10-MW Supercritical CO_2 Turbine

National Renewable Energy Laboratory
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PROJECT OBJECTIVES

Goal: To design, fabricate, and validate a supercritical-CO_2 (s-CO_2) power cycle of nominally 10 MWe that is capable of operation at up to 700°C under dry cooling conditions. Advanced s-CO_2 Brayton cycles have the potential to achieve the SunShot goal of greater than 50% thermal-to-electric conversion efficiency.

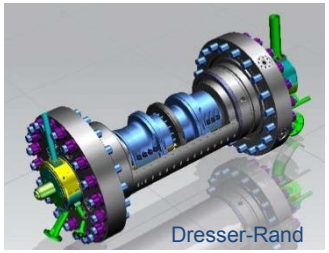
Innovation: This project will demonstrate the inherent efficiencies of the s-CO_2 power turbine and associated turbomachinery at a scale relevant to commercial Concentrating Solar Power (CSP) projects. Due to the properties of the s-CO_2 fluid, operation at ~10 MW is necessary to realize the full potential of the technology.[1]

Milestones: No milestones this quarter

[1] Sienicki, et al., "Scale Dependencies of Supercritical Carbon Dioxide Brayton Cycle Technologies and the Optimal Size for a Next-Step Supercritical CO2 Cycle Demonstration," Supercritical CO2 Power Cycles Symposium, Boulder, CO, May 24-25, 2011.

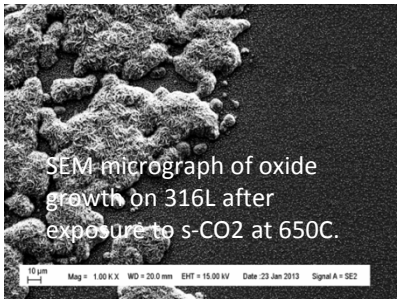
APPROACH

- Design and fabricate an s-CO_2 Brayton cycle of nominally 10 MWe that is capable of operation at up to 700°C under dry cooling conditions.
- Utilize turbomachinery design approaches and features consistent with commercial practice to facilitate follow-on deployment.
- Confirm an s-CO_2 power turbine efficiency at a commercially viable level of 80% and outline the pathway to high-efficiency power cycles exceeding 50% net thermal-to-electric conversion efficiency in CSP applications.
- Demonstrate system control and materials durability and lay framework for follow-on deployment of the power cycle.



KEY RESULTS AND OUTCOMES

- Completed 1000-hr s-CO2 exposure tests with 316L, 347SS, Inconel 800H, and AFA-OC6. Coupon analysis is ongoing.
- Developed specifications for gas-fired heat addition system and air-cooled heat rejection system to support the s-CO2 test loop.
- Created simulation model of the test loop design.
- Drafted matrix of potential s-CO2 / CSP systems and created models to simulate these designs.
- Determined modifications needed for the EPS100 turbomachinery to operate at the design point conditions of the test cycle.



NEXT MILESTONES

Phase 1 milestones:

- 1.1 Alloy test matrix with recommendations for materials (7/30/13)
- 1.2 Test plan and draft of safe operating procedures (6/30/13)
- 1.3.1 Turbomachinery design package with efficiencies (7/30/13)
- 1.3.2 Turbomachinery design study for 100 MW scale (7/30/13)
- 1.4.1 Transient performance model of test loop (7/30/13)
- 1.5 Review commercial power cycle design (7/30/13)
- 1.6 Deployment roadmap to SunShot (7/30/13)
- 1.7 Draft NEPA assessment and timeline (9/30/13)