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Robust Solar Receivers Using MAX Phase Materials

1. Impact

To achieve the Gen3 2030 cost target of $0.05/kW$_e$ for CSP, advanced receiver materials and designs are needed to collect thermal energy to operate efficient high-temperature (>700°C) super critical s-CO_2 power cycles.

2. Project Goal

To develop MAX phase based ceramic materials and associated low-cost fabrication methods to demonstrate their feasibility as receiver materials that can operate at conditions where current high-temperature alloys cannot perform.

3. Method(s)

Using combined thermal and stress modeling to develop an optimized receiver design. Leveraging ceramic powder processing, binder jet additive manufacturing, and reactive melt infiltration (RMI) techniques to fabricate the MAX phase (Ti_3SiC_2) material. Performing thermo-physical characterizations on materials and lab-scale prototypes.

4. Outcome(s)

Modeling effort showed the feasibility of the MAX phase material receivers with long-term reliability for Gen3 application. Binder jet printed and infiltrated samples were fabricated with bulk densities >95% of theoretical values. However, surface cracking was observed post infiltration. Thermo-physical properties of the bulk Ti_3SiC_2 are comparable to literature values.

5. Conclusion/Risks

Feasibility of MAX phase materials for the Gen3 receiver application has been evaluated. Next steps are to mitigate the surface cracking by control of RMI process, demonstrate fabrication of prototype receiver tubes, and perform key characterizations.

6. Team

Argonne National Laboratory

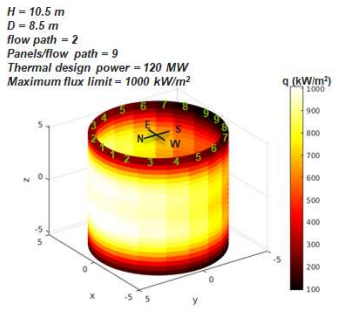

Figure 1. Heat flux distribution on the receiver exterior at noon spring equinox day

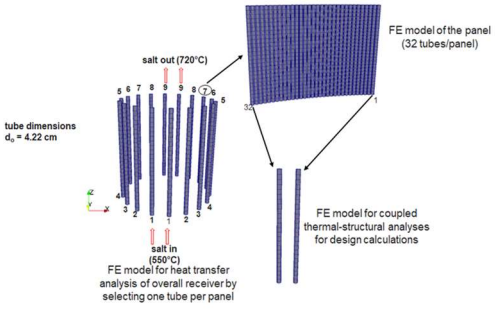

Figure 2. Finite element models for thermal and structural analysis of receiver tubes

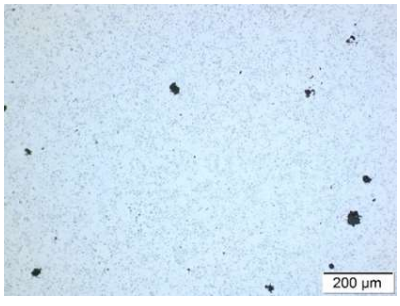

Figure 3. Microstructure of binder jet printed and melt-infiltrated Ti_3SiC_2