# CFD Simulation: Stirling Heat Exchanger for High-temperature Storage

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## Project description

With the goal of a highly flexible way of generating electricity with a Stirling generator, the decoupling of heat energy via an intermediate hot gas circuit is promising. With this option, almost any heat source, such as biomass, high-temperature storage or industrial furnaces, can be used reliably and with little effort to generate electricity. In order to transport the heat efficiently from the source into the Stirling machine, it must first be transferred to a gaseous intermediate medium such as air. Thereafter, a hot gas blower transports it at temperatures up to 1000°C at high speed to the heater-heat exchanger of the Stirling machine where it releases the thermal energy. Figure 1 shows a possible flow path with an axial inlet and a radial outlet diffuser. In order to achieve efficient thermal transfer at the least possible loss of flow, an innovative heater-heat exchanger needs to be developed. In difference to traditional sources of heat, for example the direct combustion of combustible gases, the entire thermal energy must be transferred exclusively by convection. The otherwise generally very high proportion of thermal radiation in a gas combustion is not available. In addition, the size of the heater cannot be increased subjectively due to the thermodynamic requirements of the Stirling process.

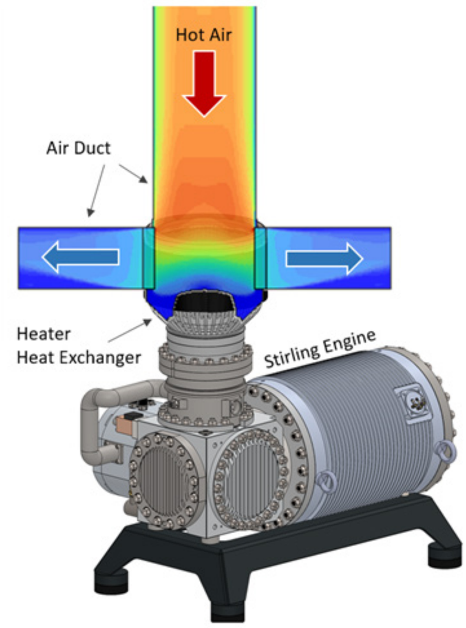


*Figure 1: Possible flow path through the Stirling heat exchanger*

### Results

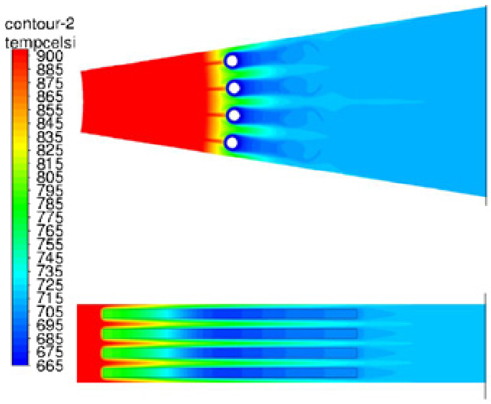


*Figure 2: Contour Plot of temperature before and after the heater-heat exchanger*

The geometry of heat exchanging has been optimized using a CFD analysis with respect to ideal fin-shape and length. The simulation showed a maximum transferrable heat power of more than 21 kW at an inlet temperature of 900°C and an operating volume flow of 1000 m³/h. Figure 2 shows the temperature profile of the cake-shaped calculation area with the direction of flow pointing radially outwards. The top area of the image shows the view from top with the heat exchanger tubes. In the side view below, the individual fins can be seen. It is evident that the hot gas flow cools down to around 715°C. The pressure loss at this operating point was calculated to be under 95 Pa.

## Summary

Whereas the required thermal transfer power is set minimally at 16.5 kW, the actual output of 21 kW clearly exceeds the expected value. In conjunction with the relatively low loss of pressure of 95 Pa the design still offers sufficient reserves and is able to transfer adequate energy even at low volume of flow and, finally, at acceptable blower power.

Please contact [Franz Diermaier] (DW 8272) for more information concerning the research project