passivated seeds
4	Discharge from liquid state with solidification
4s	Discharge of liquid material without solidification
5	Discharge of solid material
5s	Initialization of crystallization



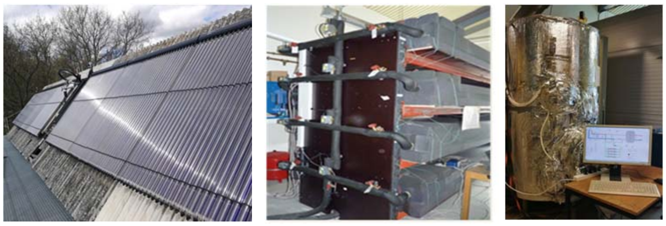
b) Heat of fusion and sensible heat capacity with stable supercooling



c) Sensible heat capacity of supercooled, liquid material



Demonstration system: A segmented PCM heat storage was formed by 4 individual flat units, each containing about 200 kg of SAT composites. The units were charged with solar heat supplied by 22.4 m^2 of evacuated tubular collectors and discharged to a 735 l water storage in periods with shortage of solar energy. On sunny days, the water storage was charged directly by the collector array. Calculated demand on hot water and space heating for a Passive House in Danish climate was drawn off at the water storage. System operation was realized via a LabVIEW control program.



Novel, economic heat storage unit:

- Hypothesis A: It will be possible to design an economic heat storage unit based on standard components from industry.
- Hypothesis B: The heat transfer will be sufficient for domestic hot water and space heating supply by combined usage of a mantle and a spiral heat exchanger.

Storage specifications:	
PCM filling:	200 kg
Inner tank diameter:	0.45 m
Inner tank height:	1.20 m
Outer tank diameter:	0.50 m
Outer tank height:	1.25 m
Heat transfer area :	2.95 m^2
PCM volume :	<150 l
Mantle volume:	54.6 l
Steel tank mass:	140.8 kg

Work flow:

- ✓ Successful system demonstration and automated system control
- ✓ Tests on operation behavior
- ✓ Periodic system performance analysis
- Economic heat storage design
- System simulation (collaboration with TU Graz) for optimized component sizing and system design
- Participation in IEA Task 58, Annex 33

References:

[1] Long term thermal energy storage with stable supercooled sodium acetate trihydrate, Mark Dannemand, Jørgen M. Schultz, Jakob Berg Johansen, Simon Furbo. Applied Thermal Engineering (91), 2015

[2] Experimental investigations on heat content of supercooled sodium acetate trihydrate by a simple heat loss method, Weiqiang Kong, Mark Dannemand, Jakob Berg Johansen, Jianhua Fan, Janne Dragsted, Gerald Englmair, Simon Furbo. Solar Energy, vol. 139, pp. 249-257, 2016

[3] Experimental investigations on prototype heat storage units utilizing stable supercooling of sodium acetate trihydrate mixtures, Mark Dannemand, Janne Dragsted, Jianhua Fan, Jakob Berg Johansen, Weiqiang Kong, Simon Furbo. Applied Energy, vol. 169, pp. 72-80, 2016

[4] Testing of PCM heat storage modules with solar collectors as heat source, Gerald Englmair, Mark Dannemand, Jakob Berg Johansen, Weiqiang Kong, Janne Dragsted, Simon Furbo, Jianhua Fan. International Conference on Solar Heating and Cooling for Buildings and Industry, Energy Procedia, vol: 91, pp. 138–144, 2016

Acknowledgement:

This research is funded by the PhD program of the Sino Danish Center for Education and Research (SDC). The work was also supported by the European Commission (Grant Agreement N_295568) as part of the Seventh Framework Program of the European Community for Research, Technological Development and Demonstration Activities under the funding scheme of "Collaborative Project".