Supercritical Carbon Dioxide Power Cycle

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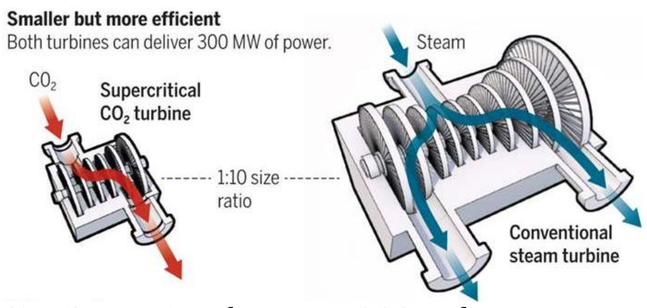
WeARE Research Area

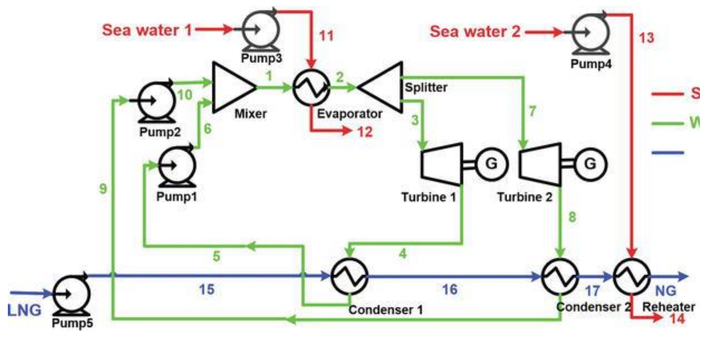
Supercritical Carbon-Dioxide, or sCO2, has physical characteristics that can be capitalized during a Brayton cycle. Compressor's during this cycle act as one of the main improvements in efficiency as the compressor need for cooling is almost negligible since CO2 becomes supercritical at 88F. The compressor work input also decreases due to the large increase in density seen by the sCO2. The primary research conducted by Daniel was to find a cost-efficient compressor compatible with sCO2

Motivation or Background

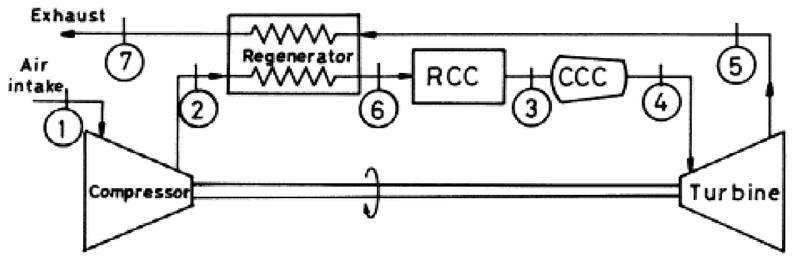
Not only is the Brayton cycle with sCO2 as the working fluid a possible better alternative to other power cycles due to the increase in cycle efficiencies, but it also utilizes a gas seen to be harmful to the environment. sCO2 allows for smaller turbomachinery due to the high pressure and density properties, which will lower the overall cost and reduction of the carbon footprint. sCO2 Brayton cycles use 4-8 stages whereas current power generation cycles use upwards of 20 stages.



Size Comparison between sCO2 and steam powered turbomachinery
Yirka, 2017



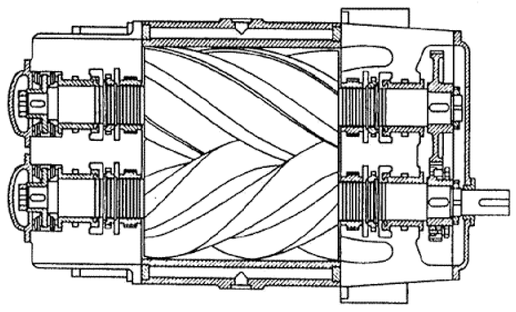
17 Stage Rankine Cycle
Bao, 2018



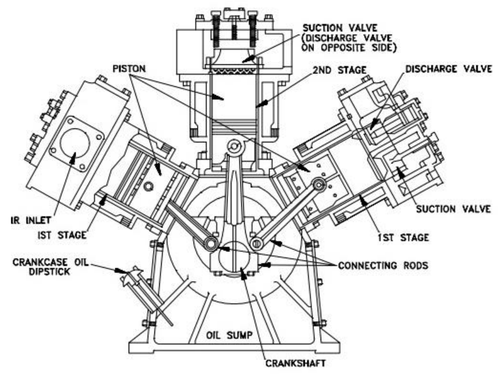
7 Stage Brayton Cycle
Göktun & Yavuz, 1999

Objectives

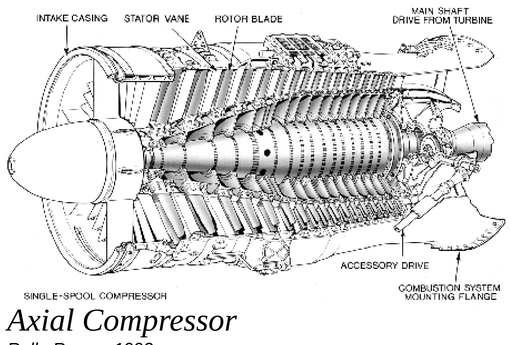
The main objective is to find and purchase a budget friendly off the shelf (OTS) compressor as well as a system to cool the compressor down in order to prevent overheating. Compressors come in many different forms and must be carefully picked before applying them to a system.



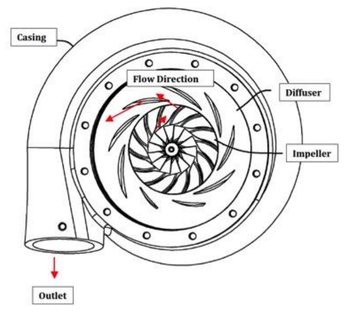
Rotary Screw Compressor
Lysholm-Holman, 1940



Reciprocating Compressor
Amit, 2017



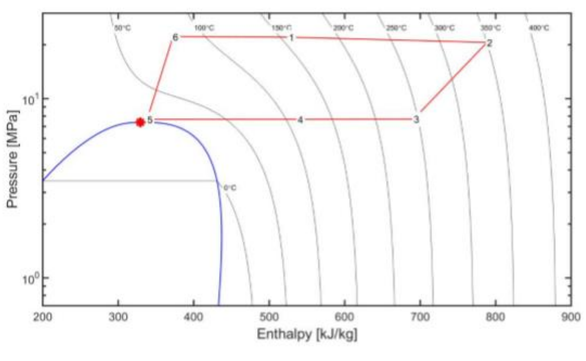
Axial Compressor
Rolls-Royce, 1992



Centrifugal Compressor
Dugan 2019

Methodology

Firstly, the physical properties for sCO2 at the inlet and outlet of the compressor were found using Refprop. Next, a list of companies that provided the correct type of compressors were created to contact. Most compressor companies were not able to provide an adequate compressor due to the high inlet pressure that would be needed to achieve a supercritical state. A few companies were found; however, the low-cost requirement was difficult to achieve.



CO2 Physical Properties Diagram
VTT, 2016

Skills and Experience

Daniel's skills involve CAD, specifically in Solidworks, some programming using MATLAB as well as years of leadership experience such as being VP of UTSA's ASME.

Future Plans

Future plan is to work for an innovative R&D company and to obtain a master's degree in mechanical engineering. He will be applying to master's programs in fall 202 as well as fulltime positions.

Results

A compressor from Hydro-Pac was found at a relatively low cost. This is important because the project has a budget. The compressor would be the largest cost of the system, and therefor needs careful budget planning. Thus far, an iterative process has taken place with the company to choose the right compressor and to clarify it fits all the system's needs.

Compressor				
Inlet P (psig)	Inlet T (F)	Oultet P (psig)	Outlet T (F)	Motor (hp)
800-3000	0-104	3000	300	20

Compressor Specifications

What I Learned

The theoretical knowledge gained in class is important but not enough and students must actively pursue experimental and real-world knowledge. Although compressors were taught in thermodynamics and compressible flow, there is more to them that needs to be understood to efficiently communicate with engineers.

Acknowledgments

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