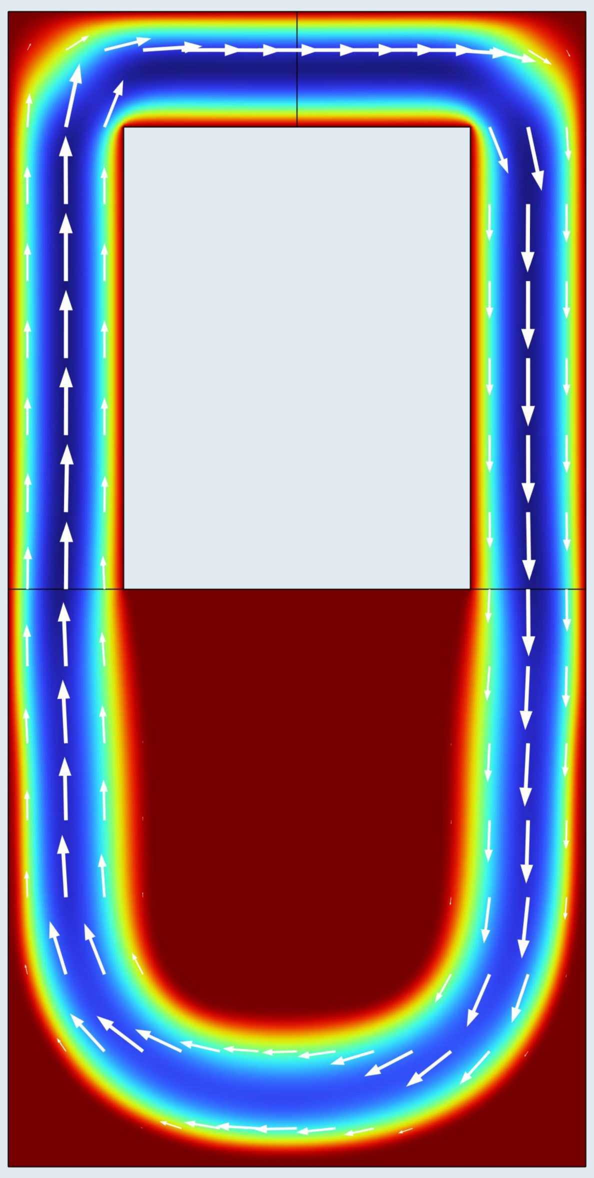
Velocity field in the micropump



COMSOL LiveLink for MATLAB code for topology optimization of conjugate heat transfer problems

This work demonstrates that COMSOL LiveLink for MATLAB offers the possibility to reduce the effort of implementing finite element analysis while being able to control all the parameters in topology optimization of conjugate heat transfer problems.

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Introduction and goals

Topology optimization can be defined as mathematical method of distributing a material quantity in a volume in an optimum manner to achieve desired objective while satisfying predefined constraints. In this work, we demonstrate a comprehensive COMSOL LiveLink for MATLAB code for topology optimization of conjugate heat transfer inspired from (Junghwan Kook et al. 2021). For conjugate heat transfer problems the governing equations are conservation of mass, momentum and energy equations in fluids and solids combined. In particular, we have focused on natural convection examples (a natural convection micropump [2]) where finite element analysis is more complicated and unhandy to code. The objective would be to find a fluid flow path through the solid area(grey area in Figure 2(a)) to maximize the flow rate at the objective boundary Γ_{mf} (see Figure 2(b)). A maximum fluid volume fraction of 0.5 is considered.

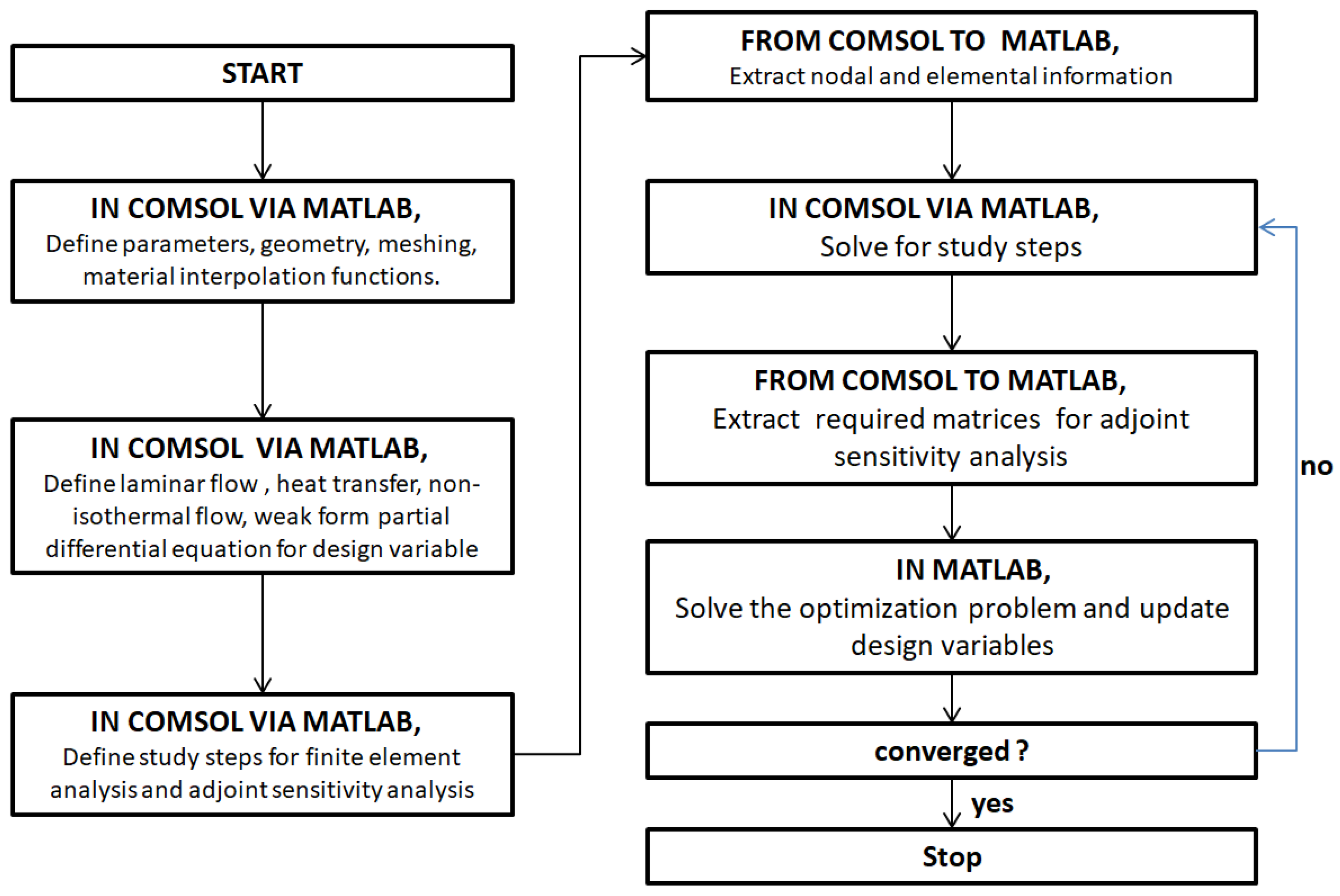


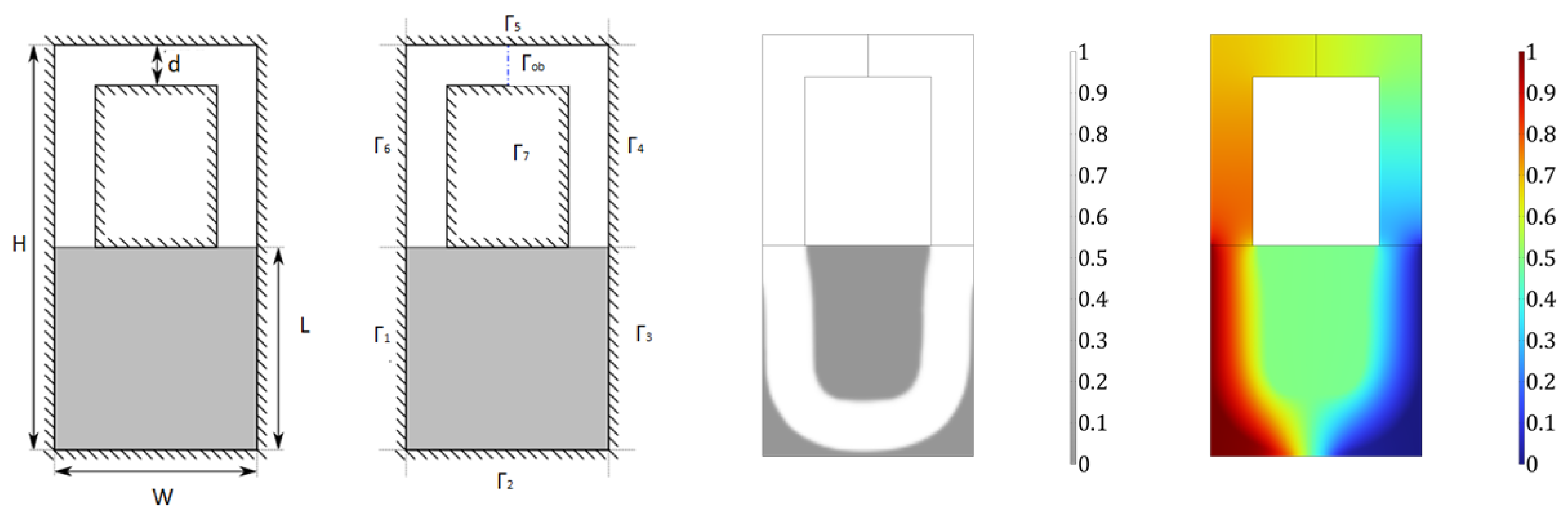
FIGURE1. Flow chart explaining the overall structure of the code.

Methodology

The methodology given in flowchart (Figure 1) is used for topology optimization of a micropump problem(Figure 2) where objective function is to maximize flow rate at the objective boundary Γ_{mf} . The problem is made non-dimensional by using appropriate scales for state variables i.e. velocity, pressure and temperature. A design variable of 1 represents fluid, 0 represents solid. Initial design is complete solid(grey area in Figure 2 (a)). Method of Moving Asymptotes (MMA) method is used as optimization algorithm.

Results

The optimized design for maximizing mass flow rate for the micropump problem shown in Figure 2(a),(b) is given in Figure 2(c). The ratio of thermal conductivities of fluid to solid is taken as 0.01. The length 'L' and width 'W' of design domain are taken as 1. Total height 'H' of micropump is taken as 2. Thickness 'd' is taken as 0.2. Prandtl number is taken as 1. Grashoff number is taken as 1000. Temperatures at Γ_1 and Γ_3 are taken as 1 and 0 respectively. At every other boundary, it is thermally insulated. All lengths are relative to 'L'. All boundaries have no-slip boundary conditions.



(a) geometry (b) boundary conditions (c) design (d) temperature profile

FIGURE 2. Geometry, boundary conditions, optimized design and corresponding temperature field for maximum clockwise mass flow for natural convection micropump . White color in figure 2(a)-(c) represents fluid and grey represents solid. The velocity profile is provided at the top of this poster.

REFERENCES

[1] Kook, J. and Chang, J.H. A high-level programming language implementation of topology optimization applied to the acoustic-structure interaction problem. Structural and Multidisciplinary Optimization, 64(6), pp.4387-4408 , 2021.

[2] Alexanderson, J., Aage, N., Andreasen, C.S. and Sigmund, O. Topology optimisation for natural convection problems. International Journal for Numerical Methods in Fluids, 76(10), pp.699-721, 2024.