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# TOPOLOGY OPTIMISATION OF PASSIVE COOLERS: From Toy Problems to Industrial Application and Beyond to Faster Approximate Models

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We live in a world with increasing pressure on diminishing resources, due to larger populations and increasing consumption – especially of electricity. A large part of this use comes from lighting sources, both domestic, industrial and public. Light-emitting diodes (LEDs) are highly energy-efficient light sources. However, it remains a challenge to adequately cool them since around 70% of the energy supplied to an LED is converted to heat. This generally leads to a high package temperature, which severely affects the light output and lifespan, unless sufficiently cooled.

This presentation will cover a broad selection of work within topology optimisation of passive coolers. Without introducing additional power consumption, passive cooling using natural convection provides both low-power and low-noise benefits. Natural convection inherently does not need an additional energy source forcing the flow, since the temperature differences, caused by the already heated LED lamp, causes the air to circulate.

Topology optimisation provides the ultimate design freedom and is an incredible tool for gaining insight into optimal design of passive coolers. From two-dimensional academic examples [1] to large-scale three-dimensional problems [2], generally, the observations are in line with classical heat sink design. However, additional insight and possible design guidelines are gained from applying the developed framework to an industrial problem, namely the design of passive coolers for light-emitting diode (LED) lamps [3].

After ramping up the workload and coping with the huge computational burden using a parallel framework, the idea is now to take a step back and investigate whether it is possible to formulate a simplified fluid flow model. The goal is to significantly reduce the workload and computational time, in order to move towards an interactive tool for the design of passive coolers. By introducing a Darcy flow model [4] coupled with the convection-diffusion equation through the Boussinesq approximation, a significantly reduced model size is obtained. From various test problems and comparisons to the full Navier-Stokes flow model, a remarkable similarity is seen. The approximate model is compared to a furtherly simplified model, using constant boundary convection, in order to show that it captures features of the governing flow physics that is neglected in the boundary convection case.

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