Project ID Oil-Free, High Temperature Heat Transfer Fluid Circulator

sCO2 Circulator Concept Technically & Economically Viable.

1. Impact

Concentrating Solar Power (CSP) plants with Thermal Energy Storage (TES), require compressors capable of circulating heat transfer fluids (HTFs) such as supercritical carbon dioxide (sCO2) at high temperatures (i.e., 500 to 700+ °C) and pressures (i.e., 8 to 25 MPa) in order to achieve thermal-to-electric conversion efficiencies of >50% and corresponding Levelized Costs of Electricity (LCOE) of $0.05/kwh.

2. Project Goal

This project leverages high temperature oil-free bearing and turbomachinery system integration technologies to support the development of next generation CSP plants with Thermal Energy Storage. This project has developed a scalable prototype, HTF compressor system capable of circulating sCO2 HTF at temperatures to >750 °C and ambient pressures from 12 to 25 MPa to support CSP plants from tens to hundreds of Megawatts of power.

3. Method(s)

The objectives will be accomplished through correspondence with a Topic 1 awardee to identify prototype scale requirements for an HTF Circulator and will leverage component technologies developed previously and concurrently. This was to be followed by component/subsystem tradeoff studies, detailed system design, prototype system fabrication, and component demonstration testing. A Techno-Economic Analysis (TEA) will also be performed to ensure commercial viability of the developed technology.

4. Outcome(s)

The high temperature circulator design, and hardware fabrication are complete. Circulator assembly and instrumentation are underway to be followed by proof testing. Completion of recent component and system testing on two separate and parallel DOE programs, demonstrated the ability to operate MiTi foil bearings in sCO2 and that closely coupled motor driven blowers can operate with 700°C inlet gas temperatures. These tests offer significant risk reduction for this program. Successful fabrication of crucial static structures via Additive Manufacturing (AM) enhances commercial viability of sCO2 turbomachinery. The Techno-Economic Analysis showed positive ROI, IRR and MIRR for the sCO2 circulator at up to 100 MW full scale CSP plants.

5. Conclusion/Risks

Turbomachinery using sCO2 as the process fluid is both technically and economically viable. Small size of sCO2 machine designs can take advantage of AM for cost and performance gains. A follow-on effort to build a prototype circulator for the 10 MW demonstration facility is important for full commercialization. Key risks to be overcome include improved shaft sealing and designs that address the expected high thrust loads.

6. Team

MiTi is able to complete the project without a major subcontractor. However, Turbosolutions Engineering, LLC, supported CFD analysis of the circulator impeller design,

Visuals

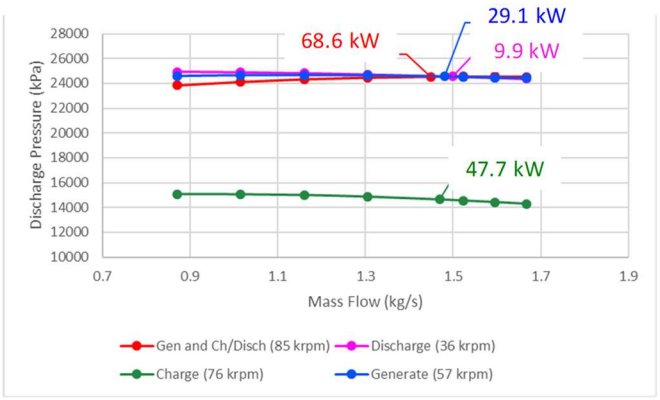

Figure 1 Performance map for compressor designed to meet specified sCO2 operating points with discharge pressures to 25MPa

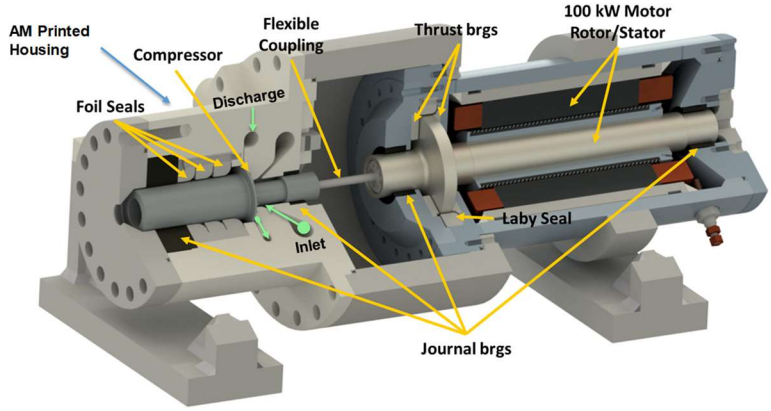

Figure 2 Heat transfer circulator system design showing key components

Figure 3 Additively manufactured circulator housing with integral inlet and discharge flow passages

Figure 4 Partially assembled heat transfer fluid circulator

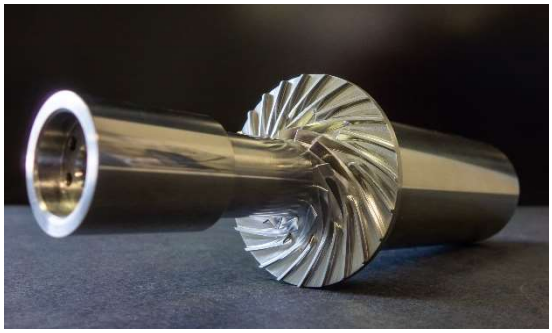

Figure 5 Heat transfer fluid circulator centrifugal compressor shaft