INTEGRATION OF A LATENT HEAT STORAGE UNIT IN A COGENERATION PLANT

Maike Johnson
Institute for Engineering Thermodynamics, German Aerospace Center
Pfaffenwaldring 38-40, 70569 Stuttgart, Germany
Phone: +49 711 6862 344
E-Mail: maike.johnson@dlr.de

1 SUMMARY

A latent heat storage unit for the production of superheated steam at >21 bar and 300 °C is being built and integrated into a cogeneration plant in Saarland, Germany. This storage unit is serves as a backup steam supply for a gas turbine, and consists of finned tubes and sodium nitrate as the phase change material. The storage design, build and beginning of commissioning will be shown and discussed.
Keywords: latent heat, integration, PCM, finned tubes

2 INTRODUCTION

In a cogeneration plant belonging to Steag New Energies in Saarland, Germany, one of the steam customers has high quality and supply standards. Due to the required availability, backup steam generators are on standby in parallel to the heat recovery steam generator (HRSG) operated in conjunction with a mine-gas fired gas turbine. This backup generator assumes the steam production within two minutes if necessary and is therefore constantly kept at a minimal load, thereby burning fossil fuels.
With the integration of a thermal energy storage (TES) unit in parallel to the HRSG and the backup boiler, the standby load of the backup boiler can be reduced to a cold load. From this load, the backup boiler requires 15 minutes to ramp up for steam production. During this time, the TES will produce steam.

3 INTEGRATION IN THE PLANT

The storage unit is being integrated between the feedwater pump and the steam main, in parallel to the existing HRSG and the backup boiler, as discussed by Johnson et al. (2015) and shown in Fig. 1. During discharging, feedwater is pumped into the bottom of the storage, evaporates and superheats in the storage and, after quality measurements are made, is passed on to the steam main and the customer.
Charging of this storage unit is also interesting, because the superheated steam from the HRSG is only condensed in the storage unit at the very beginning of discharging. Charging occurs, on the heat transfer medium side of the storage unit, primarily sensibly. This is achieved by using a controlled bypass, where the amount of steam flowing through the storage is steadily increased until the full mass flow goes through the storage unit. Due to this bypass, steam continues to flow to the customer during charging of the storage unit.

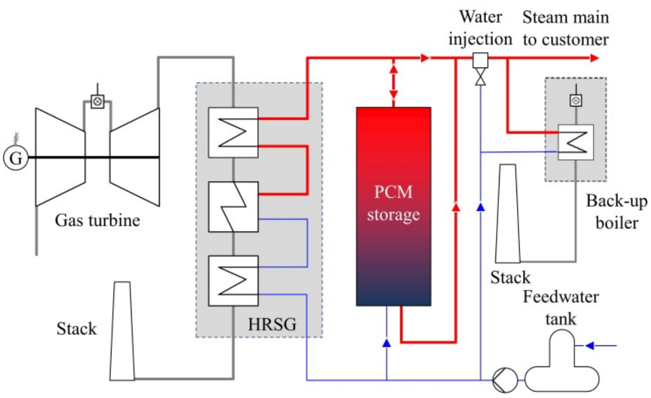

Fig. 1: Schematic of thermal energy storage unit integration in the cogeneration plant.

4 STORAGE UNIT DESIGN

The TES was designed using $NaNO_3$ as the storage material. This changes phase from liquid to solid during discharging and releases thermal energy. The storage concept is based on that of a tube-and-shell heat exchanger, with the phase change material (PCM) on the shell side and water/steam in the tubes. This water/steam absorbs energy from the PCM during discharging and evaporates. The tubes have extruded aluminum fins mounted on them, in order to enhance heat transfer throughout the discharging process. Simulation results of discharging are shown in Fig. 2, with the red line showing the outlet temperature of the storage unit sinking to 300 °C after 28 minutes, at which point the storage unit is considered to be discharged. Also shown, in green, are the averaged temperatures at the bottom, middle and top of the PCM volume.

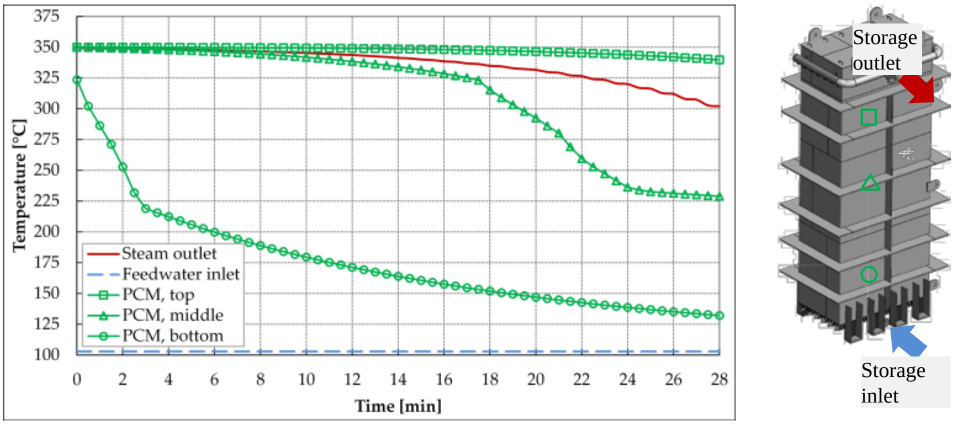

Fig. 2: Discharging temperatures of the averaged values in the PCM at the top, middle and bottom as well as the storage outlet and inlet temperatures. The schematic on the right shows approximate calculation locations.

5 OUTLOOK

The storage unit is currently in build and the site has been prepared. Erection of the unit is planned for spring/summer 2018, so that first results of the commissioning process can be shown and discussed. With this storage unit, the largest high temperature latent heat storage unit using extruded aluminum fins in a large scale deployment will be built, analyzed and tested.

6 ACKNOWLEDGEMENTS

The authors thank the Ministry of Economics and Energy for the partial funding of this project and are solely responsible for the content of this document (TESIN, 03ESP011).

7 REFERENCES

Johnson M, Vogel J, Hempel M, Hachmann B, Dengel A, (2017), Design of high temperature thermal energy storage for high power levels. Sustainable Cities and Society, http://dx.doi.org/10.1016/j.scs.2017.09.007.

8 CONFERENCE TOPIC

Heat and Cold Storages