ANALYSIS OF A SOLAR THERMAL INSTALLATION FOR MEDIUM TEMPERATURE INDUSTRIAL APPLICATIONS

Summary

Willing to actively contribute to the Swiss energy strategy for sustainable development, Colas Suisse SA, has decided to install a solar thermal system in one of its bitumen storage industrial site. This solar installation aims to provide 60% of the thermal energy demand of the site. Coupled with a gas boiler, the solar collectors were designed to meet the energy needs of an onsite building, a bitumen tank and two emulsions tanks (mixture of bitumen and water).

The behaviour and performance of medium–temperature solar industrial processes has not been greatly documented in the open literature. It is the purpose of this article to provide an overview of the behaviour and performance of the solar process heat system based on measurements and simulations. In addition, a number of failures of the solar thermal installation have been identified, corrected and the impact on its performance evaluated.

Key-words: solar thermal collectors; medium temperature industrial applications; thermal storage; numerical simulation; measurements.

1. Introduction and system description

In Europe, the share of the final energy consumption due to the industrial sector is around 26% (Eurostat, 2013) of which 67% is for heating purposes (ESTIF, 2006). Moreover, 26% of the industrial process heat demand is lower than 100°C and 19% is between 100 and 400°C (Krummenacher & Muster, 2015) which makes it very suitable for solar thermal technologies. It is, therefore, very important to capitalise on this potential as today less than 0.1% of the heat demand in industry is supplied by solar energy (Mauthner et al., 2015). The purpose of this study is to investigate the use of solar energy for bitumen and emulsion storage applications for a subsequent optimisation of the process.

The industrial site located in Yverdon-les-Bains, Switzerland is composed of a building and the heating installation situated next to the building. The advantage of this industry sector is that the road construction in Switzerland is operated only in the summer season from April to September when solar energy is most available.

A solar collector field was integrated to this industrial site during 2012, but several issues related to wrong hydraulic setups and failures of the control system were identified and therefore important modifications of the installation were performed at the beginning of 2015. The new hydraulic scheme of the system can be observed in Fig.1.

![Diagram of solar thermal installation](image)

Fig. 1: Simplified representation of the solar thermal installation at COLAS SA after hydraulic changes operated in 2015

Thirty five solar collectors type C2 (175 m² aperture area) manufactured by SRB Energy were installed on the site to cover an important share of the thermal energy demand of the industrial site. These collectors are flat plate collectors placed in front of two cylindrical mirrors. They present a very high efficiency at temperatures above 200 °C due to the ultra-high vacuum inside the collector (10-8 mbar at ambient temperature). For this particular site, energy has to be supplied at two different level temperatures:
• Between 50 and 90°C for the building needs of space heating and domestic hot water, but also for maintaining the emulsions in temperature. The temperature level for the emulsions can vary from 50°C and 70°C depending on the type of emulsion stored.

• Between 160 and 190°C for bitumen storage, also depending on the bitumen’s characteristics.

Four storage tanks are also present on the site (see Fig. 1): 2X50m3 for emulsion storage, 1X70 m3 for bitumen storage and 1X27 m3 for water storage. The latter is used both for the building and for the emulsion heat demand. With the exception of the water storage tank, all other tanks have a variable filling level as the tanks are daily loaded and unloaded depending on the demand.

Solar energy is delivered in priority to the water tank in order to lower the operating temperatures of the solar field and implicitly maximizing collectors’ efficiency. If this storage reaches the set point temperature, extra solar energy can be delivered to the bitumen at higher temperature level. Whenever solar energy is not available, a 250 kW back-up gas boiler supply the energy required.

2. Results

The described system has been monitored since April 2015 following the modifications implemented from the preliminary analysis. The summer season of 2015 have shown an important increase of the solar yield comparing to 2014 due to correction of the detected operational faults. Nevertheless, further improvements will be evaluated, especially for the control system and the electricity consumption.

Results for the summer season in 2015 show a monthly average of 2600 kWh of solar energy delivered to the system, see Fig. 2. 77% of the solar energy is delivered to the water storage, at lower temperature, while the rest is delivered to the bitumen storage above 160°C. A drastic decrease of solar yield in August was detected and was due to a malfunction of the system which prevented solar heat to reach the water storage so that the solar collectors only loaded the bitumen tank. This points out the tremendous influence of the heat consumption on the heat production especially for low exergy systems like solar thermal collectors.

![Fig. 2: Monthly solar energy delivered to the system, 2015](image)

A numerical model of the installation was developed and first results show that the initial target for an annual solar fraction of 60% could theoretically be reached for this site, but under very favourable operating conditions. Validation against experimental measurements for every sub-component and the overall system is underway in order to attest the reliability of the models to reproduce the behaviour of the system under different configuration scenarios.

On-going monitoring of the installation over four years will also be conducted in order to evaluate the potential decrease of the solar field efficiency with aging.

3. References


