New Approaches to Solar Thermal - from 50 to 250 °C

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Solar Collector Configurations
Automotive/HVAC&R Industry (years ago)
Automotive/HVAC&R Industry (current)
Minichannel tubes and Solar Energy

(a) Round tubes with water flowing inside.
(b) Flat tube with minichannels and water flowing inside.

G. Diaz, ASME IMECE 2008-67858.
Types of Minichannel tubes

- Aluminum Minichannel Condenser versus RTPF Condenser
  Equal Capacity: 7 kW
Improved Thermal Efficiency

Fig. 10. Cross-section profile of the CPC concentrator for the minichannel-based solar collector. Three sample rays out of 50,000 are shown for (a) $\theta = 0^\circ$ and (b) $\theta = 35^\circ$.

Minichannel Solar Water Heater

Minichannel tube by Hydro
Selective coating:
Black chrome (EC series): $\alpha = 0.95$, $\varepsilon = 0.12$
Storage Tank Temperature

PSP: Eppley Precision Spectral Pyranometer
Thermal Efficiency

Minichannel

Max Eff. = 0.70
Energy = 11.06 kWh/day
Potentials for industrial thermal processing

Process heat accounts for 2/3 of industrial energy consumption and 1/3 of it is below 200 Celsius. Solar thermal has non-tracking technology dominating the current market.

Source: PSG AG, Andreas Haberle
Ray tracing of the nonimaging optics design

- Concentrator designed to be efficient with wide angle. Utilizing both sides of the absorber
- Non-tracking and still able to achieve 1.8X concentration ratio over the seasonal change (34 degrees half acceptance angle)
Integrated optical design with minichannel absorber

Incident solar radiation through transparent window

Reflected solar radiation Concentrated to absorber

Absorber freely expands/shrinks under thermal expansion

Selectively coated minichannel as the absorber and fluid channel

Thermal expansion/contraction

Metal glass seal with bellow

Fluid outlet

Fluid inlet
Mass production potentials for minichannel ICPC

- Mature technology of metal glass seal thermal compression seal
- Low cost of glass and minichannel tubes
  - Glass tube < $5 for 2m x 90mm O.D. borosilicate glass
  - Minichannel (Al) is $0.23 per meter for 32mm width
- Mature technology for welding/soldering of minichannel

Soldering of small tube to the end to create the U turn for the fluid

Freely expanding

Mini-channel transition

Kovar

metal glass sealing

mini-channel end
Efficiency compared to other collectors

Comparable performance without tracking, higher optical efficacy compared to external CPC due to the reflector housed in vacuum.
One meter prototype

Demonstration of how the collector works using a heat pipe

- Purple color is the image of the absorber
- The absorber selective coated copper wrapped around a heat pipe
- Heat pipe condenser
- Metal glass compression sealing (produced at 300 Celsius)
- Reflective coating at the bottom
- Evaporated barium gas getter to maintain the vacuum for > 25 years
Acknowledgments

This project is partially funded by the California Energy Commission, Contract # POEF01-M04.

Students:

• Azucena Robles
• Adam Martin
• Jose Guadarrama
• Kevin Clayton

Thanks