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Annual performance of a hydrogen production plant based on CeO_2 thermochemical cycle: effect of plant location

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In APSRC 2017 we presented a dynamic model of a 1 MW_{th} continuous hydrogen production plant using CeO_2 thermochemical cycle. The model consisted of a heliostat field layout optimized using SolarPILOT™ that was implemented together with the rest of the components of the plant (Fig. 1) where the thermal inertia of the solids that were explored and integrated with the main physical and chemical phenomena. The effects of the direct normal irradiation (DNI), temperature, pressure or degree of oxidation on the hydrogen production rates were studied. In addition, a seasonal control strategy to obtain a continuous production of hydrogen was implemented.

This year, we have extended the previous study by exploring the effect of the plant location in the solar-to-fuel efficiency. Several key locations in Australia and around the world are investigated. The effect of the latitude, solar angle and DNI data are thoroughly investigated. In addition, the control strategy has been improved with a PID allowing a more stable flow of hydrogen.

Continuous hydrogen production rates are obtained in the simulations. The annual production rates obtained during a typical meteorological year in Learmonth (WA), Geradlton (WA) and Melbourne (VIC). The mass flow rates of $CeO_{2-\delta}$ are controlled using a PID to obtain a continuous production of hydrogen. The maximum flow of $CeO_{2-\delta}$ is obtained for Learmonth while in Melbourne is obtained the minimum. This is consequence of the lower DNI values in Melbourne as compared with the other locations. This also leads to lower temperature in the oxidizers (Fig. 1), a lower production of hydrogen and finally to lower annual efficiency. Under the same operative conditions at the receiver, efficiencies of 9.49, 9.03 and 5.98% are obtained for Learmonth, Geraldton and Melbourne respectively.

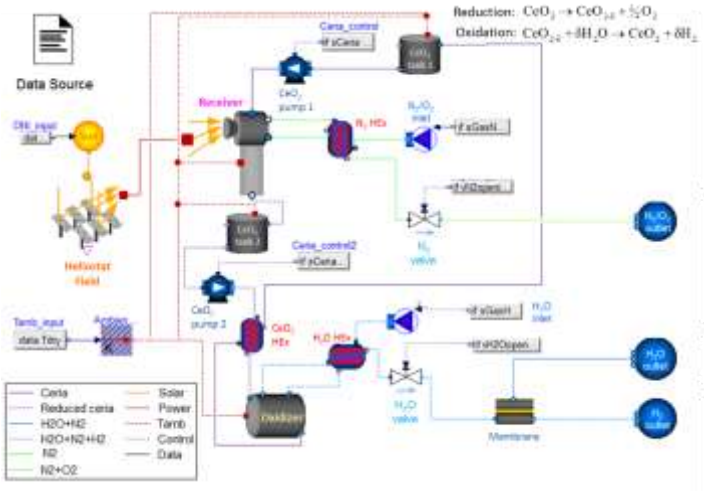

Figure 1: Modelica component diagram of the thermochemical production plant.