34240

Design and Fabrication of Ceramic Heat Exchangers (HXs)

1. Impact

To achieve the Gen3 2030 cost target of $0.05/kW$_e$ for CSP, high temperature (>700°C) efficient s-CO_2 power cycles will require reliable HXs to transfer heat, carried by a heat transfer fluid (HTF), from receiver to power block.

2. Project Goal

To develop ceramic materials and low-cost fabrication methods for HXs that can reliably operate at >700°C and pressures of 20 MPa. Current high temperature alloys cannot perform under these extreme conditions.

3. Method(s)

Using combined thermal and stress modeling to design the HX based on the ceramic material properties. Leveraging ceramic powder processing, binder jet additive manufacturing, and infiltration techniques to fabricate the SiC ceramic HXs. Performing thermo-physical and heat transfer characterizations on materials and lab-scale prototypes.

4. Outcome(s)

Single piece HX with headers was designed and fabricated using additive manufacturing. Fabricated SiC material properties meet or exceed the target values. Preliminary HX testing shows performance within <±10% of the predictions.

5. Conclusion/Risks

Feasibility of additive manufacturing of a ceramic HX has been demonstrated. Next steps are to scale-up fabrication process, develop integration approaches to test the HX at >700°C, and demonstrate long-term reliability of the ceramic HX.

6. Team

Argonne National Laboratory

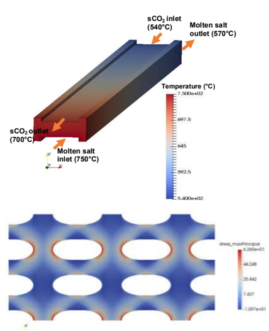

Figure 1. Thermal and stress modeling to optimize the HX fluid channel design

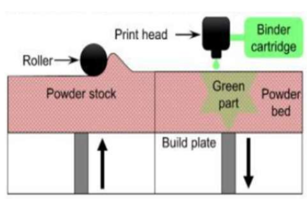

Figure 2. Schematic of the binder jet additive manufacturing process *(Ceramics Intl., 46 (2020))*

Figure 3. Cross section of the SiC ceramic heat exchanger post densification showing the fluid channels

Figure 4. Fabricated single piece SiC ceramic heat exchanger prototype