Boulder Fluid and Thermal Sciences Seminar Series

Tuesday, March 15, 2016, 3:30pm-4:30pm (refreshments at 3:15pm)
Bechtel Collaboratory in the Discovery Learning Center (DLC)
University of Colorado, Boulder

Advancing Concentrating Solar Power Plants with Thermochemical Energy Storage and Regenerative s-CO_2 Power Cycles

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Low-cost, high efficiency, energy storage is needed for the future electric grid which will include more variable energy resources, such as wind and solar. Substantial penetration of wind and solar resources into the electric power grid is challenged by their intermittancy, as well as the dynamic response limitations of central utility plants. Storing electric energy directly into batteries is one of the most efficient ways to preserve the energy generated from renewable resources, but capacity limitations of conventional batteries are too great at present to economically store enough energy at utility-scales. Energy storage for concentrating solar power (CSP) is also a critical enabling technology as it enables higher capacity factor power plants and unlike other renewables, its integration actually lowers the levelized cost of energy. However, in CSP plants, energy storage involves amassing thermal/thermochemical energy at high temperatures as a reserve for use during times when the sun is not shining.

In this talk, advancements in both a novel thermochemical energy storage (TCES) concept based on redox cycling of reducible, doped calcium manganite (doped $CaMe_xMnO_{3-\delta}$) perovskite particles and in the development of low-cost regenerative heat exchangers for supercritical CO_2 (s-CO_2) power cycles will be presented. The TCES concept utilizes the fact that perovskite oxides (with chemical structure $ABO_{3-\delta}$) can undergo endothermic partial reduction to store solar heat at temperatures as high as 900°C. By providing excess reduced oxide during periods of high insolation, the combined thermochemical and sensible energy in the partially reduced perovskites can provide total storage of nearly 750 kJ/kg such that < 1.5 m^3 of particles can be re-oxidized to produce a MWh of electricity for a 50% power cycle. The presentation highlights modeling efforts that seek to develop tools for adequate capture of the reacting, multi-phase (gas-solid) flow phenomena occuring within both high temperature solar receivers and heat rejection heat exhangers. A brief overview of a synergistic effort to develop regenerative heat exchangers for s-CO_2 power cycles that are to be employed within CSP plants is also given. Strategies and progress towards enabling these concepts are presented in the context of meeting U.S. DOE Sunshot targets of high temperature storage at <\$15/kWh_t.

Thermal systems modeling of parabolic trough solar power plants

Diego Arias, *Roccor / i2C Solutions*

With over 4 MW of generating capacity installed worldwide, parabolic trough solar power plants are currently the lowest-cost concentrating solar power (CSP) option for electricity production. A parabolic trough plant uses a large field of solar collectors to capture solar radiation and transform it into sensible energy in a high-temperature heat transfer fluid; the thermal energy can be transported to a conventional power plant, or stored in a thermal energy storage system (TES) for later use. This seminar will present an example of the development and use of thermal systems models developed for commercial parabolic troughs plants, in which the effect of individual technical improvements on the overall plant performance were analyzed, and the least cost of energy option was identified. These thermal system models are fundamental for evaluating the overall benefit achieved by technical improvements on commercial applications as well as for guiding R&D decisions. Some of the alternatives studied included solar collectors, heat transfer fluids, thermal energy storage systems and power cycles.