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High Temperature Heat Storage for Industrial Process Heat and Power Generation

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This paper gives an overview of the high temperature thermal energy storage development at the DLR Institute of Technical Thermodynamics. Within this context high temperature is defined to be beyond 100 °C as needed for comfort heating and cooling.

Thermal energy storage is a key element for effective thermal management in the sector process heat and power generation, it is indispensable for solar thermal applications. A characteristic of thermal storage systems is that they are diversified with respect to temperature, power level and heat transfer fluids and that each application is characterized by its specific operation parameters. This requires the knowledge of a broad portfolio of storage design, media and methods. Therefore, material issues, design aspects and system integration of energy storage are in the focus of the RTD activities at DLR.

Solid Media Sensible Heat Storage for Solar Thermal Power Plants

Energy storage systems increase the percentage of solar energy produced by a power plant, improve operating behavior, lead to higher utilization of the power block and enhance revenues. Through the combined effect of all these factors, the cost of solar power generation by a solar thermal plant with integrated storage technology can be reduced compared to operation without a storage system. Therefore, energy storage systems are imperative for the successful positioning of solar power plant technology.

For parabolic trough power plants using synthetic oil as the heat transfer medium, the application of solid media sensible heat storage is an attractive storage concept in terms of investment and maintenance costs. Research activities at DLR are aiming at the development and validation of energy storage for concentrated solar power plants with thermal efficiencies of more than 90%, 30 years life time expectancy and a specific investment cost of less than 20 €/kWh thermal capacity and less than 0.01 €/kW electric.

High temperature resistant concrete and cast ceramics respectively were developed as storage materials and successfully tested in 350 kWh modules at the Plataforma Solar in the parabolic trough test loop. Together with the industrial partners Ed. Züblin AG and Flagsol GmbH, DLR is actually working on further improvement in materials and design and in the optimal storage integration into the solar plant. The results will flow into in the realization of a pilot storage, which will be the basis for subsequent commercial implementation.

350 kWh concrete and cast ceramics test modules before mounting the thermal insulation

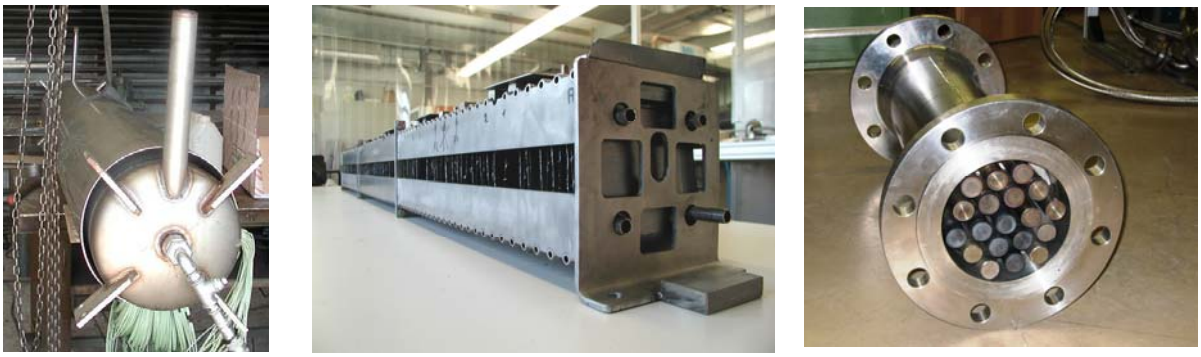
Latent Heat Storage Systems for the Industrial Process Heat Sector and Direct Steam Generation

Latent heat storage is a very attractive for all applications demanding energy supply at constant temperature. It is using phase change materials (PCM), which perform a reversible, isothermal phase transition – e.g. solid to liquid –. A PCM store a large high amount of heat in a small temperature range and is therefore especially attractive to be used in connection with two phase flow heat transfer media such as water/steam.

Current development of latent heat storage systems at DLR are directed to industrial process heat (temperature range 100-300 °C) and solar thermal power plants with direct steam generation (temperature range 300-400 °C). Candidate materials for latent heat energy storage are low cost technical salts. The dominant problem for the development of PCM systems is the limitation of power density resulting from the low thermal conductivity of the storage material.

The aim of current projects is the elaboration of the fundamentals needed for the design of cost effective PCM storage systems. Together with the industrial partner SGL Technologies improved storage media based on salt/graphite composite materials have been developed. Until now, Lithium-, Potassium and Sodium Nitrate and their binary mixtures were used, covering the temperature range between 130-350 °C. The tested salt/graphite composite materials with graphite content of 15% wt. graphite are manufactured by infiltration or compression. The measured thermal conductivity is in the range of 4-15 W/(mK). The new composites represent the first PCM storage materials, which allow the realization of cost effective latent heat storage systems for elevated temperature.

According to the respective process conditions, different latent heat storage design concepts have been developed. Within the current projects testing and validation of new materials and design concepts are conducted in the power range of 10 – 100 kW. Next step will be the integration and field testing in industrial and solar environment.



Test modules in the power range of 10 – 100 kW for different of PCM storage design concepts

Conclusion

The currently changing market conditions for energy generation and utilization as well as the legal regulations for climate protection require in many industrial sectors increasing effort regarding energy efficiency and by this increasing effort in the thermal management of heat and power. This trend will be further intensified due to the growing contribution of renewable energy sources. Hence, efficient and economic energy storage technique will be a key issue to a future sustainable energy supply.