Commissioning and tests of a mini CSP plant

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1. Introduction

A small CSP installation has been erected at the premises of the École Nationale d'Ingénieurs de Tunis (ENIT) within the project REELCOOP. It demonstrates the solar thermal electricity production in small scale. Thus it will be operated to gain experience, test components and especially to train personnel.

2. Detailed plant layout

The solar electricity installation at ENIT has been erected to demonstrate the joint operation of a solar thermal field and a biomass boiler for electricity generation in small scale. Additionally the process of direct steam generation is being investigated. The planning process resulted in a closed steam/condensate loop as displayed in Figure 1. For technical data see [1].

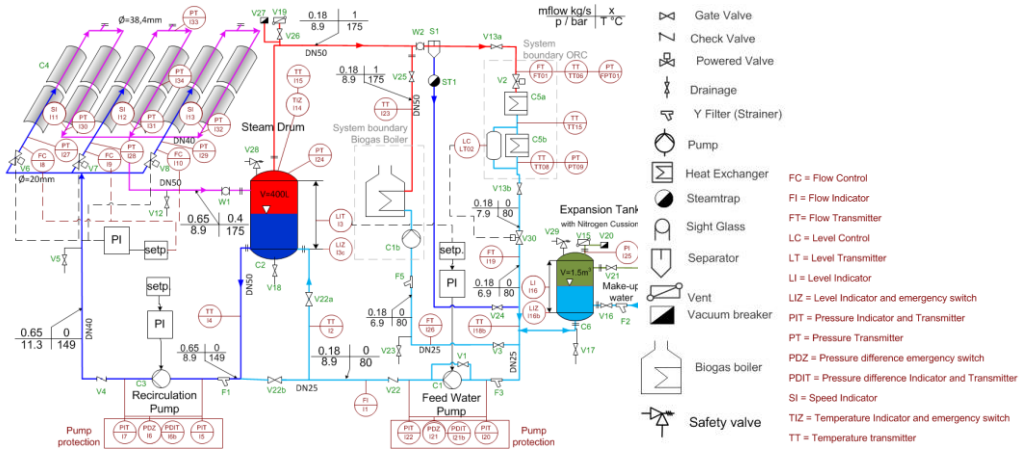

Fig. 1: P&ID and nomenclature of installation at ENIT *(will be enlarged in full paper)*.

Solar field, ORC, boiler and piping have been installed (Fig. 2). A combined biogas natural gas boiler substitutes the CSP system during the sunless periods. In this context a biomethanization unit for canteen waist is demonstrated. In order to keep producing power in the necessary transient time to change from solar field to biomass boiler a latent storage module was included as part of the design of this prototype, which was constructed and tested at PSA.

3. Commissioning of ORC

The ORC turbine has been tested at the premises of the manufacturer Zuccato Energia, Italy. Saturated steam at 170°C was provided by a boiler. The ORC machine started well without any major problems. The water steam mass flow and thus the power transferred is regulated by the valve V-2. Additionally it controls the temperature and pressure of the organic fluid entering the turbine. In the beginning high variations in the condensate level of the level tank (LT02) were observed. The reaction of the ORC loop has been to slow when pressure of steam rises quickly. As a result the condensate reached below the minimum level and

Fig. 2: Left: Solar field, right: ORC turbine.

temperature reached 150°C at the outlet of the heat exchangers. The condensate level should not fall below the lowest level to avoid the pump running with steam and it should not move to far up as this would reduce the heat transfer area of the steam. The fluctuation has been reduced by adapted control parameters for V-2.

In a next step the thermal to electric efficiency of the ORC has been tested. The thermal power has been determined by the steam volume flow and temperature at the entrance of the turbine and the temperature of the condensate at the outlet of the turbine. The electrical output is measured within the machine behind the generator. An efficiency of 14% has been reached during testing which is in line with the calculated and planning data for the ORC. For comparison with later testing in the field the cooling temperature must be taken into account. While wet cooling with low return temperatures has been used for commissioning in the facility, the cooling at ENIT will be performed with dry cooling to save water. The higher return temperature will have a significant influence on the turbine efficiency but fit better to the thermal output of the solar field and biomass boiler. The full paper will additionally include experiences in the commissioning of the full loop in Tunis and first testing results.

4. Storage

The storage module has been tested at the Plataforma Solar of Almería (Spain). Saturated steam at different temperatures up to 170°C was provided by a steam boiler for charging and hot water up to 130ºC by a water heater for discharging. The behavior of both equipment and its influence on the storage module's behavior will be explained in the full paper. As an example, it happened that the steam boiler stopped providing constant steam and reduced the steam mass flow by 50% whenever the pressure in the HTF loop went above 4 bar_g. If the storage module was cold enough at that point, discharging process was well identified since all monitored PCM temperatures became the HTF inlet temperature at the same time and when the HTF outlet state indicated that no further heat transfer occurred, Nevertheless if the PCM temperatures were high enough, the PCM in the storage module had not time enough to react to a very quick charging process defined by the state of the HTF outlet, avoiding a complete charge of the module.

References

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