Influence of hydrogen adding in the Stirling engine combustion process

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Abstract. Due to the rising interest in the optimisation of the Stirling engine and the use of hydrogen as green energy, this work considers a simulated design of a Stirling engine combustion chamber and presents the effect of hydrogen adding in the Stirling engine combustion process. The CFD simulations are performed in ANSYS Fluent, in order to obtain the thermal parameters, such as the heater temperature distribution, heat flux transferred to the heater, the energy loss of the burning cavity, the temperature distribution inside the chamber as well as the ejected stream heat. The simulations were performed for concentrations of up to 10 % of hydrogen in methane.

Initial data:

- Simulation Software: Ansys Fluent 17.1
- Stirling engine:
  - Genoa Stirling engine - 3kW
  - Start temperature: 650 °C
  - running temperature: 850 °C
- Burning chamber:
  - Inlet air flow: 0.007272 Kg/s - 0.008 Kg/s
  - Air pressure: 50 mbar
  - Inlet fuel flow: 0.00032 Kg/s
  - Gas pressure (CH_4): 250 mbar

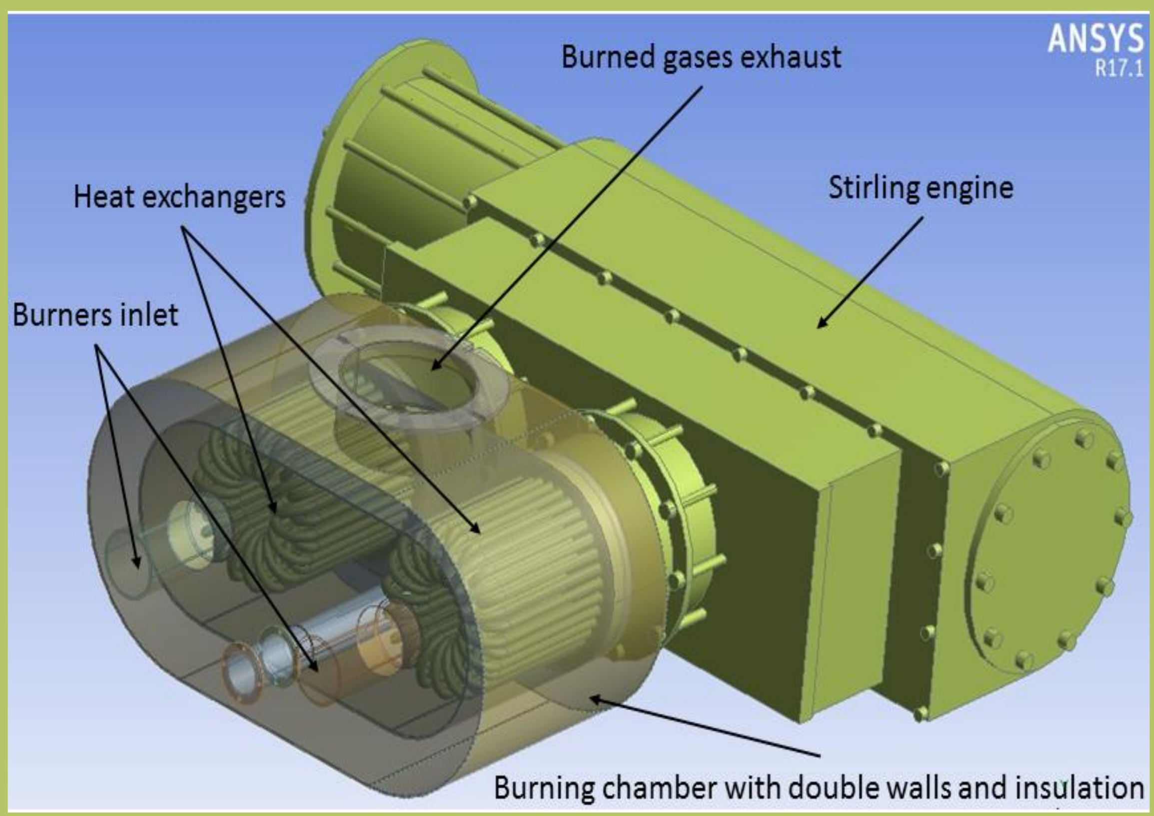
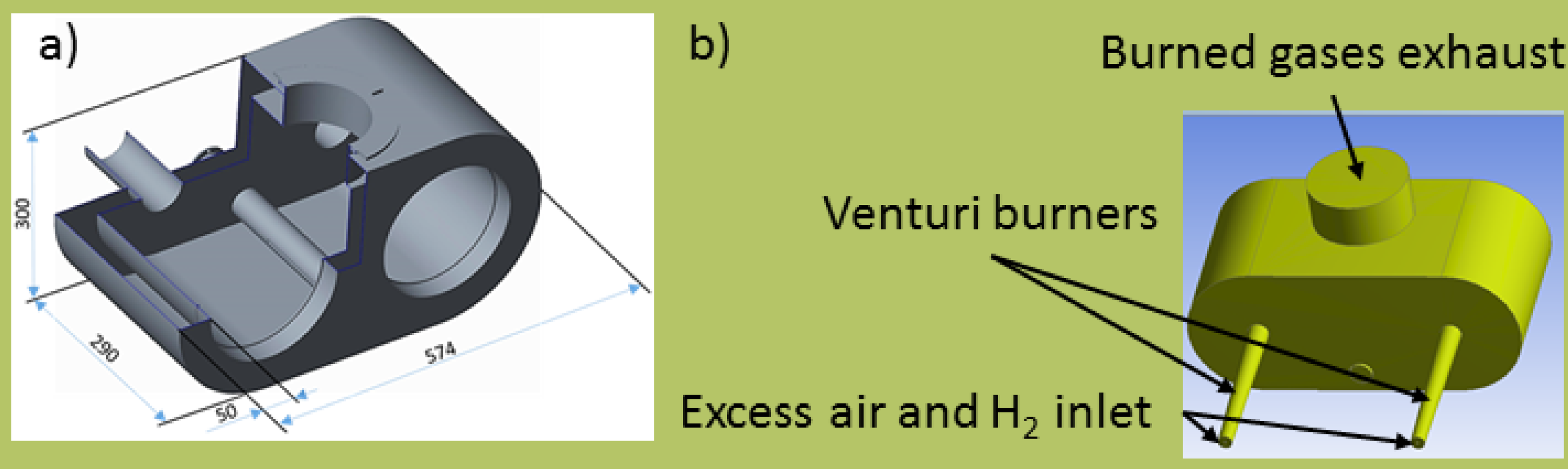


Fig 1. Stirling engine-burning chamber configuration example



Simulated configuration (Fig.2):

- a) Section view of the designed burning chamber
- b) front faced burners with excess gases inlet and top side exhaust

Ansys Fluent 17.1:

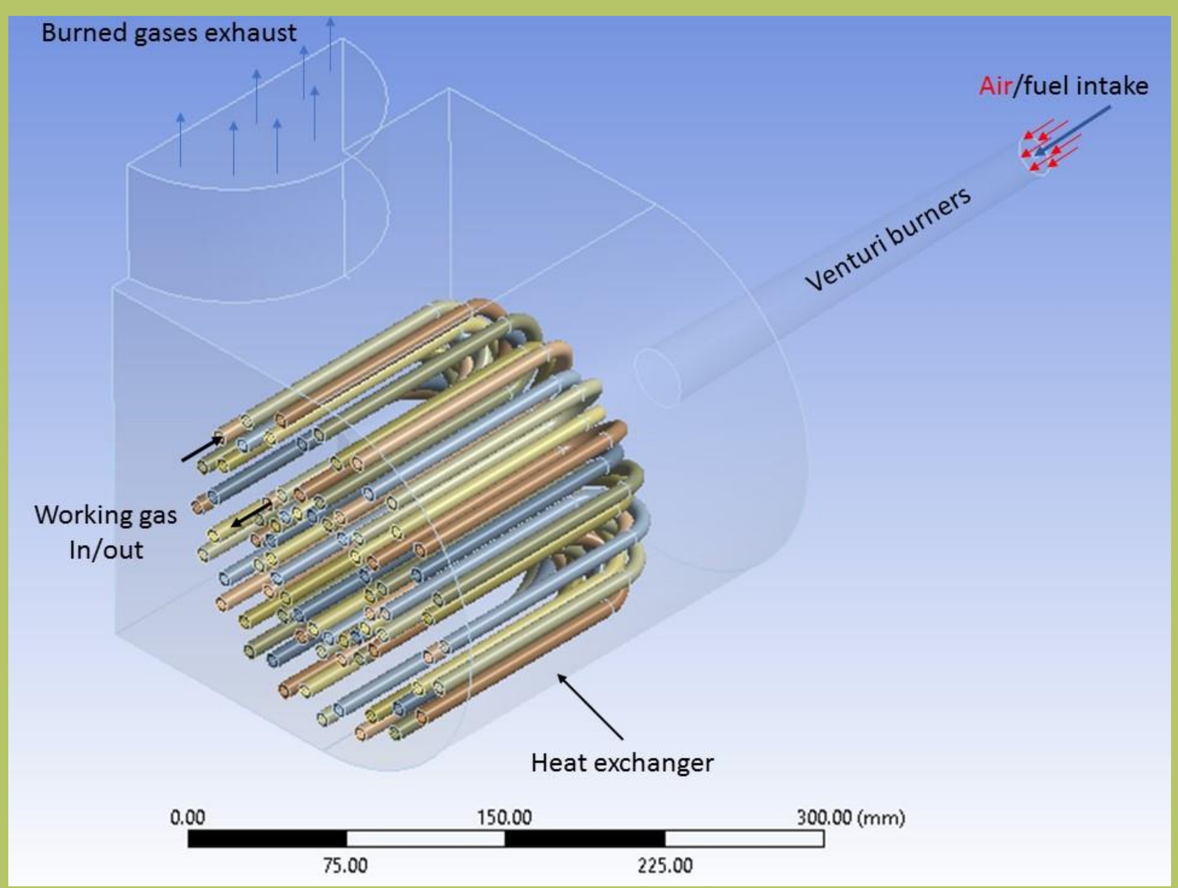


Fig 3. Reduced geometric model (Fig 2c case)

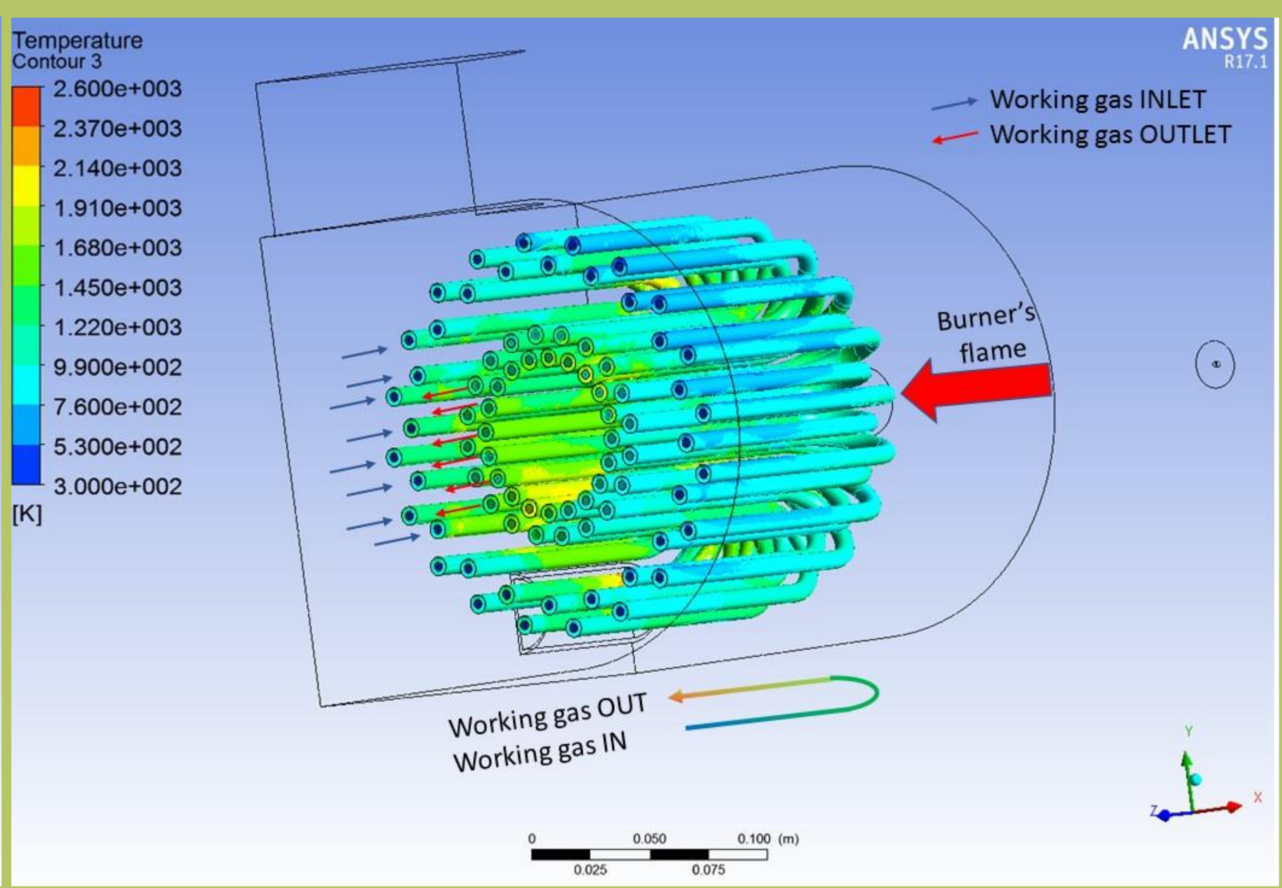


Fig 4. Heat distribution on the heat exchanger's surface and the inlet/outlet temperature of the surface inside

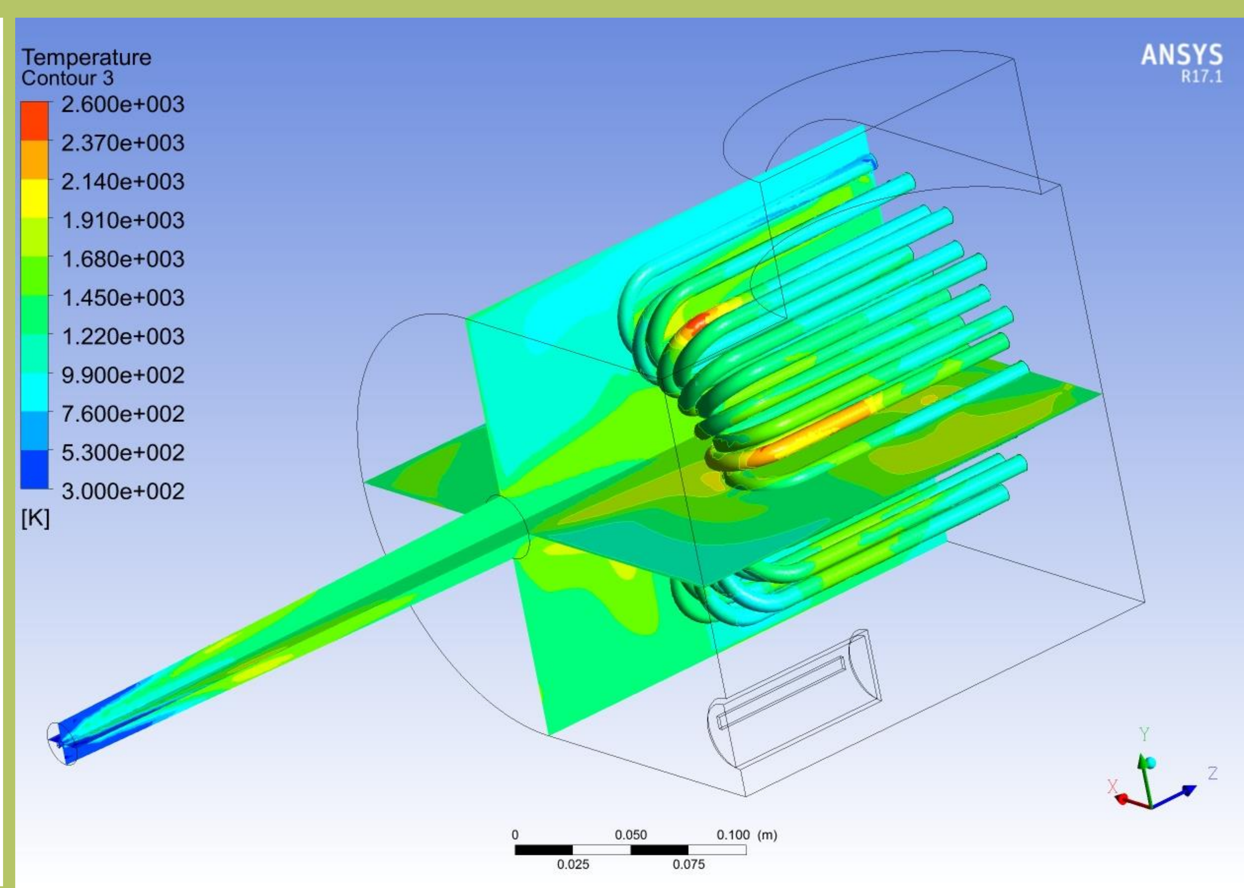


Fig 5. Temperature distribution on the heat exchanger of the Stirling engine (Fig 2c case)

CH4– H2 mixture	Outlet Temperature of the working gas (K)	Heat exchanger surface temperature(K)	Combustibles outlet temperature(K)	Combustibles outlet mass flow (Kg/s)
H_2 - 0 % Air = 0,007272 kg/s	1281.01	1471	1331.48	0.00754
H_2– 5% Air = 0,007272 kg/s	1235	1407	1299.1	0.00789
H_2– 10% Air = 0,007272 kg/s	1223.71	1392.87	1300.83	0.0082277

Table 1. Methane – Hydrogen mixture CFD results

Conclusions:

- As the hydrogen content increases, the temperature of the working fluid slightly decreases due to the presence of water vapor that takes over some of the energy when the flue gas leaves the system.
- The combustion process is cleaner due to the introduction of hydrogen in a certain percentage, because after burning it results water and not carbon dioxide.
- A heat recovery design on the flue gases outlet will be considered which will increase the overall efficiency of the system. This recovery system will convert a part of the energy lost by the hydrogen burning.

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