Study examines oxide growth in additively manufactured metals in a supercritical carbon dioxide environment

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A new joint study by Southwest Research Institute and Sandia National Laboratories examines the differences in oxide film growth on additively manufactured (AM) metals and wrought stainless steel in a supercritical carbon dioxide (sCO_2) environment.

sCO_2 is carbon dioxide held above a critical temperature and pressure, which causes it to combine the properties of gas and liquid. Current power plants typically use water as a thermal medium in power cycles. Replacing water with sCO_2 increases efficiency by as much as 10 percent, which also allows for considerably smaller turbomachinery and a smaller footprint. Its supercritical state makes sCO_2 a highly efficient fluid to generate power because small changes in temperature or pressure cause significant shifts in its density.

SwRI is a leader in sCO_2 power cycles. The Institute has received numerous Department of Energy and industry-funded projects to implement pilot-scale sCO_2 power cycle components and system-level equipment in addition to the 10 MWe Supercritical Transformational Electric Power (STEP) Pilot Plant under construction at SwRI.

Senior Research Engineer Dr. Florent Bocher began examining how oxidation affects AM materials as part of an existing sCO_2 collaborative effort with Sandia National Laboratories.

"The smaller, more complex machinery necessary for the small turbines that sCO_2 power cycles utilize makes additive manufacturing an attractive resource," Bocher said.

Additive manufacturing is a novel process that uses 3D printing or rapid prototyping to build an item by layering plastic, metal and other materials for a custom, computer-generated design. Because AM creates sturdy components with intricate design qualities, it appeals to a wide range of users, including the aerospace, medical and manufacturing industries.

"The high temperatures and pressures of the sCO_2 environment make oxidation a concern for metal components," Bocher explained. "As these two industries move forward, it's important to understand how oxidation affects them."

To test the durability of AM metals versus traditional wrought stainless steel in the sCO_2 environment, Bocher and his collaborators exposed samples of both to a simulated sCO_2 power cycle environment, including a temperature of 450 degrees Celsius and pressure of 76 bar, for two weeks. The AM materials were built and analyzed by Sandia National Laboratory.

"Both types of metals showed oxide growth," Bocher said. "But the oxide covered about 72% of the wrought stainless steel and 54% of the AM material, with the grain size and thickness of the oxide layer being statistically larger and thicker for the wrought material. Ultimately, though, this doesn't prove that one is more reliable than the other. More data is needed, but this certainly suggests that AM processes should be optimized going forward for these types of conditions."

The study was published in *Corrosion Science*.

More information: Michael A. Melia et al, Initial stages of oxide growth on AM stainless steel exposed to a supercritical CO_2 environment, *Corrosion Science* (2022). DOI: 10.1016/j.corsci.2022.110259

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