ELECTRIC POWER RESEARCH INSTITUTE

Predicting the Oxidation/Corrosion Performance of Structural Alloys in Supercritical CO_2 (sCO_2)

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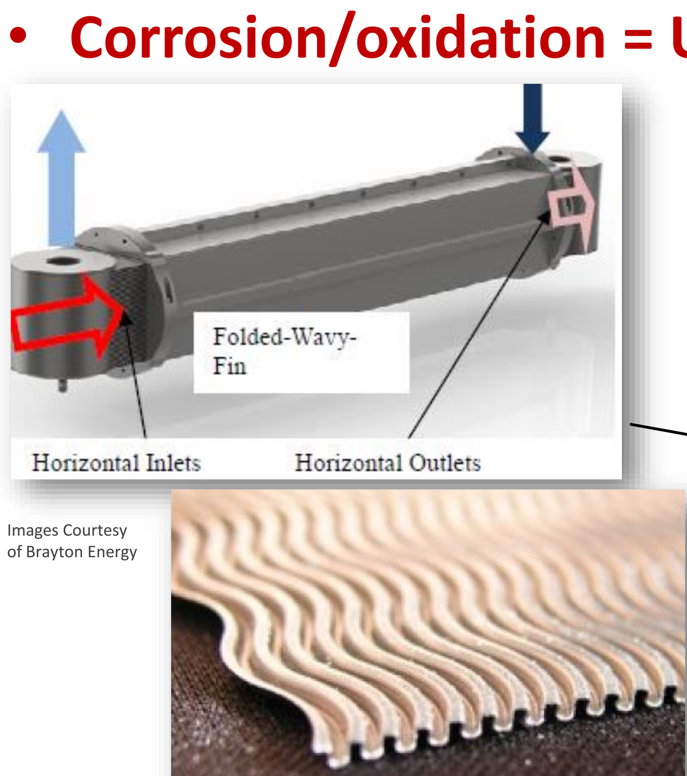
Benefits of the Proposed sCO_2 Power Cycles (Brayton Cycles):

- Efficiency (reduced fuel costs & lower emissions)
- Potential Transformational Technology (up to 4% efficiency improvement over Rankin cycle at >700°C)
- Some configurations provide sequestration-ready pure CO_2 stream

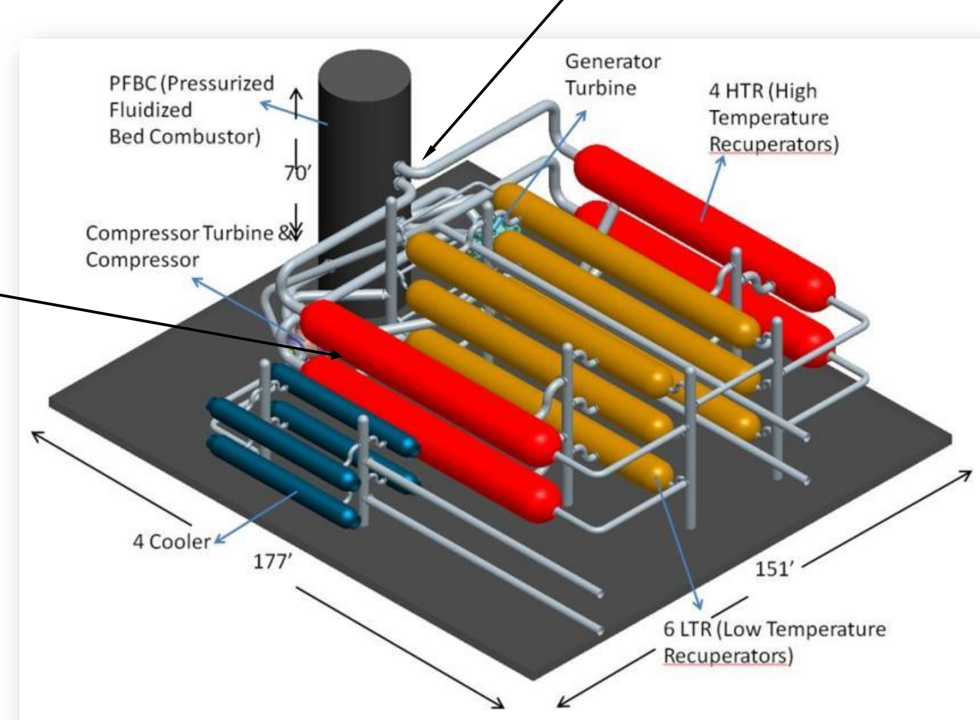
Critical Components of sCO_2 Cycles Requiring Materials Development: Recuperators / Heat-Exchangers

- 4-10X heat-duty of Rankin Cycle feedwater heaters
- Unique compact designs
- Expensive alloys required for high temperatures
- Small channels
- Large surface area
- Brazing/diffusion bonding
- Blockage
- **Corrosion/oxidation = Unknown**

sCO_2 Power Turbine (676 MW)



Images Courtesy of Brayton Energy



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Objective & Impact

- Predict the oxidation/corrosion performance of structural alloys in high-temperature high-pressure supercritical CO_2 (sCO_2)
- Combine laboratory testing & computational modeling including unique attributes of sCO_2 heat exchangers to accomplish this goal
- Improved confidence in materials selection for high-temperature sCO_2 heat-exchangers
- Stream-lined testing and/or improved criteria for materials selection based on oxidation/corrosion
- Possibility to home-in on cost-effective materials and temperature limits

Collaborative Team Approach:

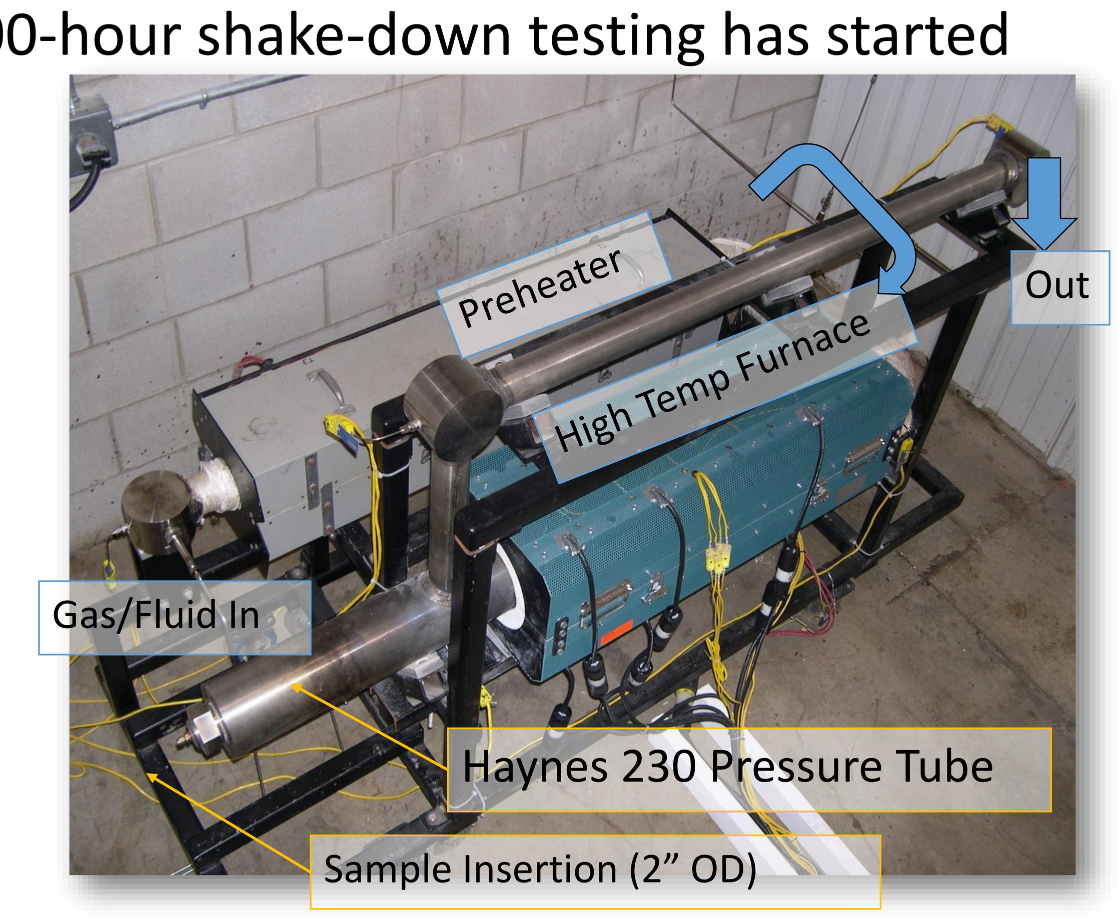
- Review status of technology and likely materials and environments. (EPRI)
- Laboratory testing: 600-750°C, 200bar sCO_2. (DNV-GL)
- Development of oxide growth kinetics, propensity for exfoliation, and comparisons with steam. (EPRI, WrightHT)
- Development of a growth and exfoliation model based on existing model architecture for steam. (ORNL)

Project Status:

- Literature review, final materials selection, and sample machining in progress and on schedule.
  - Gr. 91, 304, and Alloy 740/740H chosen for first tests and comparison with literature
  - Vendor discussion and review of literature to determine key ~7 alloys
- Summary of Proposed Conditions for Recuperators/Heat Exchangers in Various sCO_2 Cycles

Cycle Type	Thermal Resource	Max Temp. (°C)	Pressure (MPa)	sCO_2 Purity	H_2O	Others
Closed	Wasteheat	485	23.3	High	Near zero	
	Nuclear	545	20			
	Solar	700	~30			
	N. Gas	750				
	Coal	700	27.6			
Open	N. Gas / Coal Syngas	~700	30	95%	2%	O_2, Ar, NOx, SO_2

- Assembly of high-pressure sCO_2 testing facility complete, and the initial 300-hour shake-down testing has started



- Selection of test conditions for long-term tests ongoing.
  - Key issue is impurities (CO_2 purity, H_2O, hydrocarbons, others) likely in 'open and semi-open' fossil systems
  - Review of conditions for many different configurations is complete
- Review of literature indicates some useful kinetic data are available for corrosion in sCO_2 and comparison with steam.
  - Major deficiency, little useful data on oxide thickness and morphology.