Steady State Modeling for the 10 MWe sCO_2 Test Facility

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Poster #60

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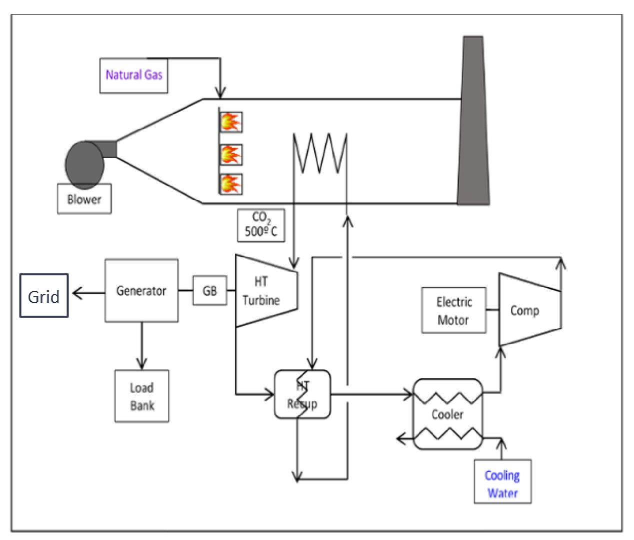
Steady State Models Uses:

- Steady state models provide input for equipment specifications, piping designs, cycle performance, guide overall control logic and methodology
- Components are modeled based on vendor datasheets and operational constraints
- Evaluate other sCO_2 cycles and applications

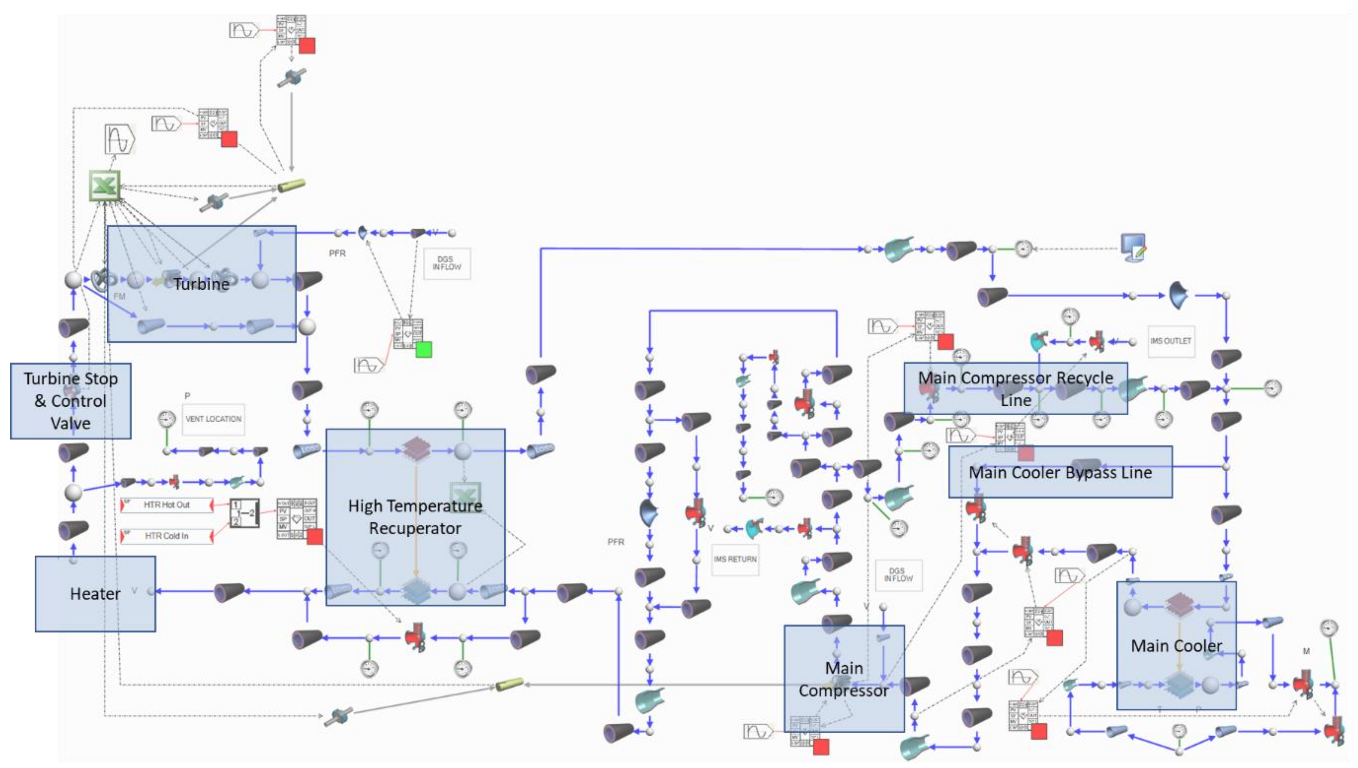
Near Term Objective:

- Update cycle power outputs, efficiencies, and other key performance parameters based on new test data from commissioning

Simple Cycle Configuration



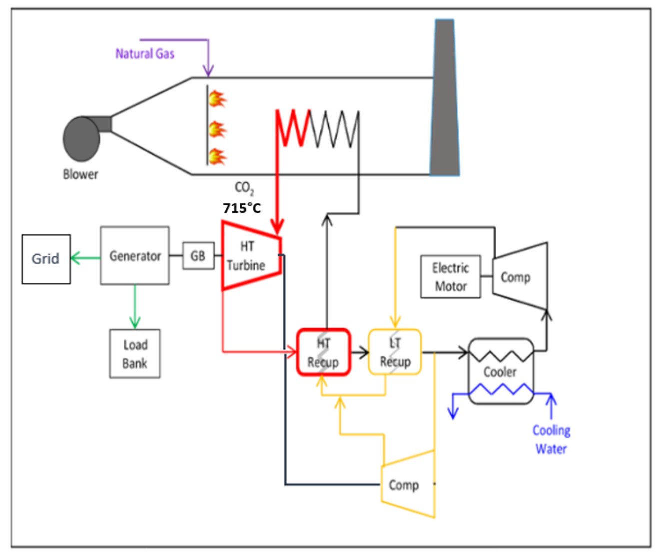
Simplified Diagram



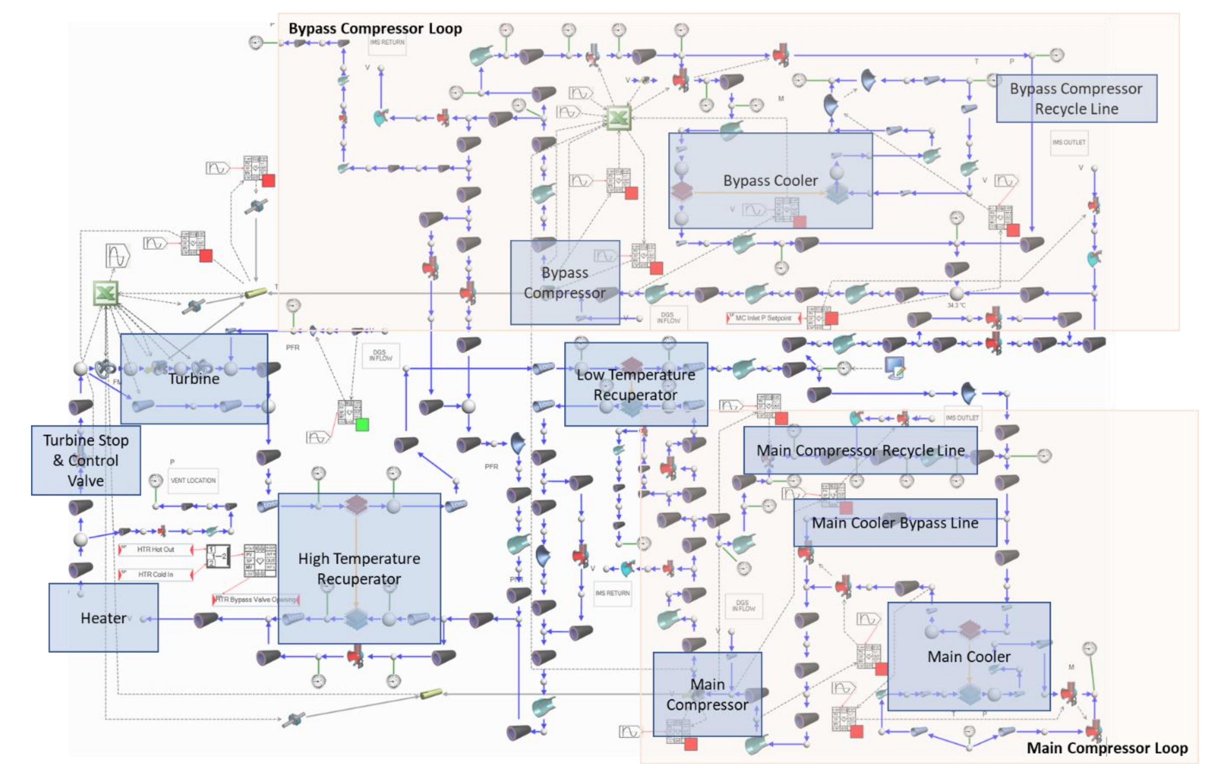
Flownex Model

- Simple cycle fundamental layout: heater, turbine, compressor, heat recuperator, coolers
- Baseline for efficiency and performance metrics in sCO_2 cycles

RCBC Configuration

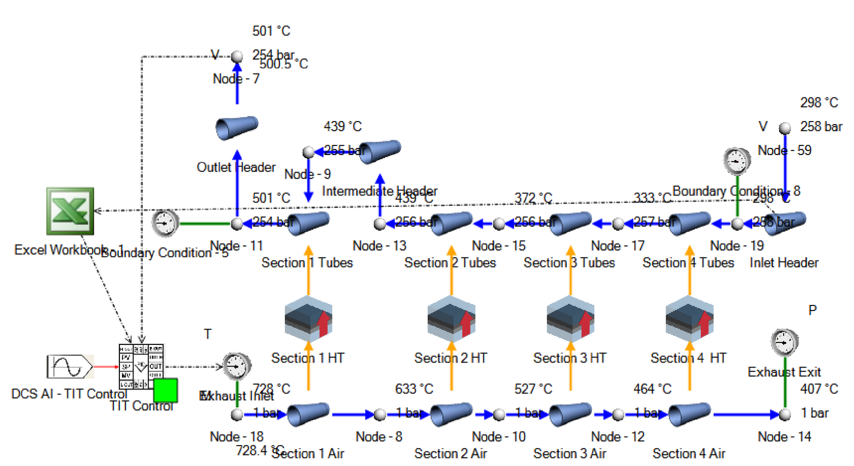


Simplified Diagram



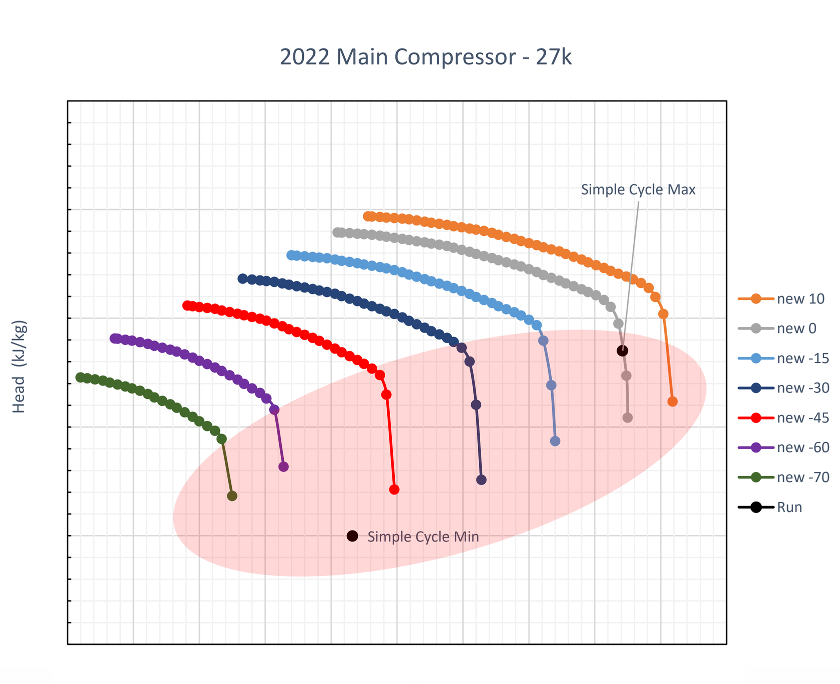
Flownex Model

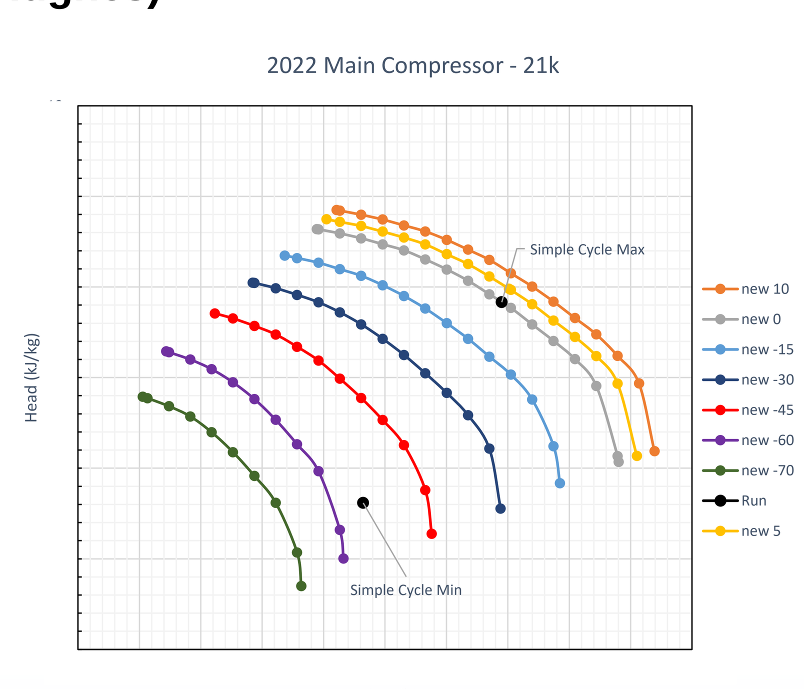
- RCBC cycle fundamental layout: heater, turbine, main compressor, bypass compressor, high temperature recuperator, low temperature recuperator, coolers
- Advanced sCO_2 cycle with integrated recompression loop



- STEP turbine is modeled through a combination of Flownex elements linked to a spreadsheet
- Spreadsheet houses calculations such as: turbine flow function, balance piston leakage, inlet and exit pressure losses
- Heater has been modeled as a series of tubes with composite heat transfer elements
- Compressors modeled using Flownex compressor elements; vendor compressor maps using real gas properties incorporated
- PID (proportional, integral, derivative) controllers are implemented in the model, used for automatic or manual control (controlling speed, load, pressures, temperatures, mass flows)

Compressor Maps from Vendor (Baker Hughes)





- Compressor maps are incorporated into Flownex models
- Compressor commissioning data will be implemented into Flownex models
- Commissioning data provides a more realistic perspective on operational behavior
- Projected system performance will be accessed with updated test data

Performance Parameters Update

Model Names	Cycle Configuration	Description	Load %	Net Power Level	Cooler Exit Temperature	Turbine Inlet Temperature	Cycle Efficiency
233	Simple	Simple cycle minimum load case MC 21k RPM (2022)	Min	1.8 MWe (1.76 MWe)	35 °C	500 °C	17.56% (14.90%)
236	Simple	Simple cycle maximum load case MC 21k RPM (2022)	Max	4.6 MWe (4.38 MWe)	35 °C	500 °C	26.67% (26.13%)
230	Simple	Simple cycle minimum load case MC 27k RPM (2023)	Min	3.5 MWe (1.90 MWe)	35 °C	500 °C	23.04% (13.16%)
N/A	Simple	Simple cycle maximum load case MC 27k RPM (2023)	Max	8.9 MWe (6.41 MWe)	35 °C	500 °C	30.91% (28.33%)
251	Recompression	Baseline case	100%	10.0 MWe	35 °C	715 °C	43.21%
252	Recompression	"Hot" Day Case	70%	6.7 MWe	50 °C	690 °C	38.15%
254	Recompression	Partial load case using inventory control	40%	4.0 MWe	35 °C	685 °C	37.86%
255	Recompression	RCBC at 500°C turbine inlet temperature	75%	7.5 MWe	35 °C	500 °C	33.51%
257	Recompression	Partial load case using TSV throttling (transient condition)	40%	4.0 MWe	35 °C	715 °C	35.59%
257a	Recompression	Partial load case using TSV throttling	40%	4.0 MWe	35 °C	682 °C	35.18%

- Table illustrating updated Net Power Output and Cycle Efficiencies
- Performance updated base on vendor provided main compressor maps and test data
- Emphasis on updating Flownex model with real test data for accuracy

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