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Model validation of a thermal high performance system for the further expansion of renewable energies

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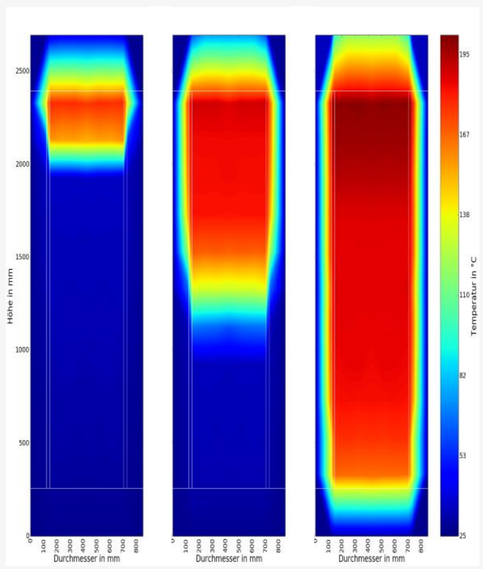
Goal

The goal of our work is to contribute to an increased flexibility of thermal power plants with different nominal outputs providing control energy for the stabilization of the interconnected grid and to guarantee the security of electrical energy supply for the Saxon economy. The investigations include experimental analyses for thermal energy storage within the range of minutes and hours, and the derivation of static and dynamic parameters in order to evaluate possible applications of a fully developed thermal energy storage system. An additional task is the methodical advancement and validation of models for the simulation-supported design of thermal energy storage systems. We aim to establish an experimentally validated and scalable overall model for a highly transient thermal storage system. The overall model enables the design and evaluation of appropriate storage systems for thermal energy plants as well as the design and testing of safe control concepts for the entire process.



Loading process of displacement storage in the THERESA test facility (experimental database)

Requirements for a highly transient thermal energy storage system

The dynamic requirements and boundary conditions for a high-transient thermal energy storage system were defined on the basis of the future requirements for a stable transmission grid for the supply of electrical energy:

- High load change rate of the overall process
- Transmission of high power to and from the storage system
- Suitable for high operating pressures up to 60 bar
- High-cycle stability of the storage system
- Use as short-term memory in the hour range
- High availability and long service life (30 years+)
- Simple construction, robust and low maintenance costs
- Variable storage capacity/design, depending on application
- Completely traceability to the recycling cycle (sustainability)
- Decentralized application possible in SMEs and industrial applications

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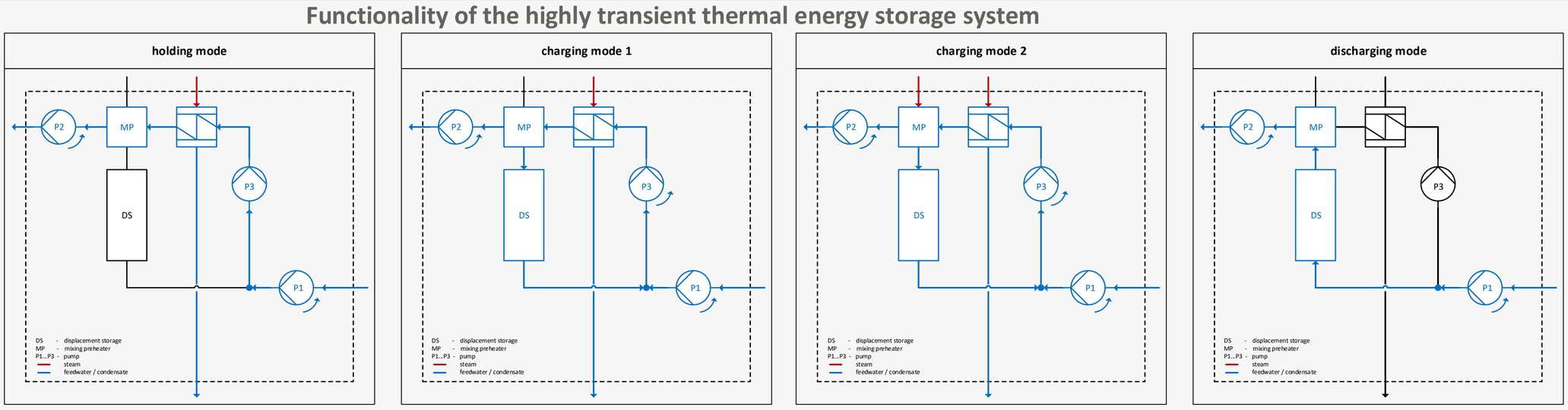
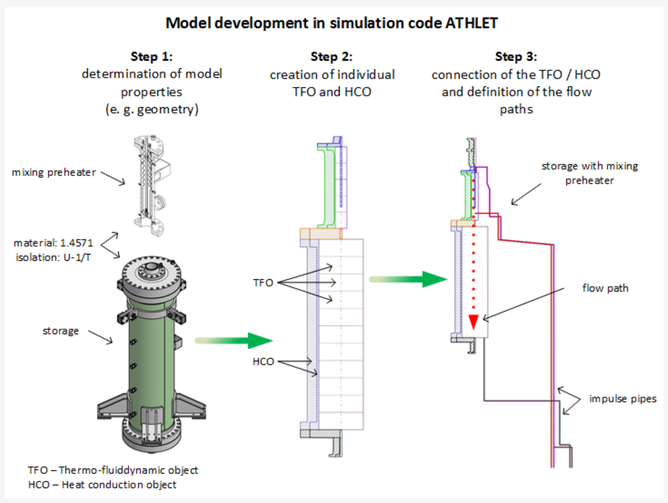
Functionality of the highly transient thermal energy storage system

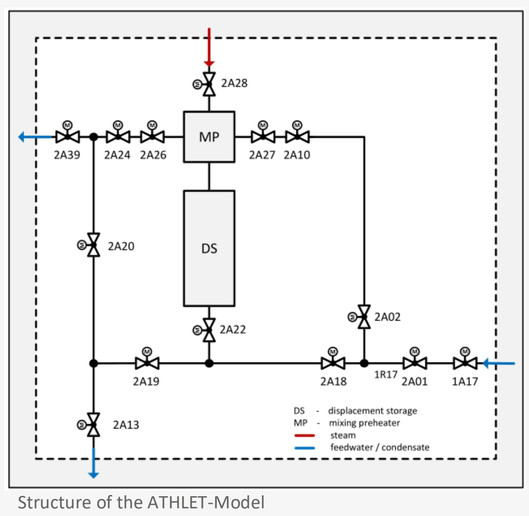
The highly transient thermal energy storage system is used for demand-oriented storage of preheating energy in thermal processes. The integrated mixing preheater is used for the direct condensation of tap steam in the feed water, which is stored as hot water (near saturation water).



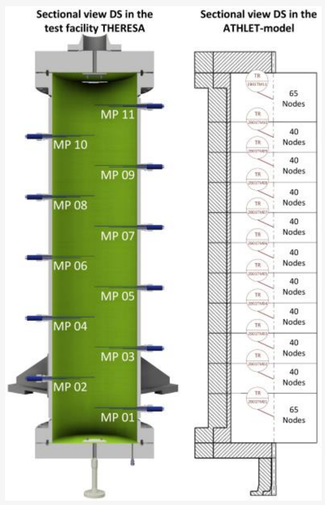
Model development with the ATHLET simulation code



The dynamic model was created using the validated ATHLET simulation code (Analysis of Thermal-Hydraulics of Leaks and Transients) from the Association for Plant and Reactor Safety (GRS). The model development of the highly transient thermal energy storage system is based on the equal pressure displacement cylinder and the mixing preheater of the THERESA pilot plant. For a dynamic simulation, we reproduce the components with their geometry and material data as well as adjacent peripheral components (eg. pipelines and valves). For the subsequent experimental validation, the instrumentation of the pilot plant will continue to be accurately mapped in the model. In addition, the model is being developed with regard to scalability for alternative applications in thermal plants.

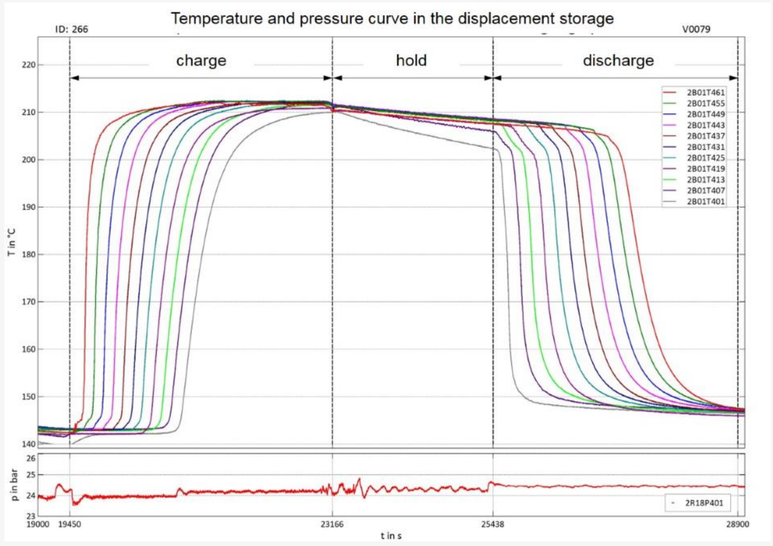


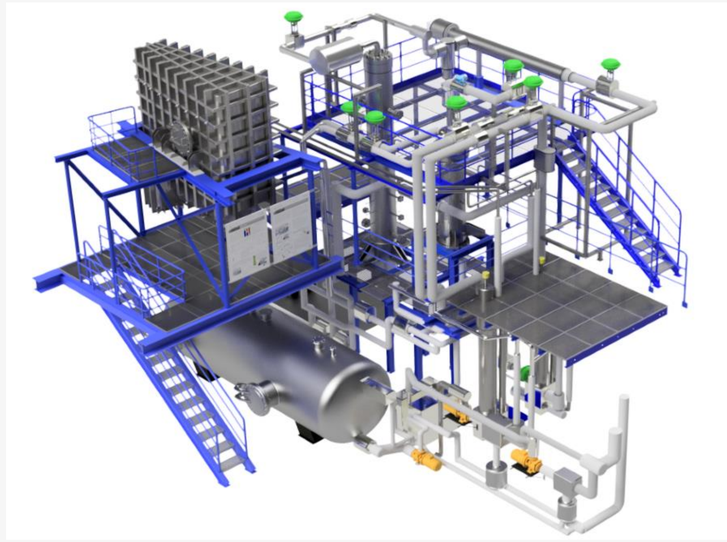
Structure of the ATHLET-Model



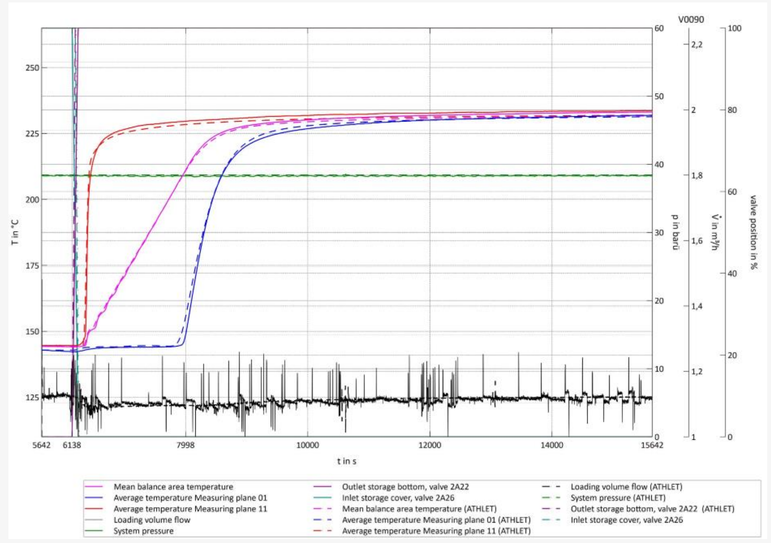
Characteristics and experimental model validation

The THERESA test facility is used to create a database for the development and quantification of characteristics for the evaluation, design and scaling of thermal energy storage systems in the high-pressure range. The experimental work focuses in particular on the determination of charging and discharging characteristics as well as the development of efficient charging and discharging strategies for the equal pressure displacement accumulator as part of a highly transient thermal energy storage system. Furthermore, the generated simulation model is validated on the basis of experimentally acquired measurement data from the THERESA test facility, and thus enables scalability and transferability of the developed model to other thermal energy plants.





THERESA test facility in Zittauer power plant laboratory



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