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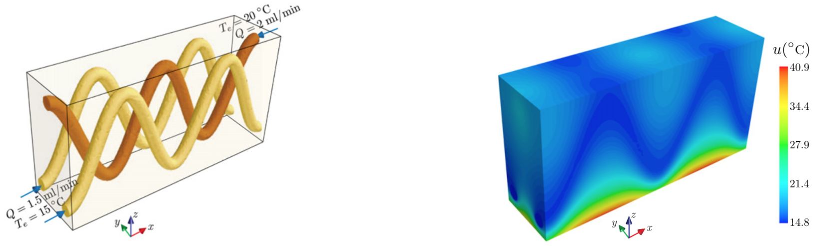
Vasculature optimization of actively-cooled materials

Master of Science project

Abstract

This M.Sc. project consists in the shape optimization of a vascular material block with active-cooling. The student will implement advanced numerical methods for the optimization of a material subjected to thermal loads. The implementation will take place in *Hybrida*, a new finite element package being developed within the Structural Optimization and Mechanics (SOM) group.

Introduction Bio-mimetic materials are currently being investigated for their applications in the industry. These materials can be used to provide self-healing properties, sensing capabilities, and even active-cooling. The latter application is achieved by mimicking the circulatory system of the human body, by means of an embedded network manufactured using fugitive ink printing techniques or sacrificial fibers. Yet, the topology of the vasculature within the material cannot be randomly created, for its detrimental effects to the overall mechanical properties of the material. Therefore, a vasculature design that optimizes the device for a set of critical thermal is problem dependent. Numerical tools can help cope with this design process. Figure 1a, taken from [1], presents the schematic of an epoxy fin, actively-cooled by a set of channels with sinusoidal shape. The effect of the cooling is then shown in Figure 1b.



(a) (b)

Figure 1: Active-cooling of an epoxy fin [1]. a) Schematic of the thermal boundary value problem; b) Numerical result of the temperature distribution.

Tasks *i)* Conduct a thorough literature review on the different methodologies used in the optimization of actively-cooled materials. *ii)* The study of the interface-enriched finite element method (IGFEM) and the streamline upwind/Petrov-Galerkin method for the modeling of thermal problems combining solid and fluid mechanics. *iii)* The implementation of the new formulation within *Hybrida*, a new finite element library that is being developed within the Structural Optimization and Mechanics (SOM) group. *iv)* Coupling of the numerical tool with an optimizer to design the best vasculature shape given a set of thermal loads. *v)* Presentation of results and the preparation of a report that could potentially lead to a peer-reviewed journal publication.

Requirements The student should have modeling experience and basic knowledge of finite element analysis. Programming experience with the Python language is recommended.

References

[1] S. Soghrati and P. H. Geubelle. A 3d interface-enriched generalized finite element method for weakly discontinuous problems with complex internal geometries. *Comput. Methods Appl. Mech. Engrg.*, 217–220:46 — 57, 2012.