FONaR: Flux-Optimised Sodium receiver
Multi-objective and evolutionary approach to geometry optimisation
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Raising the temperature of operation of solar receivers presents some interest in improving the efficiency of the subsequent power block. High temperature receiver design is challenging and multidisciplinary: increased emissive losses significantly impact the efficiency, thermo-mechanical stress affects numerous design options, the cost of materials rises, etc.

Design by multi-objective optimisation is a promising way of taking into account all constraints to produce more robust and efficient receiver designs.

**Influence of receiver geometry on performance**

The optimal temperature of photo-thermal conversion depends on the incident flux.

**Flux distribution on receiver surfaces**

The incident flux on a receiver is imposed by the optics. The geometry has a strong influence on the receiver flux distribution [1].

**Optimal geometry of receivers**

Considering a given optical concentrator, there is an optimal receiver geometry that maximises the amount or work that can be extracted from the concentrated solar radiation. This geometry is also influenced by:

- The thermo-mechanical limits of the materials constituting the receiver.
- Economical constraints such as materials and manufacturing cost.

To study the optimal geometry for a set of constraints, the receiver geometry is parameterised and multi-objective optimisation is applied to it.

**ASTRI P12: Sodium receiver concept**

Sodium as a heat carrier

- Very good conductivity = very good heat transfer coefficient
- Liquid and stable at high temperature, in absence of oxygen or water
- Demonstrated high flux receiver operation capability

**Flux-Optimised Sodium (Na) Receiver: FONaR**

Sodium gives more freedom in the selection of the geometry of the heat carrier circuit and is therefore suitable for receivers with non-conventional, flux-optimised geometries.

**Optimisation of tower receiver geometry**

**Receiver Energy balance**

**Absorber energy balance**

Figure 2: Tower receiver geometry class example with variable geometry parameters and wall energy balance scheme.

Semi-gray assumption is adopted. Radiative heat transfer is solved using Monte-Carlo Ray Tracing, “path tracing” (energy partitioning) with the “Tracer” in Python/NumPy for the visible part of the spectrum and a radiosity method using view factors for the thermal part.

**Multi-objective optimisation**

<table>
<thead>
<tr>
<th>THERMODYNAMIC EFFICIENCY</th>
<th>AREA WEIGHTED TEMPERATURE UNIFORMITY</th>
<th>SURFACE AREA</th>
</tr>
</thead>
<tbody>
<tr>
<td>η_W = \frac{\sum C_i \eta_W^i}{\eta_W}</td>
<td>η_T = \frac{1}{1 + \sqrt{\frac{\sum (\eta_W - \eta_T)^2}{\eta_W}}}</td>
<td>η_A = \frac{1}{1 + A}</td>
</tr>
</tbody>
</table>

The evaluation of a large number of geometries can lead to intractable simulation time. Two techniques are used to greatly improve the runtimes:

- **Evolutionary behavior** for geometry generation: The simulation learns about performing candidates.
- **N-dimensional Pareto front detection stochastic screen algorithm**: based on Asselineau et al. 2015 [2], underperforming candidates are removed from the simulation as soon as they are statistically unfit.

**Sample results**

**Conclusions and outlook**

A new approach to receiver design is proposed. A simpler version of this method was used with success in a previous project leading to a highly efficient Dish receiver. The method offers potential receiver efficiency gains as well as controlling the inherent reliability of the receiver from the design stage. Sodium circulation strategy will be implemented in further work.

Further information: [https://eng.anu.edu.au/people/charles-alexis-asselineau](https://eng.anu.edu.au/people/charles-alexis-asselineau)