Construction of an sCO₂ Joule-Brayton Cycle For High Exergy Heat Source Conversion To Electricity

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Summary

- The I-ThERM project
- $sCO_2$ scope & market
- Cycle description
  
  Frame components - CAD & assembly

  CGT - CAD & assembly

  First test

- Conclusion and next steps
I-ThERM Project aims to

Investigate, design, build and demonstrate innovative **plug and play** waste heat recovery solutions to facilitate **optimum utilisation of energy** in selected applications with high replicability and energy recovery potential in the temperature range 70°C – 1000°C.
sCO$_2$ targeted market

Potential high grade energy sources at the selected range

Improve actual power generation cycles

Industrial waste heat recovery
- Iron & steel
- Chemical processes
- Cement
- Glass

... 

Why sCO$_2$ to power generation?

Reachable working conditions

High energetic density

High compressibility

Great compactness

Up to 60% efficiency
Depending on the configuration

Clean, harmless & cheap fluid

Thermodynamic cycle

Isentropic CFD efficiency

- Turbine 70%
- Compressor 76%

Cycle efficiency

About 25%
General overview

Small scale installation

Max 780 °C Heat source

Flexible Up to 830 kWth

20 °C Cold source

50 kWth

500 kWth

Hot Heat Exchanger

Turbine

Generator

Compressor

Cold Heat Exchanger

630 kWth Regenerator

2.08 kg/s

Hot Loop

sCO2 Loop

Cold Loop

Max 780 °C

Heat source

Flexible

Up to 830 kWth

20 °C

Cold source

500 kWth
Brunel test rig

- CGT unit
- Plug & Play container 18ft
- recuperator
- Heat source
- sCO₂ heater
- cooler

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CGT Unit P&ID

Highly integrated unit

Electricity
Automation
Mechanic
Cooling
Lubrication

Inverter

Cooling loop

Water tank

Connecting flanges

Oil separator

Drain

Lubricant loop

To sCO2 loop
CGT Unit CAD

- Cooling fans
- Sliding CGT frame
- Electrical cabinet
- Inverter
- Drain compressors
CGT CAD

Fully instrumented

Compact

Pressure resistant pipings & parts
Mechanical CGT Design

- Volute
- Labyrinth seals
- Rotational guidance
- Permanent magnets
- Cooler
- Coils
- Compressor
- Turbine
- Drain
- Cooling
- Casing maintained via tie rods

Drain from the generator air gap to remain at a subcritical (gaseous) state
Skid assembly process

Components installation

Custom welding...

... & passivation

Strong attachment

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CGT assembly process

Magnet hooped on the shaft

Several balancing works

Balancing zone 1

Balancing zone 2

P1

P2

Resistant volutes

Cooler and coils.... mounted in the casing

Wheels

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First check up rotational tests

Showed good mechanical and electrical sizing
Conclusion

- **Promising efficiency** and **compactness** compared to **power generated** thanks to high rotational speed wheels & CO₂ properties

- **Plug&Play philosophy** ready for high grade heat sources

- Manufacturing difficulties due to the **harsh thermodynamic working conditions**, but can be lifted with off-the-shelffe components

**Future work**

- Finish the system assembly and automatization
- Installation in the container at the final test bench
- One year test campaign

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