Materials Engineering Program
Texas Center for Superconductivity at Univ. of Houston
Center for Integrated Bio and Nano Systems
10:00 am, Friday, Oct. 20, 2023

This seminar will be held in hybrid mode.

Face to Face: **at HSC 102.** Zoom:
https://uh-edu-cougarnet.zoom.us/j/97136580701
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Design and manufacturing of advanced solar receiver tube for heat transfer enhancement and temperature leveling in concentrated solar power

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Abstract:

For concentrating solar tower applications with temperature above 700ºC, the peripheral heat flux distribution on the receiver tube is not uniform due to the direct upward exposure to the concentrated rays and exposure of the other side to the interior of the receiver. Furthermore, such a non-uniform solar flux distribution will lead to uneven circumferential temperature gradients on the receiver tubes and cause cyclic thermal stress under the daily startup and shutdown operations, eventually it will lead to tube deformation and structure failure due to the creep-fatigue fracture. To enhance the heat transfer performance in solar absorber tubes for high temperature applications, a very popular strategy is adopting the passive inserts to levelize the heat flux distribution thus reducing the thermal stress and non-uniform temperature gradient. Nonetheless, the installation of inserts create significant technical difficulties, such as poor integration with the inner wall, flow-induced vibration, and increased maintenance cost.

To tackle the technical obstacles, we first performed Computational Fluid Dynamic (CFD) simulation to optimize internal fin shape and pattern for enhancement of internal heat transfer at mild increase of pressure loss in fluid flow. Various helical/twisted fin designs were explored, and their geometric parameters such as height, helical pitch, and number of heads were optimized for thermo-hydraulic performance. We adopted Gaussian Processes surrogate models to assist the optimization process. Then a coupled hydro-thermal-mechanical model was developed in COMSOL and adopted to explore the receiver thermal efficiency of the absorber tube with the optimal fin designs. We utilized Laser Additive Alloying (LAA), an additive manufacturing (AM) technology, to 3D print the entire receiver tube with optimized helical fins. Design of Experiments (DOE) was adopted to explore the appropriate mixing ratio between IN718 and Boron by printing series of test matrices using a Selective Laser Melting (SLM) machine. Various advanced microscopic imaging techniques were used to explore the microstructures of 3D printed samples and verify the printing quality. Eventually, the optimized finned tubes were printed and tested for their thermal-hydraulic performance in a flow loop with water. The 3D printed absorber tubes can increase the uniformity of circumferential temperature distribution, reduced the thermal stresses, decrease the heat loss, and reach the target receiver thermal efficiency.

Bio: Dr. Ben Ben Xu is an Assistant Professor, Presidential Frontier Faculty Fellow in the Department of Mechanical Engineering at University of Houston (UH). He obtained his Ph.D. from University of Arizona in 2015. His research interests focus on multiphase flow and heat transfer in advanced energy systems, high temperature solar thermal storage, additive manufacturing of Nickel-based super alloys, and laser-assisted 3D bioprinting. Prior to joining UH, Dr. Xu worked as Assistant Professor of Mechanical Engineering in Mississippi State University (MSU) and University of Texas Rio Grande Valley (UTRGV), Postdoctoral Research Fellow at Drexel University. Dr. Xu has been PI, Co-PI and senior personnel at UH, MSU and UTRGV on multiple funded projects from US Department of Energy, Department of Agriculture, National Science Foundation, and NASA. He has more than 50 peer reviewed journal publications, and his total citation on Google Scholar is more than 2000.