2010 HIGHLIGHTS

SHC/ECES Task 42/24
Thermal Energy Storage: Material Development for System Integration

THE ISSUE

To reach high solar fractions, it is necessary to store heat (or cold) efficiently for longer periods of time. At this time, there are no cost-effective compact storage technologies available. For high solar fraction systems, hot water stores are expensive and require very large volumes of space. Alternative storage technologies, such as phase change materials (PCMs), sorption materials and thermochemical materials (TCMs) are only available at the laboratory scale, and more R&D is needed before they are available commercially.

OUR WORK

The objective of this joint Task with the IEA Energy Conservation through Energy Storage Programme is to develop advanced materials for compact storage systems, suitable not only for solar thermal systems, but also for other renewable heating and cooling applications such as solar cooling, micro-cogeneration, biomass, or heat pumps. The Task covers phase change materials (PCMs), thermochemical and sorption materials (TCMs), and composite materials and nanostructures. It includes activities on material development, analysis, and engineering, numerical modelling of materials and systems, development of storage components and systems, and development of standards and test methods.

The main added value of this Task is to combine the knowledge of experts from materials science with that of experts in solar/renewable heating and energy conservation.

PARTICIPATING COUNTRIES

Australia
Austria
Belgium
Denmark
Finland
France
Germany
Italy
Netherlands
New Zealand
Slovenia
Spain
Sweden
Switzerland
Turkey
United Kingdom
United States

Task Date 2009-2013

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KEY RESULTS OF 2010

In the second year of the Task, most of the work was aimed at creating a comprehensive overview of the work in the R&D projects and their interrelations and at setting up the structures and mechanisms to compare the improved storage materials and storage systems.

Material Development

In this area, the activities under materials engineering and processing were grouped into high temperature sensible storage materials, phase change materials and thermochemical materials.

A new type of sorption storage material was developed by the University of Applied Sciences Wildau, Germany in collaboration with the chemical company Chemiewerke Bad Köstritz. They synthesized novel binderless molecular sieves of type A and X using following a new manufacturing strategy for zeolite pellets. These new products (13XBF and 4ABF, see Figure 1) were investigated to determine their water adsorption properties, hydrothermal stability and storage capability. The results prove that the binderless molecular sieves, compared to ordinary materials, are well suited for thermochemical storage and heat transformation due to faster kinetics, higher water adsorption capacities, good hydrothermal stability and improved storage capacities.

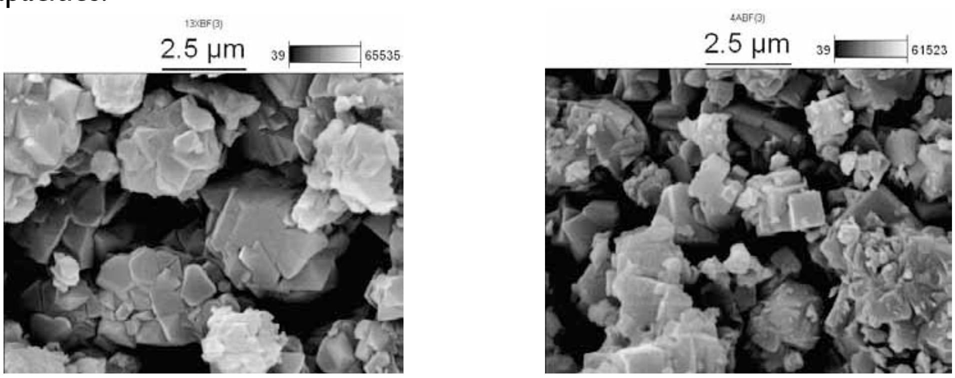

Figure 1. The SEM images show a tiny detail of the surface of molecular sieve beads (diameter 1.6-2.5 mm) of 13XBF (left) and 4ABF (right) exhibiting an overall zeolitic morphology without any binder.

At the National Institute for Chemistry NIC in Slovenia, sorption materials are synthesised in order to arrive at materials with improved performance. One of the new materials is microporous aluminophosphate. This zeolite P has good water uptake capabilities and thus a high sorption heat storage value. In Figure 2 the material is compared to zeolite 13X, a material that is presently used as sorption heat storage material.

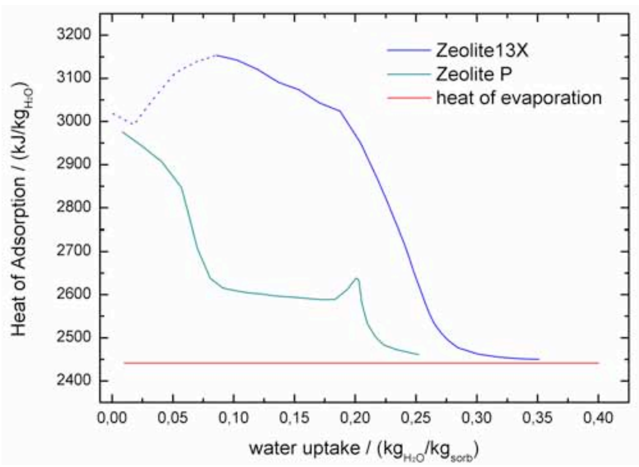

Figure 2. Heat adsorption of zeolite P and zeolite 13X.

In the framework of Task 42, the new zeolite material and other so-called disordered mesoporous metal silicates and their composites with $CaCl_2$ will be sent to other participating institutes to determine their thermo-chemical properties.

Applications

This work is divided into three application areas 1) cooling, 2) heating/domestic hot water, and 3) high temperatures. Experts are considering a long list of applications in the different projects. Two highlights in the application developments are:

- A phase-change storage technology that employs the subcooling effect of sodium acetate developed at the Technical University of Denmark, DTU. The objective of the research is to develop seasonal heat storage suitable for solar heating systems and that can fully cover the heat demand of low energy buildings under Danish conditions. A seasonal heat storage module with a salt water mixture volume of 235 litres has been tested in a laboratory heat storage test facility. The salt water mixture in the module super cools in a stable way if all crystals are melted during the charge, the activation of the solidification is reliable and the heat content of the module is as high as theoretically calculated. The test showed that the heat exchange capacity rate to and from the salt water mixture was far too low, and so the module will be redesigned and tested during the winter 2010-2011.

Figure 3. Seasonal heat storage module test at DTU in Denmark.

- The University of Minnesota is developing a seasonal thermal storage system based on the liquid sorption material lithium chloride. The laboratory prototype was completed in September 2010. It includes a 1.44 m^3 storage tank, a 3.89 m^2 polypropylene immersed heat exchanger, and supporting fluid circuitry and controls. The tank is constructed of glass to enable optical measurements of the spatial and temporal distributions of the flow field and liquid desiccant concentration during charge and discharge operation. These measurements will be used to validate prior CFD simulations.

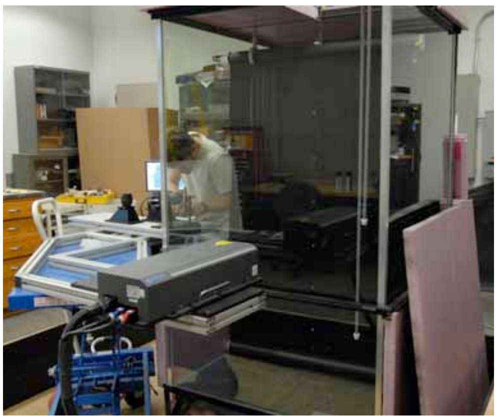

Figure 4. Laboratory storage tank with optical measurement instrumentation.

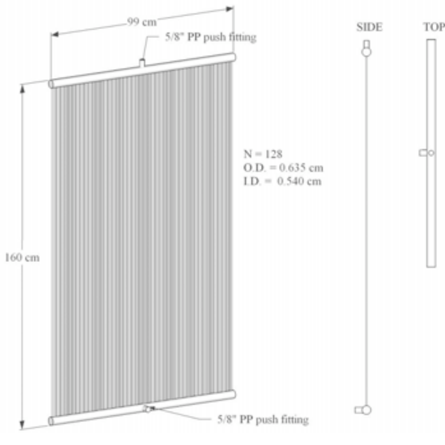

Figure 5. Schematic of the immersed polymer heat exchanger.