Innovative integration of desalination into an air-based CR-CSP plant with Compressed Air Storage

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CONTEXT

The ASTERIx-CAESar project, funded by the European Commission, is focused on the development of a novel high-efficiency CSP plant with integrated electricity storage solution, combining air-based central receiver system and Compressed Air energy Storage (CAES). One of the main objectives of this project is the optimal integration of this novel CSP plant with Reverse Osmosis (RO) desalination to cover 24/7 renewable power supply. The 24/7 operating strategy would be as follows: during the day, the RO plant will be powered by a PV array, recovering the energy contained in the concentrated brine leaving the membranes by means of a conventional liquid-liquid Energy Recovery Device (ERD). After sunset, a dedicated gas/liquid pressure exchanger (called GL-PX) that uses the energy stored in the CAES, will power the RO desalination unit. This work evaluates the integration of the RO unit and the GL-PX with the CAES at pilot scale. The desalination system will be manufactured by the Spanish company Apria Systems S.L (Cantabria, Spain) and will be implemented at Plataforma Solar de Almería (PSA, in Almería, Spain).

DESCRIPTION OF THE DESALINATION PILOT PLANT

The desalination pilot plant (see the piping and instrumentation diagram in Figure 1) consists of a RO membrane module through which brackish water is pumped from the Feed tank using a GL PX (i.e. a pneumatic pump) driven by air from the CAES. In the RO unit, the salt separation process takes place, and two streams leave the membrane module, the retentate solution and the permeate solution. The first goes to the retentate tank and contains most of the salts, while the second goes to the Permeate tank and is almost free of salts. There are two automatic valves (VD2 and VD3) that allow testing at different Recovery Ratios (part of the retentate solution is mixed with the feed at the inlet of the GL-PX), and an automatic valve (VD5) that allows varying the air pressure and flow rate at the outlet of the CAES. The pilot plant has been then designed in order to evaluate the amount of permeate obtained, as well as the energy and time spent, with the aim of finding the best operating strategies to achieve the optimum Recovery Ratio and air pressure.
It is going to be implemented at PSA next to the air compressed station that will be installed nearby a Central Receiver Solar (CRS) tower whose receiver will be modified and used under the framework of ASTERIX CAESar project (see figure 2). Likewise, a demineralized water tank already located at PSA will provide water for flushing to the RO module.

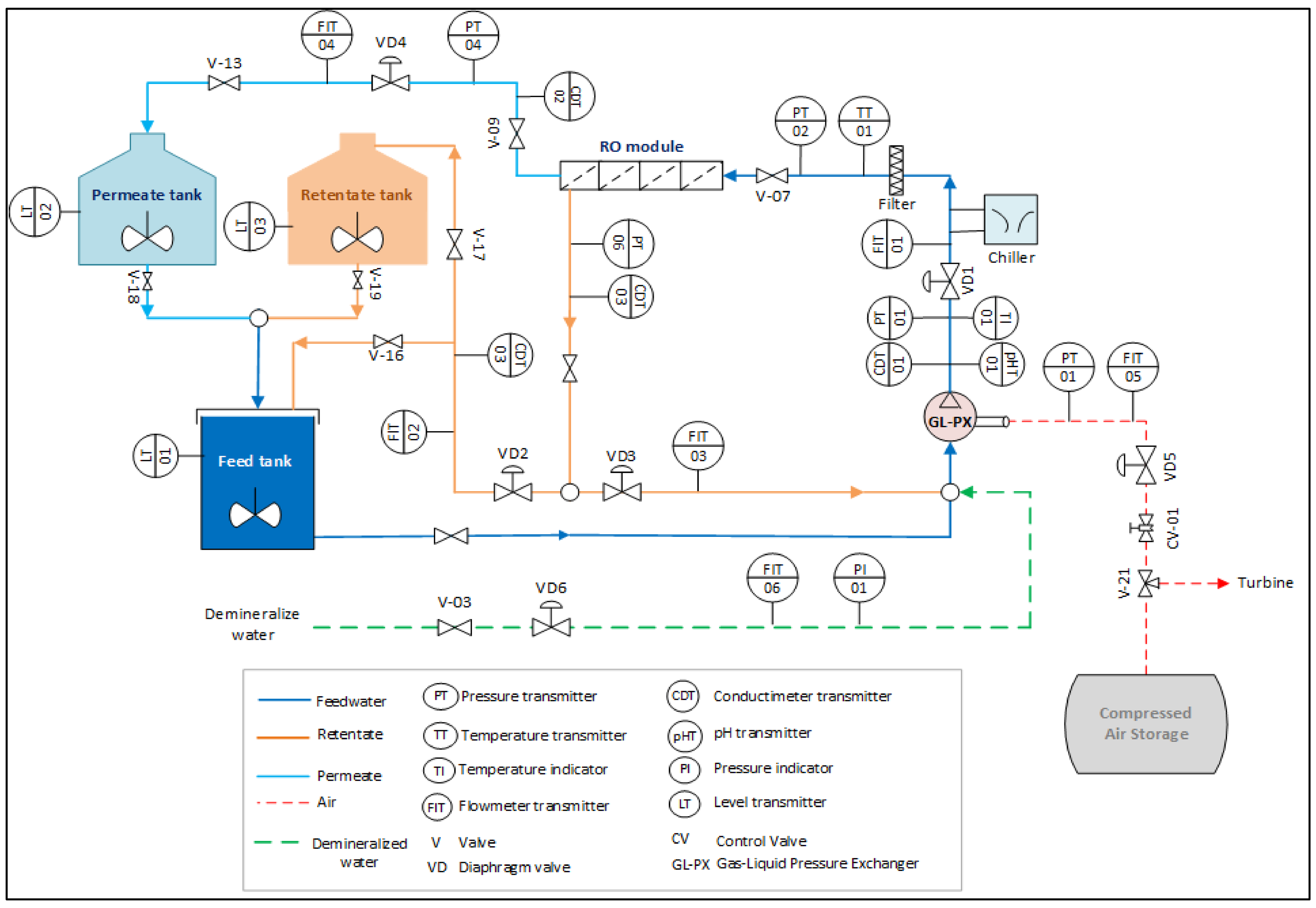

Figure 1. Process flow diagram of the RO pilot plant driven by pressurized air

Figure 2. Location of the RO pilot plant at the base of the CRS tower at PSA

DESIGN SPECIFICATIONS

The compressed air storage will provide air at a pressure between 10-15 bar, which will go either to the turbine located on the CRS tower or to the GL-PX through valve V-21 (see Figure 1). In case RO plant is on operation, the pressure will be adjusted by valve VD5 (see Figure 1) at values between 4-5 bar before entering the pressure exchanger. The air flow rate will be roughly 0.1 kg/s, which will allow an operation time between 2-3 hours. The pressure exchanger will then raise the brackish water pressure at the RO module inlet to 10-12 bar, with a feed water flow rate of 2 m^3/h. The feed water will be supplied from wells located at PSA, being its salinity between 2000-3000 ppm. All the design specifications are summarized in Table 1

Process variable	Value
Salinity feed water	2000-3000 ppm
Feed water flow rate	2 m^3/h
Feed water pressure at the inlet of the RO	10-12 bars
Air pressure from CAES	4-5 bars
Air flowrate from CAES	0.1 kg/s

Table 1. Design specifications of the pilot RO plant driven by pressurized air from CAES

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