Development of an Ultra-High Efficiency Wide-Range Integrally Geared Supercritical CO_2 Compander

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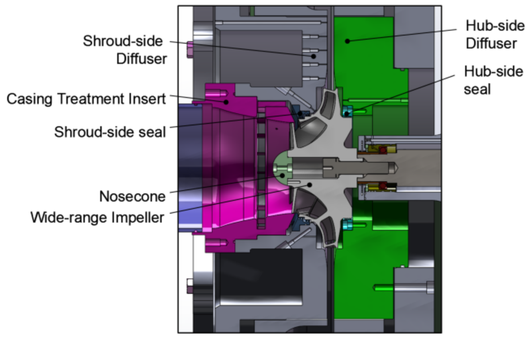
PROBLEM STATEMENT

Develop a concentrated solar power block configuration capable of achieving 50% cycle efficiency and 6¢/kWh cost by utilizing a supercritical CO_2 cycle.

PROJECT OVERVIEW

The team is developing an integrally-geared compander that allows for compressor inter-stage cooling and turbine re-heat to into a recompression Brayton cycle. The close integration of all elements into a single integrally-geared (IG) machine creates a design that lends itself to power block modularization.

TECHNOLOGY OVERVIEW



The design also includes the development of a novel flow path wide-range sCO_2 compressor impeller. The novel flow path designs are enabled through the application of Direct Metal Laser Sintering (DMLS), an additive manufacturing process that increases design flexibility and produces high-strength parts.

PROJECT OBJECTIVES AND MILESTONES

Design of a 10 MW_e cycle using a compander as the power block (targeting 50% efficiency)

Investigate off-design cycle operation, wide-range compression capabilities, and control schemes of an IGC based power block.

Design a reduced flow 1 MW_e IGC test loop.

- Full flow wide-range compressor test (70% range)
- Reduced flow expander (705°C inlet temperature)
- Full frame core (900$/$kW_e$, 6¢/$kW_e$ LCOE)

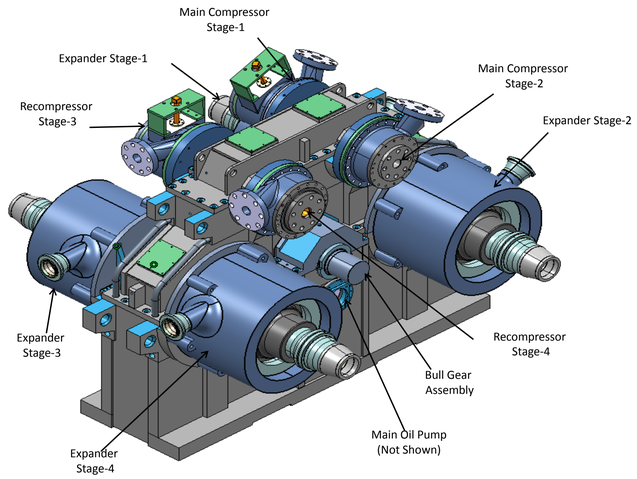
Test the expander at full temperature and pressure.

RESULTS

The main milestones achieved in this project include a nominal 10MWe compander design that has the following characteristics:

- 50% thermal-to-electric cycle efficiency
- 6¢/kWh LCOE system model with SVS site
- 670 $/kWh capital cost for installed power plant items
- 86% compressor efficiency with a range of 73.6%
- 50,000 hour turbine life with an efficiency of 92%

The machine designed and analyzed is shown to the right and is currently in prototype manufacturing phase. The prototype will be tested at Southwest Research Institute.



INDUSTRY IMPACT

- The technology developed herein is focused on distributed CSP applications in the 1MWe to 100MWe range.
- Allows the ability to achieve 50% cycle efficiency at 705 °C heat sources.
- The technology developed is broken down into individual turbomachinery frames from 1MWe to 25MWe.
- The technology is directly applicable to other areas as well: fossil energy and combined heat cycles with GT's (WHR.)

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