SunShot
U.S. Department of Energy

High-Flux Microchannel Solar Receiver

Oregon State University

Award Number: EE0005801 | November 15, 2012 | Drost

Oregon State UNIVERSITY OSU

PROJECT OBJECTIVES

Goal: Microchannel heat exchangers can attain very high rates of heat transfer. This will allow an increase in the maximum receiver flux by a factor of 5 to 10 which will result in a reduction in the size of the receiver by a similar amount which in turn leads to a reduction in thermal losses from the receiver and possibly receiver cost.

Innovation: This use of microchannel geometries for heat transfer can attain allowable receiver fluxes of 100 W/cm^2 for supercritical CO_2 receivers and 400 W/cm^2 for molten salt receivers. This should be compared to a maximum allowable flux of 30 to 100 [1]W/cm^2 for current receiver technology.

[1]Romero, M., Buck, R., and Pacheco, J. E., 2002

Milestones: None during reporting period

APPROACH

- Use simulation to develop designs of both a supercritical CO_2 receiver and a molten salt receiver capable of achieving the performance includes in the project objectives
- Based on simulation results use microlamination to assemble laboratory test articles for supercritcial CO_2 and molten salt.
- Assemble a flux concentrator capable of achieving 400 W/cm ^{2} incident flux and assemble test loops for supercritical CO_2 and molten salt
- Complete a laboratory demonstrate the ability of the test articles to meet the required performance.
- Based on laboratory results, assemble a supercritical CO_2 test article and test using the PNNL solar dish concentrator
- Use simulation to design a microscale adaptive flow control system
- Complete a laboratory demonstration of a single and multiple channel adaptive flow control device

KEY RESULTS AND OUTCOMES

Table 1: Comparison of surface efficiency and maximum surface temperature for the three configurations (a. high-aspect ratio micrcochannel; b. low-aspect ratio microchannel; and c. pin-fin microchannel) varying the geometric features.

geometry	H (μm)	W (μm)	L (μm)	W_{wall} (μm)	Re	Δp (bar)	μ_1	Surface T_{max} (K)
(a)	40	1000	6600	100	1178	0.39	89.5%	1067.3
(a)	40	1000	7500	100	1334	0.46	89.6%	1064.9
(a)	40	1000	8400	100	1491	0.57	89.7%	1056.6
(b)	250	100	13000	50	741	0.19	89.6%	1063.0
(b)	250	100	18000	50	1016	0.32	89.6%	1066.9
(b)	250	100	23000	50	1290	0.50	89.9%	1052.2
(c)	200	1800	9000	100	1428	0.22	90.2%	1000.0
(c)	200	1700	9800	100	1554	0.30	90.4%	1039.0
(c)	200	1800	8000	100	1276	0.14	90.2%	1051.0
(c)	200	1600	9800	100	1559	0.40	90.6%	1025.0

- As table 1 shows, our simulation has identified supercritical CO2 designs that can achieve the project objectives for incident flux, receiver efficiency and pressure drop while keeping the temperature of the receiver material well below the temperature limit of stainless steel..

NEXT MILESTONES

- No goals from the SOPO will be completed in the next reporting period.

- Task 1 – Key risk is that no design will meet the projects objectives, the use of arrays of pins appears to meet all of our performance goals
- Task 2 – The key risk is delamination due to the high pressure of supercritical CO_2. We will consider laser welding as an alternative to diffusion bonding
- Task 3 – The key risk is in the performance of the flux concentrator, we are minimizing that risk by using approaches developed and documented by others
- Task 4 – Risks will be minimized by using simulation to identify attractive designs before initiating experimental investigations