Volume Changes in DSG-Solarfield and Steam Drum due to Changes in Evaporation Conditions from Experience

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1. Introduction

At the Jordanian pharmaceuticals manufacturing company RAM Pharma, a direct steam generation (DSG) solar field supplies saturated steam at 6 bar_g as solar process heat [1]. The collector field consisting of 394 m² of linear Fresnel collectors has been constructed by Industrial Solar GmbH in March 2015 and operated since then (Figure 1).

Fig. 1: Collector Field and Steam Drum on the RAM Pharma Rooftop

In the frame of the SolSteam project, an extensive amount of operational data is being analyzed by the partners. In this paper the measured volume changes in the steam drum are analyzed to evaluate the typical layout. To dimension the steam drum, the volume of steam filled piping is calculated. This volume needs mostly to be filled from the water content in the drum when clouds appear and vice versa the drum needs to be able to take the flush of water appearing when evaporation starts.

2. Direct Steam Generation (DSG)

In the concept of DSG, liquid water is pumped from the steam drum to the solar field, where it is first preheated and then evaporates partially. The mixture of liquid and steam flows back to the steam drum, where it is separated. The saturated steam leaves the steam drum towards the costumer's steam line. To maintain the same water mass within the solar field and steam drum circuit, the equivalent mass flow of feedwater has to enter the steam drum (Figure 2).

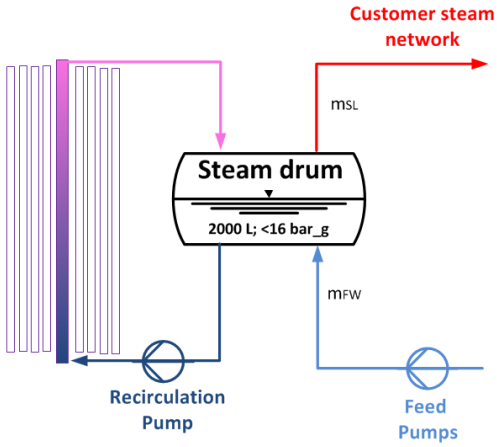

Fig. 2: Schematic mass balance of steam drum

During nominal, stable operation the mass flow to the solar field equals the mass flow out of the solar field. A difference between feed water mass flow and steam mass flow directly translates to a change in the steam drum level, as displayed by the calculated values (blue dotted line) in Figure 3. A comparison between the calculated and measured steam drum level reveals that the water volume is shifted to the steam drum during evaporation and that the water volume is shifted back to the solar field during condensation in the solar field (Figure 3). This effect is due to the considerable difference in densities of liquid water and steam.

As an example, the measured steam drum level data of December 6th in 2015 are shown in Figure 3.The rise in level at about 8 a.m. is the result of the start-up of the solar field. Between about 10 a.m. and 4 p.m. the fluctuations in the level are caused by defocusing for power control. The decline of the level after 4 p.m. results from the shutdown of the plant and the filling of the solar field with water.

The analyzed data have been used to validate the layout calculation. This approach is similar to [2] but in this case applied to a solar process heat plant instead of a power plant.

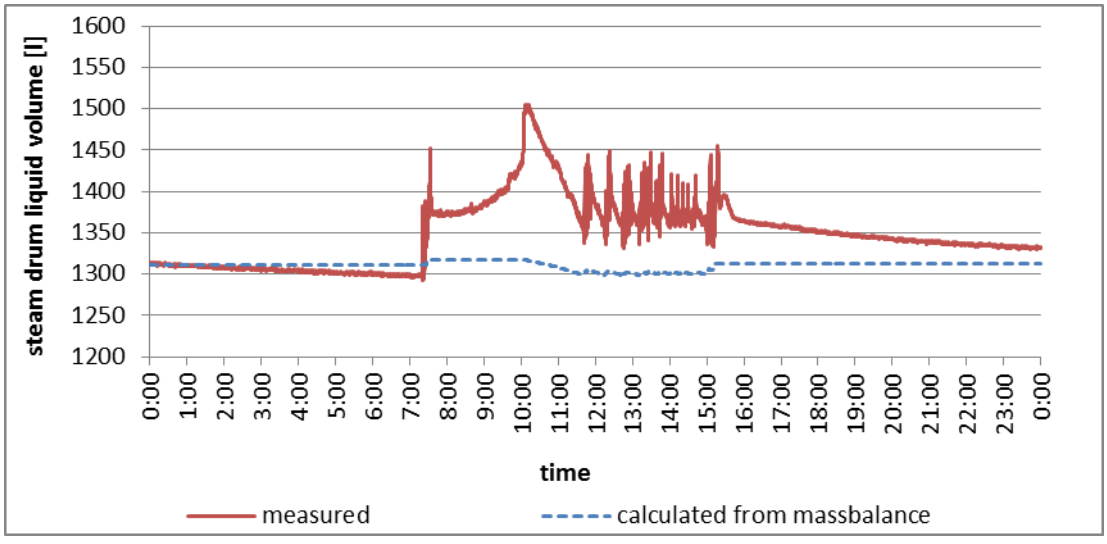

Fig. 3: Diagram of the measured and calculated steam drum level in comparison

References

[1] M. Berger, (2015). Solar Process Steam for a Pharmaceutical Company in Jordan, SolarPaces

[2] L. Willwerth et al., (2016). Steam Drum Design for Direct Steam Generation, SolarPaces