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# An Overview of Direct-Fired $sCO_2$ Power Cycles

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## Abstract

Supercritical Carbon Dioxide ($sCO_2$) power cycles take advantage of the favorable thermophysical properties of $CO_2$ when it is at conditions beyond its critical point (over 31.1°C and 7.38MPa), where steep density gradients allow for efficient work extraction at relatively low operating temperatures. One specific approach is direct-fired oxy-fuel combustion, where fuel and oxygen are injected directly into the $CO_2$ stream and burned. This produces a high-temperature mixture of $CO_2$ and water vapor. Since $CO_2$ is already the working fluid and the system is closed loop, this approach offers near-complete carbon capture, making it an attractive option for eliminating most of the harmful emissions from burning fossil fuels. The most popular example of this approach is the Allam-Fetvedt cycle, which is a recuperated Brayton cycle that uses transcritical $CO_2$ in a closed-loop, direct-fired, oxy-fuel configuration.

The prospect of retaining the benefits of burning hydrocarbons while avoiding many of the environmental and regulatory drawbacks is attractive. However, there are remaining technological hurdles to clear before adoption. Though nominally based on existing gas turbine technology, the high-pressure conditions required to stay above the critical point contribute to a number of complications in component design. For example, $sCO_2$ combustors must operate at conditions akin to rocket engines, turbomachinery must accommodate a wide range of possible fluid densities over the operating range, and water and other contaminants must be removed from the loop.

This oral presentation will provide a survey of the state of the art for direct-fired $sCO_2$ power cycles. Specific examples of Southwest Research Institute's experience in this field will be examined. Cycle approaches, component design challenges, and broader implications for the power generation industry will be discussed.