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Performance Assessment Of An Existing Multi-effect Desalination System Driven By Solar Energy

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Abstract : Desalination is considered the primary alternative to increase water supply for domestic, agricultural and industrial use. Sustainable desalination is only possible in places where renewable energy resources are available. Solar energy is the most relevant type of renewable energy to driving desalination systems since most of the areas suffering from water scarcity are characterized by a high amount of available solar radiation during the year. Multi-Effect Desalination (MED) technology integrated with solar thermal concentrators is a suitable combination for heat-driven desalination. It can also be coupled with thermal vapour compressors or absorption heat pumps to boost overall system performance. The most interesting advantage of MED is the suitability to be used with a transient source of energy like solar. An experimental study was carried out to assess the performance of the most important life-size multi-effect desalination plant driven by solar energy located in the Plataforma Solar de Almería (PSA). The MED plant is used as a reference in many studies regarding multi-effect distillation. The system consists of a 14-effect MED plant coupled with a double-effect absorption heat pump. The required thermal energy to run the desalination system is supplied by means of hot water generated from 60 static flat-plate solar collectors with a total aperture area of 606 m2. In order to compensate for the solar energy variation, a thermal storage system with two interconnected tanks and an overall volume of 40 m3 is coupled to the MED unit. The multi-effect distillation unit is built in a forward feed configuration, and the last effect is connected to a double-effect LiBr-H2O absorption heat pump. The heat pump requires steam at 180 ºC (10 bar a) that is supplied by a small-aperture parabolic trough solar field with a total aperture area of 230 m2. When needed, a gas boiler is used as an auxiliary heat source for operating the heat pump and the MED plant when solar energy is not available. A set of experiments was carried out for evaluating the impact of the heating water temperature (Th), top brine temperature (TBT) and temperature difference between effects (ΔT) on the performance ratio of the MED plant. The considered range for variation of Th, TBT and ΔT was 60-70°C, 54-63°C and 1.1-1.6°C, respectively. The performance ratio (PR), defined as kg of distillate produced for every 2326 kJ of thermal energy supplied to the MED system, was almost independent of the applied variables with a variation of less than 5% for all the cases. The maximum recorded PR was 12.4. The results indicated that the system demonstrated robustness for the whole range of operating conditions considered. Author gratitude is expressed to the PSA for providing access to its installations, the support of its scientific and technical staff, and the financial support of the SFERA-III project (Grant Agreement No 823802). Special thanks to the access provider staff members who ensured the access support.

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