Realization of a test rig for small solar collectors and preliminary test

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1. Introduction

The global energy policy look forward to the development of both centralized and distributed energy conversion systems at different scale mixing thermal and electrical final user supply. The renewable sources (including above all the solar one) have to play an important role especially in urban areas for residential or industrial applications. The electrical energy is assumed the best available vector also for heating and cooling but grids are not prepared to supply hi-current for all the feasible users [1]. Moreover, the growth of the distributed generation with RES requests the capacity to store the surplus energy matching with the demand profile. Actually, electrical storage systems such as batteries, are very costly and not enough efficient [2]. On the other side, small-size/hi-efficiency thermal solutions integrated with thermal storages (for examples water tank) could represent a good compromise in this contest for performances, feasibility and costs, covering a consistent part of the annual demand for heating and DHW.

A novel concentrator based on parabolic trough technology has been developed into the Department of Industrial Engineering of Florence: the system is designed to reach medium temperatures (180°-200°) with the aim of cogeneration (with ORC) and trigeneration (with absorption chiller).

A specific test bench is realized to test the novel concentrator as well as commercial ones according to ISO 9806-1 [3]: the components and the layout is presented with the description of features and characteristics. Some preliminary test for the novel concentrator are reported.

2. The test rig and the prototype of solar collector

The test rig for solar collector has been designed to be compact, self-standing and transportable. The starting idea suggested that it could be easy to install and to run to perform on-site tests according to ISO 9806. It also lead to carry out tests with the real working conditions referred to a specific site (geographical, climatic, position, etc.). The system is mainly composed of three components: an Alt-Azimuth Platform, a closed loop box and a weather station. The alt-azimuth platform (Fig. 1) has a usable area of almost 7 m^2, able to accept different modules of panels: photovoltaic, thermal, hybrid, etc. The azimuthal movement is carried out by means of a gear-motor equipped with an encoder, while the elevation movement is fixed with an adjustable angle in the range 0-45°. The elevation movement could be properly modify with an electric piston to obtain continuous tracking on two axes. The Closed Loop Box (Fig. 2) contains the supply hydraulic circuit for the collector, flow, temperature and pressure sensors with the aim of for monitoring the parameters and evaluating of the collectors' performance. Finally, the system consists of a two axes Weather Station (Fig. 3), with a pyrheliometer, two pyranometer, a thermos-

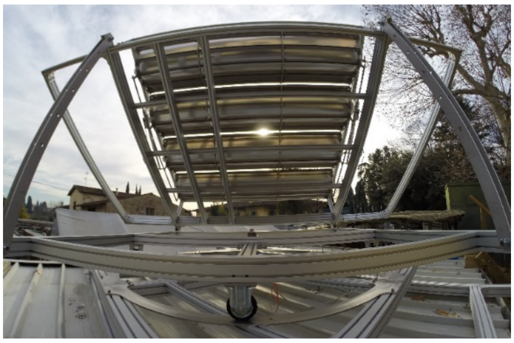

Fig. 1: Alt-Azimuth Platform.

Fig. 3: Weather station.

Fig. 1: Closed loop box.

hygrometer and an anemometer respectively for the measurement of direct, global and diffused radiation, outdoor temperature and humidity, wind direction and intensity. The CLB P&I is illustrated in Fig. 4, underlining two different hydraulic circuit (red and blue) divided by a heat exchanger (Cooler). The red side is designed to be connected to the solar collector and to work with pressurized hot water at medium temperature (up to 200°C and 16 bar). All the components, as well as the pump, are properly selected for them. Otherwise, the blue side assures the dissipation of the heat gained from the Sun and contains the main control system to stabilize the collector inlet temperature. The components in this side operate at low temperature and pressure levels inducing minor stresses and safer conditions (high performance with reduced cost).

In hot circuit the pumped water, reaches the tested solar collector after passing through the main heat exchanger (Cooler) and after measuring pressure, temperature and flow rate with high accuracy (RTD Pt100 1/10 DIN, membrane transducer and vortex with errors <1%). Also in outlet similar sensors evaluate the pressure and temperature again in order to derive the generated thermal power. Before the cycle restarts the water flows inside a storage tank with 9 kW resistances for pre-heating by joule effect and running the test at different temperature levels.

The cold circuit is used to control the SC inlet temperature automatically, in a precise way. After the cooler the mass flow is managed by modulating control valves with magnetic actuators: it has a fast positioning (<2 sec) and high-resolution (1:1000). If the inlet temperature of the SC is too high, the water is diverted to a cold sink, otherwise it is recirculated.

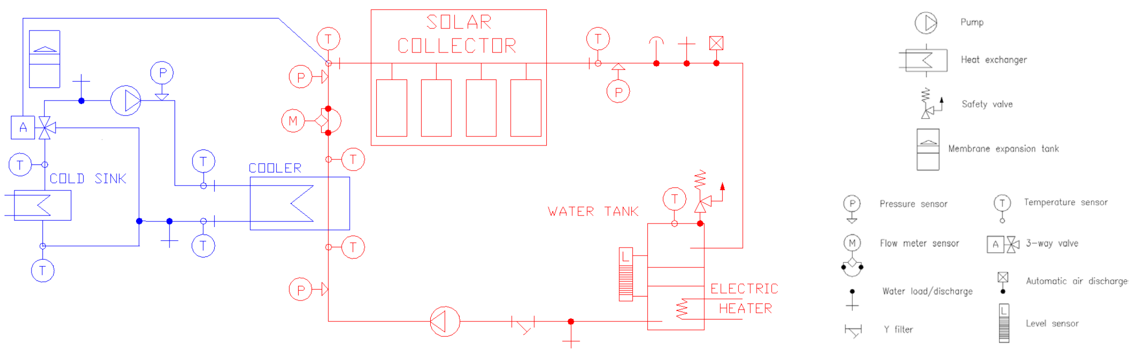

Fig. 4: Layout and P&I of the test rig for solar concentrators.

3. The prototype of solar collector

The solar collector developed by DIEF is a replicable module called m-PTC that is meant to be realised with polymeric materials and installed inside a prefabricate roof. It consists in a box (2x2 m^2) containing four parabolic mirrors for concentrating solar radiation into receivers with vacuum conditions, where water flows up to 200°C (Fig. 5). Actually the reflecting surfaces use a thin aluminum layer fixed along rigid aluminum frames. The structure is meant to be realized in plastic material in future. The collector is installed in the mentioned measurement system and some preliminary test demonstrates its features and potential of the test rig itself to operate in different conditions.

Fig. 5: The m-PTC developed by DIEF.

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