

# Hidden energies

## Industrial uses for thermal storage

### Contributors:

**Dr. Martin Christ**

SGL Carbon GmbH, Technology & Innovation, Senior Project Manager

**Dr. Marcus Franz**

SGL Carbon GmbH, Head of Device Development

**Dr. Martin Haas**

Xella Baustoffe GmbH, Head of Energy Management and Automation Technology

**Dipl.-Ing. Wolfgang Eden**

Director of Forschungsvereinigung Kalk-Sand (Sand-Lime Research Association)

**Dr. Wolf-Dieter Steinmann**

Thermal Process Technology, DLR Institute of Technical Thermodynamics

Since developing storage systems for solar thermal power generation, DLR has collaborated with several industrial partners to develop storage systems for the process industries. Energy storage can significantly improve the utilisation of waste heat for processes with heat requirements that vary over time. Storage can also convert intermittent waste heat into a secondary energy source that generates cooling and electricity. Component manufacturers and operators describe the advantages of the new storage concepts below.

The storage of heat can take advantage of an interesting physical phenomenon: When a substance changes its physical state, this is accompanied by a change in energy rather than in temperature. The evaporation of water into steam demonstrates this well. This phenomenon is utilised to provide heat through latent heat storage systems. Latent heat storage is particularly suitable for industrial processes where steam is used as the process medium; the temperature remains constant for the energy

intake and outlet (evaporation/condensation). The crucial property of any thermal storage system is its power density. DLR and SGL Carbon GmbH have jointly developed a new concept to ensure superior power density. By integrating graphite structures into the storage material, the heat transfer during charging/discharging is greatly intensified. This improves the economic viability of latent heat storage systems considerably.

### Utilising waste heat – an example from the building materials industry

The first detailed investigations into the industrial use of the new latent heat storage technology are being conducted for autoclaved aerated concrete (AAC) production and for the sand-lime brick industry. In these production processes, the energy consumption takes up around 20-25 percent of the costs, and is predicted to rise even further. In collaboration with the Bundesverband Kalksandsteinindustrie e.V. (Federal German Association of the Sand-Lime Brick Industry), DLR is searching for ways to increase energy efficiency through the integration of storage systems. Germany's 96 sand-lime brick factories have a total annual production volume of around six million metric tons; their total annual energy consumption is more than 700 gigawatt hours. Latent heat storage could help to reduce this, particularly in the most energy-intensive stage of brick production – steam curing. Here, the raw bricks are placed in an autoclave with a steam atmosphere pressurised to 16 bar, where they are cured at a temperature of around 200 degrees Celsius.

In the area of AAC production, DLR is collaborating with SGL to develop storage systems that can be deployed in the production plants of Xella Baustoffe GmbH. In 2007, Xella's plants produced around seven million m<sup>2</sup> of aerated concrete. The production of AAC is also based on steam-curing the raw materials. Within their joint PROSPER project, SGL, Xella and DLR have developed, built and tested a latent heat storage system designed specifically for the concrete industry. The laboratory model was cyclically charged and



Autoclaves for steam-curing building materials

discharged with process steam, successfully demonstrating the functionality of the new storage concept. At a temperature reduction of 20 Kelvin, the system achieved a volumetric storage density of around 65 kilowatt hours per cubic metre (kWh/m<sup>3</sup>). At the same temperature reduction, the Ruths hydraulic accumulator that is currently being used achieves a power density of only around 22 kWh/m<sup>3</sup>. After these very encouraging results, the research group is now investigating how the storage technology can be integrated into the production process.

### Energy storage in combined heat and power systems

Thermal energy stores can also be used industrially with combined heat and power (CHP) systems to provide process steam. With a thermal energy storage system, the provision of power is no longer coupled directly to the provision of heat. The exhaust gas of a diesel engine, for example, can be used to generate steam, which in turn is used to permanently charge a latent storage system. When there are significant fluctuations in the production plant's steam consumption – as is the case when autoclaves are filled – the steam is provided by the steam generator

and the latent storage system. Working with SGL, DLR has developed a latent heat storage system with a melting point of 225 °C that is designed specifically for such applications. This type of system can provide steam at a pressure of 15 bar.

### Thermal rectifiers

The effective operation of energy converters such as cooling units, ORC processes or Stirling engines relies on constant thermal energy. In many cases, even huge amounts of waste heat (as produced by a foundry, for example) cannot be utilised as it isn't continuously available; there are fluctuations either in the power or the temperature. Thermal energy stores can provide a solution when they are inserted into the waste heat cycle as thermal rectifiers. The store can provide a constant heat flow to the energy converter, and the output is the average of the intermittent waste heat previously absorbed into the store. Using such a concept, the energy converter can operate at an optimal efficiency level; there is no risk of the converter being over- or underdimensioned. Research is focusing in particular on the combination of thermal rectifiers with ORC processes that are suitable for the conversion of low-temperature heat.