Title

Developing Experimental Control Methods and Simulations Models for Solar cookers with heat storage.

Abstract

The use of wood and fossils for cooking among others has led to a number f environmental issues like global warming, deforestation among others. There is therefore need to use renewable energy sources. Solar energy is a renewable energy source that is clean and freely available all over the earth's surface during sunny hours of the day. Due to the intermittent nature of solar energy, indirect solar cookers are preferred because they can store thermal energy in Thermal Energy Storage (TES) systems. The developed TES systems are not yet widely accepted due to some shortcomings like thermal stratification and low efficiency that need to be addressed. Thermal stratification can be guaranteed in a TES system when thermally charged at a constant temperature. A mechanical thermostat has been developed to charge oil in a TES system at a constant temperature. The mechanical thermostat was composed of: a slider-valve, pneumatic cylinder, heating chamber and copper-coil filled with expansion oil. The mechanical thermostat was demonstrated by thermally charging a 3-tank TES system. The 3 tank TES system was composed of a cold oil reservoir tank, a hot oil storage tank, a drainage tank for storing used oil and a cooking unit. A simulation model for charging an oil-based TES system with a forced thermal stratification was also developed and validated using experimental data. The results showed that the thermostat charging temperatures would oscillate at these preset values: 116±18 ◦ C, 150±16 ◦, 230±15 ◦ C and 200±9 ◦ C and in 1 hour: 13.3, 11.7, 3.4 and 0.096 liters were delivered to the storage tank respectively. The oscillations were reduced via partial opening of the valve along the pipe from the cold-oil reservoir to the thermostat. The 3-tank TES system was charged at an efficiency of 51.3% using the thermostat and later discharged through a cooking unit by boiling 0.5 liters of water at cooking efficiencies of 14.1%, 32.5% and 19.0% for the flow rates of 2.1, 2.8 and 6.5 g/s, respectively. The results for the 3-tank TES system showed that 1 kg of rice that required 0.032 kWh could be cooked using 0.82-1.92 liters of oil at 200 ◦ C which is equivalent to 0.09-0.24 kwh of energy. The developed 1D model was able to predict the effect of insulation and flow rate on the thermal profiles at selected points with a mean absolute percentage error in the range 4.9%-8.2%.

Supervisors

- **Dr. Karidewa Nyeinga**, (Department of Physics, Makerere University)
- **Dr. Denis Okello** (Department of Physics, Makerere University)
- **Prof. Ole Jorgen Nydal** (Department of Energy and Process Engineering, Norwegian University of Science and Technology.)