Modeling and simulation of fixed bed regenerators for the CAPTURE project

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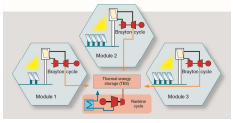
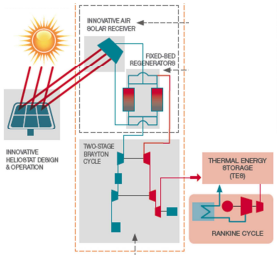
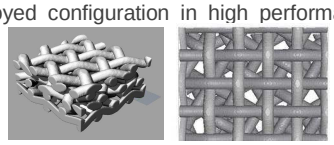
Introduction

CAPTURE project proposes a new concept of central receiver system based on a Decoupled Solar Combined Cycle (DSCC). A non-pressurized volumetric receiver is employed to feed the solar turbine using a **fixed bed regenerative heat exchanger** system for connecting both, pressurized and non-pressurized air loops. The fixed bed regenerative heat exchangers are alternatively connected to the two different air loops through a group of two way on-off valves. Thus, the system allows the continuous operation of the receiver and the turbine through the charging and discharging of a certain number of fixed bed regenerators.





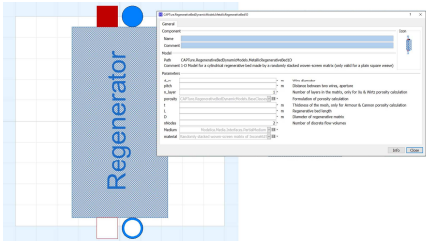
For the regenerative bed stacked **metallic wire mesh** screens with plain square weave are selected as porous media for the heat exchange, a commonly employed configuration in high performance Stirling engine regenerators.



Regenerative fixed bed modeling

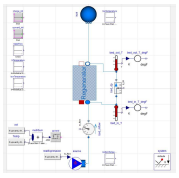
For the modeling task, **one-dimensional dynamic parametric model** have been developed in **Modelica®** with these characteristics:

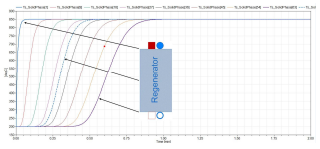
- Fluid flow is normal to wire screens
- Geometric parameters: wire diameter, aperture and thickness of the screen; number of stacked screens; diameter and length of the cylindrical bed
- Different matrix volumetric porosity expressions can be selected
- Thermal properties of the metallic material are temperature dependant (four different materials are already available in the model)
- DryAirNasa (Modelica Standard Library) selected as air model
- Different fluid friction and heat transfer correlations from available works on wire screens are implemented
- Regenerative bed can be divided into nodes representing radial sections of the matrix material
- Heat losses to the ambient are negligible



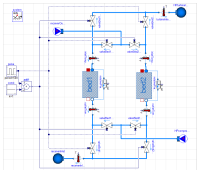
Simulation examples

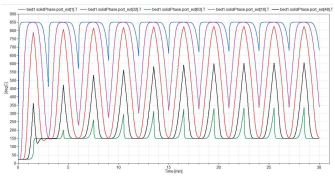
- Simulation of a **single blow** in a bed
  - Initial condition regenerator at constant T = 200ºC
  - Flow of hot air at T= 850ºC enters upper inlet of regenerator
  - Evolution of metallic matrix temperature at different sections normal to air flow during single blow





- Simulation of **cyclic operation** of **two beds**
  - Initial condition regenerators at constant T = 25ºC
  - Flow of hot air at T = 850ºC and cold air at T = 150ºC
  - Cyclic operation of both regenerators
  - Evolution of metallic matrix temperature at different sections normal to air flow during cycling





Conclusions

- A simulation model for evaluating the performance of fixed bed regenerative beds have been developed
- Temperature evolution along the length of the bed can be determine with time for thermocline analysis
- Cyclic steady state onset can be identified for continuous operation
- Configurations for two or more regenerative beds can be simulate

The model is part of a public deliverable of CAPTURE project that will be published on the website

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