Modeling a Low-temperature Compressed Air Energy Storage with Modelica

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The usage of compressed air in order to store electricity has been applied already in the 1970ies. Recently, the concept again gains a lot of attention due to it's ability to balance out the power output of intermittent renewable energies such as wind power or photovoltaics. The basic idea of compressed air energy storage (CAES) is to absorb electricity by compressing ambient air by an electrically driven compressor in times of surplus electricity in the grid and store it in a pressurized containment of any kind. During discharge the compressed air is released and heated up with fossil fuel to drive an expansion turbine. The turbine is connected to a generator supplying electric power to the grid. Nowadays, CAES approaches aim on cycle operation without the need of fossil fuels to heat up the compressed air during expansion. Therefore, a thermal energy storage (TES) is applied. It captures the heat of compression during the charging process and allows to use it to heat up the air in the discharging process [1]. The main challenges are the demand for a compressor redesign to face temperatures of up to 650°C and the development of a large packed bed TES.

In order to avoid the challenges associated to high temperature TES Fraunhofer UMSICHT investigates the possibility to design A-CAES plants for lower TES temperatures. Interesting results for a two-stage A-CAES at 350°C [2] and the fact that the cycle efficiency of A-CAES is not governed by the Carnot efficiency led to the current 100-200°C LTA-CAES concept [3]. One part of the development process is the dynamic simulation of the plant to examine the thermodynamic behavior of the system. Here, off-design behavior regarding turbomachinery output temperatures, pressure losses and heat flows are of particular interest.

References

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