Mechanical Engineering Department Seminar

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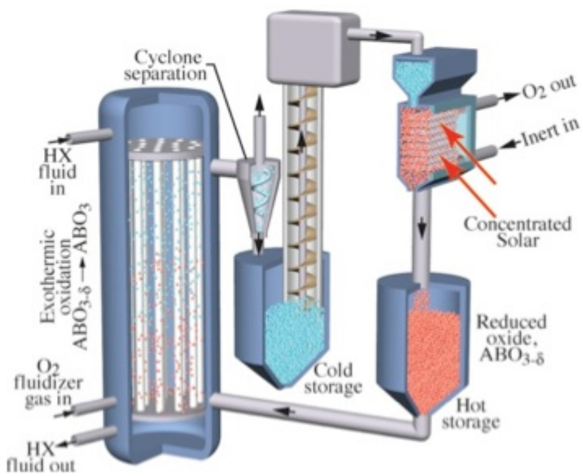
1130 Mechanical Engineering
111 Church Street SE, Minneapolis, MN 55455

Capturing the Sun's Energy in Reactive Rocks

Greg Jackson

Professor and Department Head; Department of Mechanical Engineering, Colorado School of Mines

Concentrated solar power (CSP) will play a significant role in a future electric power grid if new cost-effective energy capture and storage systems can allow CSP plants to operate closer to 24/7. Such storage systems must enable efficient heat-driven power plants with firing temperatures higher than the 600 °C limit of molten salt technology used for concentrated solar energy storage today. Solid particulate oxides offer a promising way to store solar energy cost-effectively at higher-temperatures, but sensible energy storage alone requires very high temperatures (> 1000 °C with high re-radiation losses) to obtain the specific energy storage expected to help CSP approach the DOE LCOE target of 6¢/kWh. Our team is working to overcome these limitations by identifying low-cost, perovskite oxides derived from earth-abundant precursors that can provide chemical plus sensible energy for high specific storage densities at temperatures ≤ 1000 °C. Highly reducible perovskites based on doped calcium manganites (CaMnO3-δ) can store energy at over 700 kJ/kg through heating and endothermic reduction in O2 partial pressures of ≈ 10-4 bar in a solid-particle central solar receiver. The stored thermochemical energy can be released to a power-cycle working fluid as needed by reoxidation and cooling in a fluidized bed reactor / heat exchanger. The challenges for this storage approach are identifying materials and designing solar receivers that realize the thermodynamic potential of perovskite reduction by facilitating rapid energy capture through effective heat transfer and fast material kinetics. This talk will present experimental studies to assess preferred doped CaMnO3-δ based on thermodynamics and kinetics and validation of material models for assessing different compositions. Incorporation of material models into multiphase reactor models for design of a particle receiver and full thermochemical energy storage systems provide a basis for exploring the possibility of a perovskite-based thermochemical energy storage system that may enable efficient 24/7 CSP power plants for the future.



Bio: Prof. Greg Jackson is the Dept. Head of Mechanical Engineering at the Colorado School of Mines (CSM) where he also manages a research group active in concentrated solar energy storage and high-temperature solid-oxide electrochemical systems. He has expertise in evaluating material thermochemistry for heterogeneous reacting systems in a range of energy conversion applications. Before joining CSM in 2013, Jackson was a faculty member for 15 years at the University of Maryland (UMD) in Mechanical Engineering and served as the Acting and Associate Director of the campus-wide Energy Research Center. At UMD, he led active research programs in fuel cell systems, catalysis, and other energy conversion applications. He received his Ph.D. from Cornell University where he performed research on liquid fuel combustion. After his Ph.D., he worked at Precision Combustion Inc. where he led research and development efforts on catalytic reactors for low-NOx combustion and on catalytic ignition for various applications.