ETH zürich

Energy Science Center

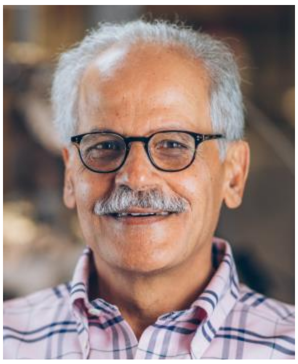
Recent Developments in Solar Thermochemical Fuel Production Research at MIT

by Prof. Ahmed Ghoniem

Date: Monday, 18th November 2024, 4.15 pm

Venue: ML J 25, ETH Zurich, Sonneggstrasse 3, 8092 Zurich

Abstract – Solar thermochemical fuel production, in which high temperature, low pressure reduction is followed by lower temperature water/CO2 oxidation of a metal oxide and the production of hydrogen/CO has the potential for achieving high efficiency and productivity, high-capacity factor and better overall economics by integrating a number of innovations at the system, reactor and materials levels. We will show that solids heat recovery between reduction and oxidation can be implemented by employing a number of reactors that circulate between the two stages and exchange heat via radiation in a counter flow configuration. Pressure swing and deep vacuum for reduction can be accomplished by staged oxygen evacuation and novel thermochemical/electrochemical oxygen pumping. Products separation energy can be minimized using membrane or similar technologies. And waste heat recovery on the exothermic oxidation side can be used to produce electricity to power auxiliary components in the system. These and other ideas aimed at energy and mass integration form the basis for the design of the reactor train system under development at MIT. We will how that to enable round the clock operations with optimally sized units, individual reactors should be indirectly irradiated using thermal energy stored in a high temperature storage system. These reactors may house the redox material inside a high temperature shell hence eliminating the need for transparent windows while using quick release gas exchange ports. Novel Perovskites that readily reduce at moderate temperatures can further improve performance, but with potential extra requirements. While coarse-grain models are used to optimize performance at the system's level, high fidelity multiphysics simulations are being used to design the reactors. Critical to the operation is material selection for different components and their assymbly.



Ahmed Ghoniem is the Ronald C. Crane Professor of Mechanical Engineering. He is a leading expert in computation, combustion and energy. Among his contributions is developing novel algorithms to simulate turbulent reacting flows and dense multiphase flows; new methods for passive and active control of combustion; new technologies for biofuel production; membrane systems and reactors for oxy-combustion, reforming and the production of hydrogen and other chemicals; and reactor and systems' designs for renewable and alternative fuel production. Ghoniem supervised more than 120 masters, Ph.D. and post-doctoral students; published more than 500 articles and a book on energy conversion engineering, and multiple patents. He is a fellow of the ASME, the APS, and the Combustion Institute, Among his awards are the ASME James Harry Potter Award in Thermodynamics, the AIAA Propellant and Combustion Award, the KAUST Investigator Award, the "Committed to Caring Professor" at MIT and the Bernard Lewis Gold Medal from the combustion Institute.

Host: Prof. Aldo Steinfeld, Professorship of Renewable Energy Carriers, www.prec.ethz.ch

PREC
Professorship of Renewable Energy Carriers