

Optimization of Heat Transfer in a Process Gas Heater for Substituting Fossil Fuel Burners

What is it about?

Energy-intensive thermal processes (e.g., heating, preheating, annealing) can be electrified to reduce the use of fossil fuels. To transfer electricity "from the outlet" into the material being heated (e.g., strips or billets) in the form of heat, electric resistive heating elements are used. These elements work similarly to a toaster, where wires glow due to electrical resistance.

This project focuses on resistive heating elements surrounded by a process gas, transferring heat predominantly through convection to the gas. These heating elements are typically designed very simply, e.g., a ceramic rod around which a wire is spirally wound, carrying the current. Your task is to design a new geometry—ideally, one that is nearly optimal! You have complete freedom to use any optimization strategies, whether genetic algorithms, topology optimization, or mathematical-analytical methods, which are all welcomed and encouraged.

The goal in the research field of resistive heating elements is to achieve an optimum balance between (convective) heat transfer, resistive heating, mechanical strength, and pressure loss. Your contribution would be to develop a minimal example with a 2D geometry and find an optimum balance between two or more of these factors. For instance, the geometry in Figure 1 was created using topology optimization and is optimized for heat transfer with minimal pressure loss. However, you are free to explore and apply other optimization strategies.

Since the overall project might be too large for a single thesis, smaller contributions are also welcome. Feel free to contact me if you are interested to discuss your ideas. We can tailor your thesis topic accordingly, whether it's a project assignment, bachelor's thesis, or master's thesis.

Time for orientation and familiarization with the topic will be provided.

There is already a solid foundation of research (extensive literature review available) that you can build upon.

After successfully completing your thesis, there may be an opportunity to continue working as a research assistant (HiWi).

Your profile:

- Interest in optimization
- Independent working style
- Interest in computer-based research
- Experience with FEM, FVM, CFD, or similar tools is advantageous
- Programming experience is a plus

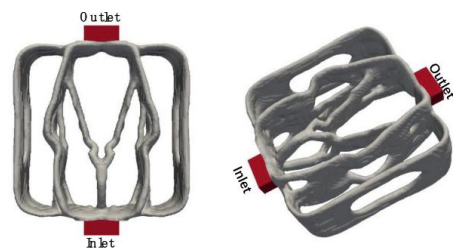


Figure 1: Yu et al. 2020 [1]

[1]: Yu, M., Ruan, S., Gu, J., Ren, M., Li, Z., Wang, X., Shen, C.: Three-dimensional topology optimization of thermal-fluid-structural problems for cooling system design. *Struct Multidisc Optim* 62, 3347–3366 (2020). <https://doi.org/10.1007/s00158-020-02731-z>

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