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High-temperature heat storage FP-TES

for waste heat of 400-800 °C (750-1,500° F); without any rotating components

Thermal energy storage systems are used in many areas for balancing or decoupling between volatile energy supply and energy consumption. The spectrum ranges from small units for providing heat or cooling energy in households to large systems for the industry, with temperatures above 400-800 °C (750 °F). These storage tanks can significantly increase both the flexibility and the degree of utilisation of heat.

While a large number of industrial solutions already exist for low-temperature storage applications, there is still a need for industrially applicable systems in the medium and high-temperature ranges. An important requirement for storages for the industry is the separation of heat output and storage capacity. This reduces both the unused storage volume and the size of the heat exchanger and thus the investment costs. To achieve this separation, it is necessary to transport the storage material between the hot and the cold hopper and through the heat exchanger. This usually requires special plant components for material transport, such as e.g. screws or chain conveyors that have to withstand the given temperatures. The higher the operating temperature and the more complex the energy storage process, the higher the investment costs but also the probability of failure of individual components.

Objective

Systems for storing energy in the form of thermal energy become increasingly complex with an increasing temperature of the storage and heat transfer medium, because the strength characteristics of the required components and system parts decrease with increasing temperature.

The aim of the research work at the Institute of Energy Systems and Thermodynamics (IET) of TU Wien was to minimize the number of components necessary for the transport of the storage material and to realize a separation of the heat output from the storage capacity. In addition, the storage solution should be compact, technically easy to handle and economical. Other aims were good environmental compatibility, operating pressure of the system in (near) ambient conditions, and a temperature range between 300 °C and 800 °C.

FP-TES pilot plant at TU Wien

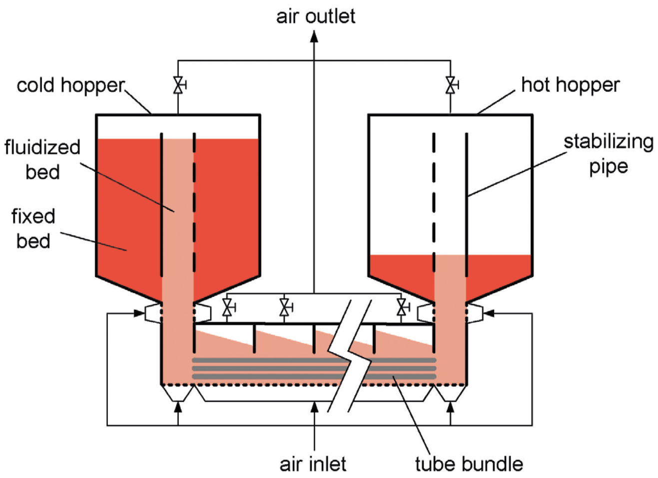
Solution

The development of the new storage technology was based on the experiences gained with the SandTES storage developed at TU Wien. Merely a replacement for the rotating system components for filling and emptying the storage hoppers was to be found. The advantages of the SandTES technology, such as a single heat exchanger for charging and discharging the thermal energy and the low overall height of this heat exchanger could be retained. The transport between the storages and the heat exchanger should be carried out by air if possible. This is already available for the optimized transport through the heat exchanger – by means of fluidizing the storage material. Therefore, other units that would have to be acquired in addition are not required.

The big challenge in the development of the technology was the design of the hoppers. They had to fulfill two initially conflicting tasks: On the one hand, it must be ensured that the storage material can be removed from the storage tank without mechanical aids and, on the other hand, the material must be stored in the hopper after flowing through the heat exchanger. The solution to this problem is the so-called stabilizing pipe with its special geometric design. It makes it possible to separate a hopper into two sections: Within the stabilizing pipe, a fluidized bed may be realized, which enables the transport of the storage material into the hopper; outside of the stabilizing pipe, the material is in a fixed bed state. By means of the fixed bed it is possible to ensure that the storage material remains in the hopper. The discharge of the material from the hopper is achieved by a slight fluidization of the fixed bed at the outlet of the hopper – which gave the name to the storage system: Fluidization based Particle-Thermal Energy Storage.

Results

The hoppers for storing the cold or hot storage material are positioned above the heat exchanger.



Schematic diagram of the FP-TES heat exchanger

The functionality of the FP-TES storage technology was demonstrated with a pilot plant at the laboratory location of the Institute of Energy Systems and Thermodynamics. In a large number of test runs it has been proven that the system is highly dynamic and can be adjusted very well to different load conditions.

The flow direction of the storage material in the heat exchanger can be reversed within a very short time. Thus, this storage technology may also be used for applications requiring a rapid change between charging and discharging processes or vice versa.

Through its extremely high flexibility in terms of storage performance, storage capacity and temperature level during heat charging and discharging, the system may be precisely adapted to the respective process requirements.

Your benefits

- only one heat exchanger required for charging and discharging the thermal energy
- use for temperatures up to approx. 1,500° F (depending on the storage material used)
- easily scalable, full integration into thermal power plant and industrial processes
- short reaction time between charging and discharging of heat energy
- use of cost-effective and environmentally friendly storage materials
- high reversibility between charging and discharging of thermal energy
- heat output decoupled from storage capacity
- high energy density
- storage capacities of up to 6 MWh

Notes

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