High-Temperature Supercritical Carbon Dioxide Coupled Receiver Analysis (CSP-1)

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Scientific Achievement:

A new coupling method that combines optical, thermal-fluid, and structural analyses has been developed and implemented for the analysis of high-temperature pressurized receivers.

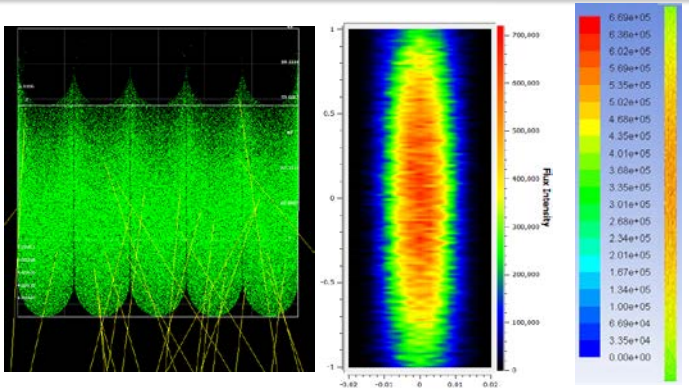
Significance and Impact:

Previously, oversimplified models were used to analyze the solar receivers. This new methodology can provide a more detailed evaluation for the new generation of receivers.

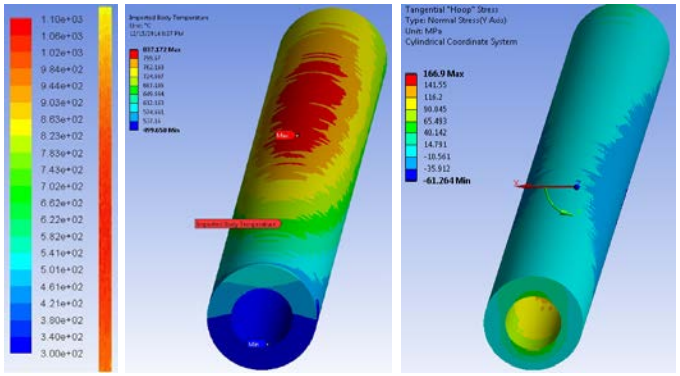
Research Details:

We developed a MATLAB script to couple SolTrace to ANSYS Fluent, which is then coupled to ANSYS Structural to complete the analysis.

- The script developed is used to build a boundary condition for the thermal-fluid analysis that contains the heat-flux data on the surface of the receiver obtained from the ray-tracing optical analysis.
- The resulting temperature distribution is transferred from ANSYS Fluent to ANSYS Structural to evaluate the structural integrity.
- This script has been used to analyze the receivers at Sandia National Labs, Indian Institute of Science (IISc), and Indian Institute of Technology (IIT-Bombay) and has been updated to enhance its performance.



Left: SolTrace ray intersections on tubes. Middle: Heat-flux distribution on a single tube. Right: Heat-flux distribution used as boundary condition on the tubes in ANSYS Fluent.



Left: Resulting temperature distribution on the tubes computed in ANSYS Fluent. Middle: Temperature distribution mapped on a tube in ANSYS Structural. Right: Resulting stresses computed in ANSYS Structural.

Publication(s):

J.D. Ortega, S.D. Khivsara, J.M. Christian, C.K. Ho, "Structural analysis of a directly heated tubular solar receiver for supercritical CO_2 Brayton cycle," *Proceedings of the 9th International Conference on Energy Sustainability (ES2015), San Diego, CA*, 2015.

J.D. Ortega, S.D. Khivsara, J.M. Christian, J.E. Yellowhair, C.K. Ho, Yellowhair, C.K. Ho, "Coupled optical-thermal-fluid modeling of a directly heated tubular solar receiver for supercritical CO_2 Brayton cycle," *Proceedings of the 9th International Conference on Energy Sustainability (ES2015), San Diego, CA*, 2015.

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