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Thermodynamic assessment of the hybridisation of a mid-temperature process with concentrated solar thermal energy

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A thermodynamic study is presented of the potential for hybridisation of a mid-temperature process with concentrated solar thermal (CST) energy, based on an industrial process in South Australia using data provided by a company. The process presently utilises natural gas to produce steam at a temperature of 180 °C and a pressure of 8 bar for process heat. We report an assessment of the potential for the use of solar thermal energy to mitigate both the fuel consumption for, and emissions from, the process, whilst also seeking to minimise the changes to the configuration of the main process. A schematic representation of the proposed hybrid process is shown in Figure 1.This hybrid process comprises a solar collector field, based on trough concentrators, storage tanks for the storage of oil, as the heat transfer fluid in the solar collectors, the plant and a low pressure boiler. For the proposed hybrid operation, the energy required for the steam production can be supplied with CST, energy stored in tanks, natural gas or a combination of them, depending on the solar insolation and the available stored energy in tanks. An algorithm was developed to control the fuel consumption and energy flow through the system considering the turn-down ratio of the boiler, time varying energy demand of the process, the solar insolation and the available energy stored in tanks. A dynamic model of the process was also developed, using MATLAB Programming linked to a spreadsheet software, to evaluate the influence of parameters including direct normal insolation, area of the solar collectors, efficiency of the collector field and the capacity of the storage to calculate both the hourly solar share and annual fuel saving. Calculations show that with the use of a parabolic trough with an area of 20,000 m^2 together with 8 hours of thermal energy storage can lead to approximately 42 % decrease in the fuel consumption of the process, while the fuel consumption deceases by approximately 35% without the storage. The solar share of the process was also estimated to be approximately 45%, with 8 hours of solar thermal storage capacity and 35% without it.

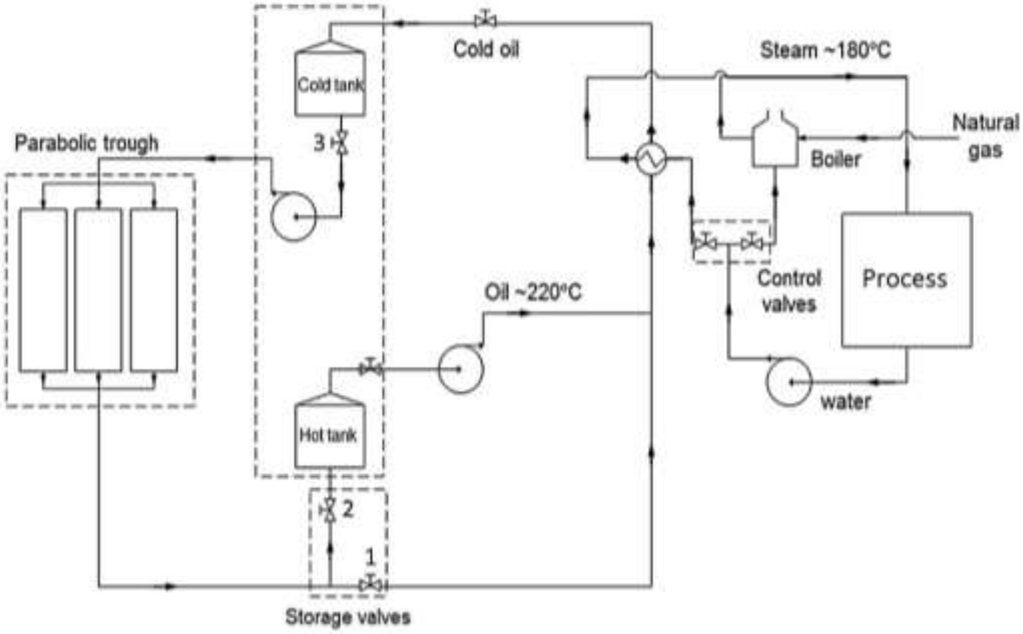

Figure 1. A schematic diagram of the propsoed process, hybridising a mid-temperature process with concentrated solar thermal energy. Storage tanks are employed to store hot and cold oil as the working heat transfer fluid.