Development of a Supercritical CO_2 Heat Exchanger Test Facility for Waste Heat and Solar Thermal Applications

Erfan Rasouli, Caton Mande, Matthew Stevens, Vinod Narayanan (University of California, Davis)

Supercritical CO_2 Power Cycles Symposium

UC DAVIS UNIVERSITY OF CALIFORNIA

ABSTRACT AND FACILITY OVERVIEW

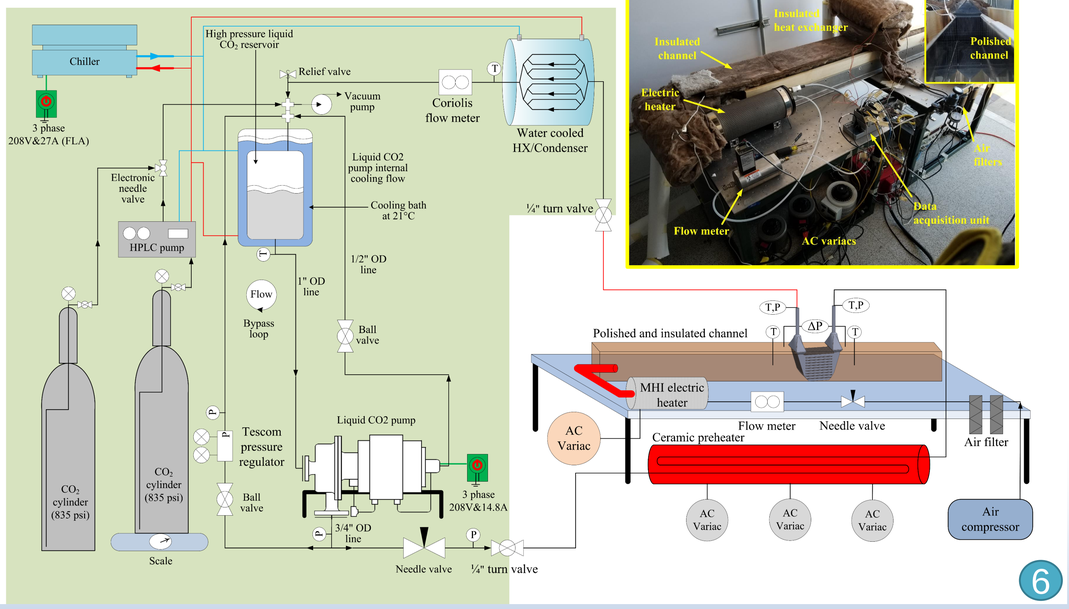
A high-temperature high-pressure supercritical CO_2 (sCO_2) test facility has been developed for multiple-kW-scale heat exchanger testing for waste heat and concentrated solar thermal applications. The facility is comprised of modular racks and can be configured to meet the requirement of the particular type of heat exchanger being tested. The system pressure and temperature is limited to 200 bar and 750 ˚C, respectfully. A circulator pump supplies the closed loop test facility with a mass flow rate of up to 0.1 kg/s at 10 bar differential pressure and a burner facility (4) can be used to preheat the sCO_2 flow to the desired inlet temperature of the heat exchanger at temperatures up to 550 °C to the receiver.

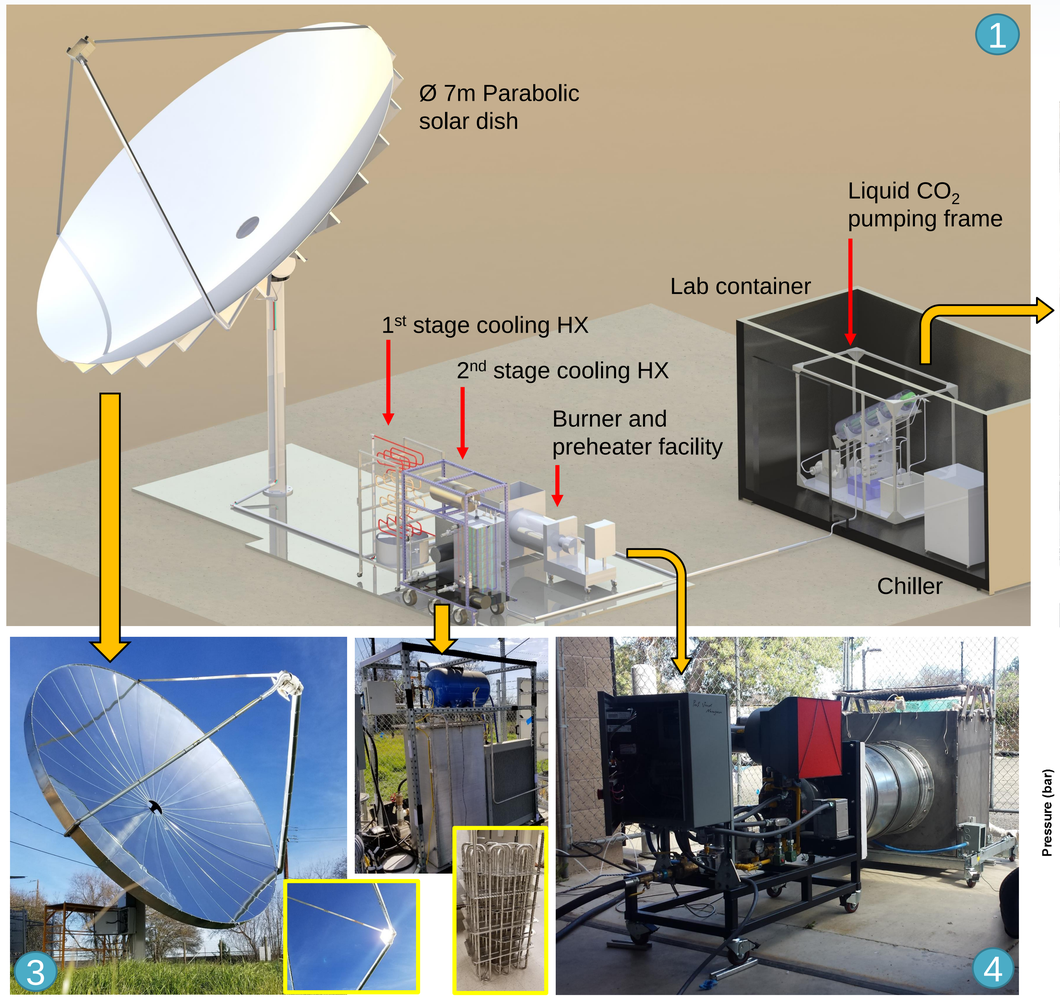
SOLAR THERMAL TEST CONFIGURATION 1 2 3

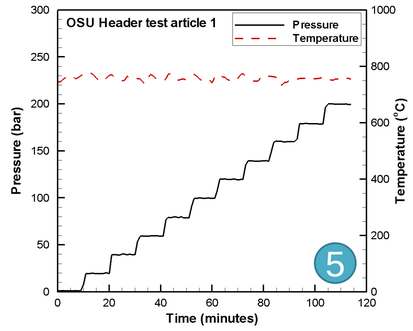
Concentrated solar input is provided by means of a seven meter parabolic solar dish (1, 3) capable of a concentration ratio of 900-1000 suns and a heat rate of 25 kW. A 3-stage cooling heat exchanger system is implemented in the facility to reduce the sCO_2 temperature from a high of 720 °C at the exit of the receiver to ambient temperature prior to the liquid CO_2 pumping frame (1, 2).

WASTE HEAT/PRIMARY HEAT EXCHANGER TEST CONFIGURATION 6

The simulated exhaust/high temperature air flow is provided by an electric burner for < 4.5 kW heat exchangers. The sCO_2 flow path is reconfigured to bypass the dish and flow through the recuperator/heat exchanger directly. The heated sCO_2 flow is directed back to the cooling stages at the exit of the test recuperator/heat exchanger. Alternately the burner facility (4) can be used to pre-heat larger capacity recuperators.







HEAT EXCHANGER INTEGRITY TESTING- PRESSURE AND TEMPERATURE TEST STAND 4

The pressure and temperature (P&T) test stand is used to test the mechanical integrity of the test heat exchangers through static and cyclic pressure testing at pressures up to 200 bar and temperatures of up to 800 ˚C. The test stand consists of the burner facility (4), a 500,000 BTU/hr natural gas burner connected to a steel P&T test chamber by a 21-inch diameter quick connect rigid steel ducting and electronically-controlled instrumentation that is used for cyclic pressure and temperature testing of sCO_2 heat exchangers, recuperators and receivers. Figure 5, illustrates an example outcome from static testing at temperature.

ONGOING PROJECTS

- Microchannel sCO_2 solar receiver integrity and on-sun testing (Funding Agency: US Department of Energy, award: DE-EE0007108; Lead institution: Oregon State University
- Additively Manufactured Primary Heat exchanger/waste heat recuperator- (Funding Agency: US Department of Energy, grant DE-FE0024064; Collaborators: Carnegie Mellon University, Oregon State University)