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Steam transformer as an inexpensive production system for desalinating water

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Abstract

An untypical seawater distillation project is now being engineered according to the special requirements of a power plant in Venezuela. The project consists of 5×20 t/h steam transformers, totalling 100 t/h production capacity. Each unit is fed with the second last steam bleeding from the steam turbine at 0.64 bar, and generators vapour at 0.25 bar equal to the turbine end pressure. The new vapour generated by the evaporation of seawater after control of the conductivity, is returned into the main steam flow to the turbine condenser. The quality of the vapour is guaranteed carrying less than 0.1 ppm residual salinity according to the (patented) SED technology. The seawater evaporates at 65°C as appropriate for the prevention of scaling, with the condensation of the steam extracted from the turbine at 88°C. The condensate is available as distillate suitable for make-up service to the cycle. The steam transformer is arranged with horizontal tubes identical to a typical MED effect, and the seawater is uniformly sprayed through nozzles, outside the tube bundle. No steam consumption is actually accounted for, being the energy consumption only consisting in the difference of the enthalpy of vapour feed at 0.65 bar(a) and returned at 0.24 bar(a), for the condensation. This technology is applicable with remarkable benefits whenever two steam flows are available at very low pressure, as appropriate for seawater evaporation. This possibility is often confirmed in the steam cycles of the power generation plants.

Keywords: Steam transformer; Distillation; Evaporation; Energy cost; GOR

1. General concept

The evaporative desalination technology is now focused on the energy cost for the steam input which is by far the highest cost for the production of distillate. Many efforts are now devoted by the designers to increasing thermal efficiency, to limit heat dispersion and optimize heat recovery. The

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results of these efforts is the increase of the GOR (gained output ratio) and accordingly the reduction of the steam consumption.

In many occasions however (mainly inside power plants or refineries), some steam may be borrowed for the production of distillate and returned at a lower pressure, without any consumption of mass and without penalization for the steam utilization. In this case it is convenient to produce distillate at a theoretical GOR = infinite (no steam consumption) taking advantage only of some reduction of the steam pressure, and without any heat rejection from the desalination plant.

2. Applicability

The steam transformation may be applied very well when the following conditions are confirmed:

- The steam available (example: bled from the turbine) may be reduced in its pressure without penalization for the utilization (example: heating the BFW in a deaerator).
- Proper demisting technology is available for the guarantee of the transformed steam (generated from evaporation) purity, adequate for the make-up into the cycle as replacement of the original steam (example SED technology by SWS [1]).
- No devoted production regulation is requested. The production rate is in fact modulated by the steam demand of the final utilization of the transformed steam.

  Referring to typical power plant cycle, the steam demand of the deaerator is controlled by the pressure transmitter in the deaerator, and accordingly the production of condensate and transformed steam shall instantaneously fit the requirement of the deaerator. Some storage of condensate is therefore recommended for matching the fluctuation of the production requirement.
- The transformed vapor can be utilized at a reasonably low pressure, as feasible for the evaporation of the raw water as follows:
  - Seawater: Transformed steam approximately 0.3 bar(a) if produced by an effect and 1.4 bar(a) if produced by a flash.
  - Brackish water: Transformed steam pressure as to be checked considering the risk of precipitation of calcium salts (sulphate and carbonate). Some correction of pH may help in raising the achievable pressure up to 3.5 bar.

3. Projects in progress

Two projects are now in progress by SWS in two different sites and working conditions. Both of them are adequate to produce make up water to boilers with no energy consumption.

3.1 Busto Arsizio (Italy) — waste to energy plants

Raw water = potable water from local onshore wells

Steam available = 5 bar bleed from a steam turbine

Steam utilization = 1.5 bar deaerator (the steam pressure was reduced in the control valve)

Steam flow = 8 t/h as requested in the deaerator

Condensate = 8 t/h (the entirety of the steam requested by the deaerator)

Steam transformed = 8 t/h at 3 bar and delivered to the deaerator (the existing control valve works properly ensuring the reduced ΔP)

Steam transformer arrangement = single effect, consisting of approximately 100 m^2 of SS316L heat exchanging tubes

Steam transformed purity = TDS <0.1 ppm, according to the SED application, to be checked in laboratory. A sampler is included in the scheme.

Condensate purity = equal to the bled steam, adequate for make-up in the steam cycle. The condensate is siphoned in the deaerator tank, without any treatment.

The process flow scheme of the project is shown in Fig. 1.

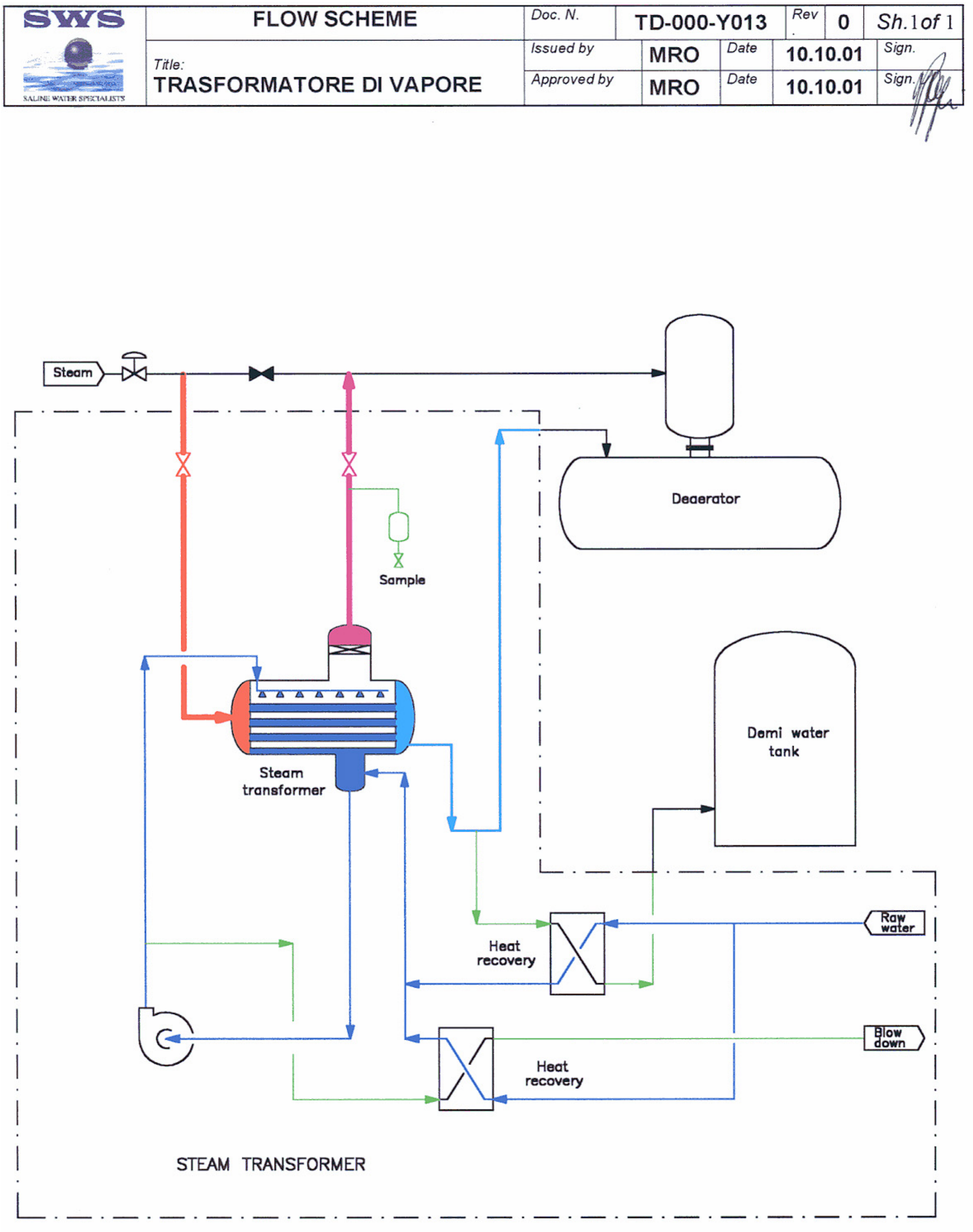

Fig. 1. Process flow scheme of the Busto Arsizio project.

2.2. Planta Centro Power Plant (Venezuela)

Raw water = seawater (Caribbean sea)

Steam available = bleed form steam turbine at 88°C

Steam utilization = preheating of the condensate (2nd preheating stage)

Steam flow = 20 t/h as requested by the preheater

Condensate = 20 t/h (Entirety of the 2° last turbine bleed)

Steam transformed = 20 t/h at 65°C, delivered to the 1st preheating stage

Steam transformer arrangement = single effect consisting of 200 m^2 of titanium tubes

Steam transformer purity = TDS <0.1 ppm according to the SED application

Condensate purity = equal to the bled steel, adequate for make up to the cycle. The condensate is pumped to the deaerator for proper heating and deoxygenation.

4. Project targets

The main target of the projects is the dramatical reduction of both the investment and the running costs of the plant. Some other technical benefits are however ensured by the steam transformer application, compared to the alternative systems of production of demineralized water, as follows:

Reliability: The steam transformer ensures the highest rate of reliability, without rotary equipment, regulation automation, or any other source of possible malfunction.

Ease in construction and fast schedule: The simplicity of the plant arrangement allows for the very easy location and quick erection.

Ease in operation and maintenance: The self regulating working mode of the plant requires no attendance and no specific skill in operation, or in maintenance.

The cost estimate of the investment is envisaged as follows:

a) Busto Arsizio Installation — approximately 70% of the equivalent ion-exchange demineralization plant
b) Planta Centro Installation — approximately 60% of the equivalent MED desalination unit.

5. Conclusion

The easy and inexpensive operation of the steam transformer provides extensive advantages and the relevant installation under suitable conditions listed in Section 2. The engineers of SWS are available to discuss and assess the conditions of applicability of the steam transformer technology in power stations, refineries and chemical plants.

Reference

[1] M. Rognoni, A. Trezzi and P. Lucchi, Spray enhanced demisting (SED). Desalination, 152 (2002) 185–190.