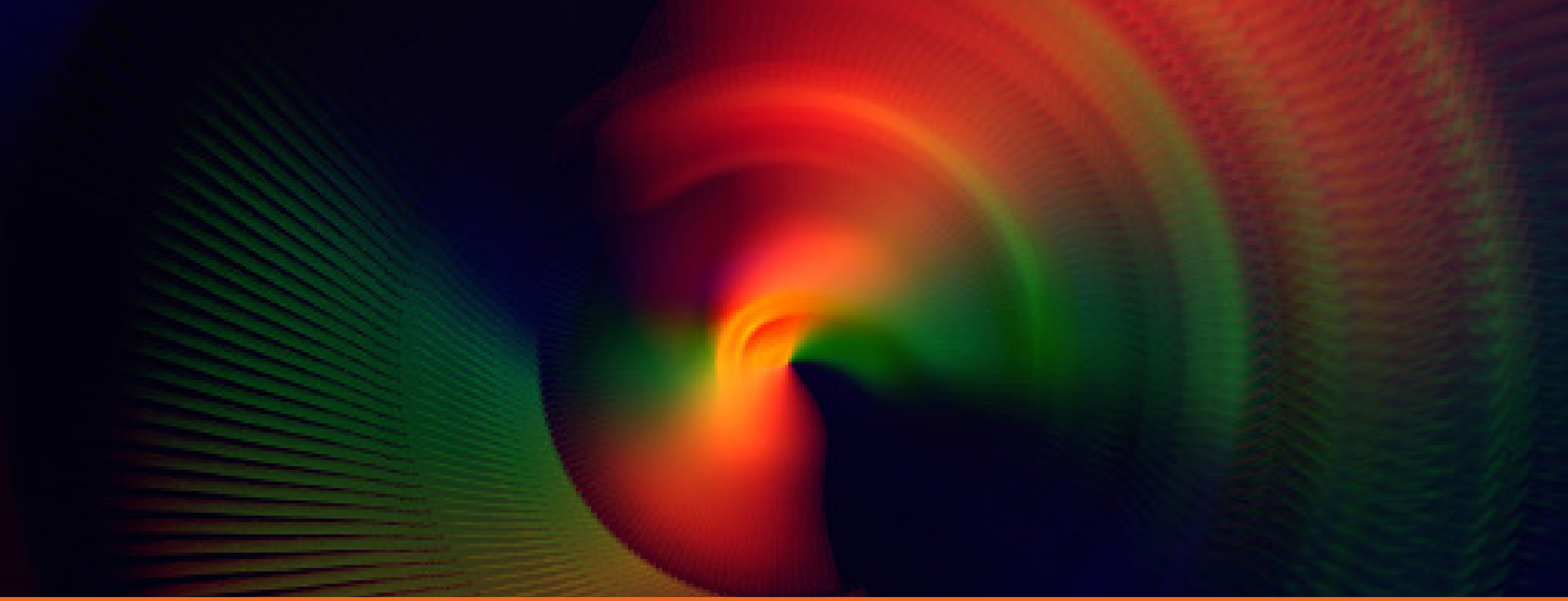

COOLING PLATE TOPOLOGY OPTIMIZATION

Context

Systems operating in vacuum environments often become unacceptably warm due to internal heat sources. To overcome this problem, cooling plates can be added to extract thermal energy from the system. We believe topology optimization could help in the design process to improve the performance of cooling plates.

A well-designed cooling plate not only extracts a lot of heat, but also has a low pressure drop (caused by flow resistance). For energy-efficiency, we want to minimize the pumping power required to force the fluid through the channels. In general, these design objectives are conflicting, as a good heat transfer leads to increased pressure drops and vice versa.

In addition to the two key objectives, constraints need to be added to obtain feasible designs from the topology optimization procedure. A few examples are:

- Volume constraints to limit the amount of fluid allowed in the design space (100% fluid is optimal, but unrealistic).
- Cooling channel geometry (to limit stresses from internal pressure, manufacturing, etc.).
- A minimum channel-to-channel wall thickness for manufacturing reasons.
- No fluids allowed near mechanical interfaces (e.g. bolt locations).

Internship overview

- Master Student
- Internship
- Industial Mathware/Mechanical Engineering
- Location: Eindhoven

Technologies

- Topology optimization
- Finite element method for solids & fluids
- Python programming

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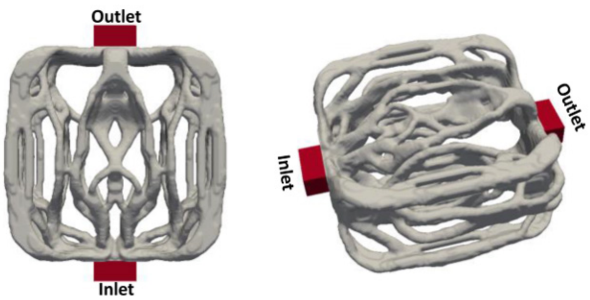
Assignment

A cooling plate is a metal plate that contains internal channels with a (cold) moving fluid. In mechatronic systems, such cooling plates are used to extract thermal energy, such that temperatures remain within limits.

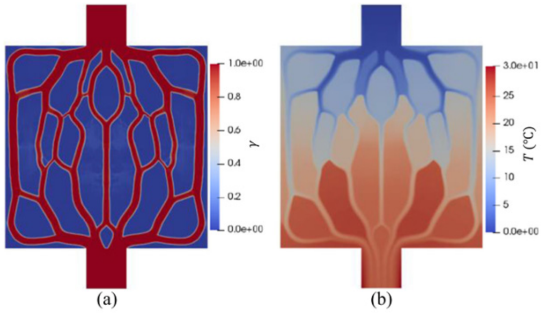
The aim of this assignment is to develop a Python script (theoretical physics model is in place) using FEniCS & Dolfin-adjoint that can derive an optimized cooling plate design. This task boils down to finding a best cooling channel layout such that the heat transfer between solid & fluid is maximal and the pressure drop between the inlet & outlet is minimal. The script should account for several constraints (manufacturing, assembly, mechanical interfaces, etc.) to obtain realistic designs.

Activities

- Working in a Linux environment (e.g. on a virtual machine).
- Performing conjugated heat transfer simulations.
- Usage of open-source software (such as Salome, FEniCS & Dolfin-adjoint).
- Mathematical derivations from strong to weak forms for the problem setup.
- Python programming.
- Post-processing results in Paraview.



Example of an optimal channel volume in 3D (Yu, et al., 2020)



Example of an optimized cooling plate in 2D. (a) Channel design [0 = solid, 1 = fluid]. (b) Temperature field corresponding to the optimized design (Yu, et al., 2020).

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Would you like to know more about this student assignment?

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