From Concept to Simulation: SIMTEC, your COMSOL Partner for Game-Changing Innovation

Humusoft COMSOL Conference 2025
May 22th 2025

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Patrick Namy – CEO and founder
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Outline

I. SIMTEC : Who we are

II. Case study 1: Heat dissipation in a head lamp

III. Case study 2: Thermal and mechanical multiscale modelling

IV. Q&A session

SIMTEC : Fundamentals

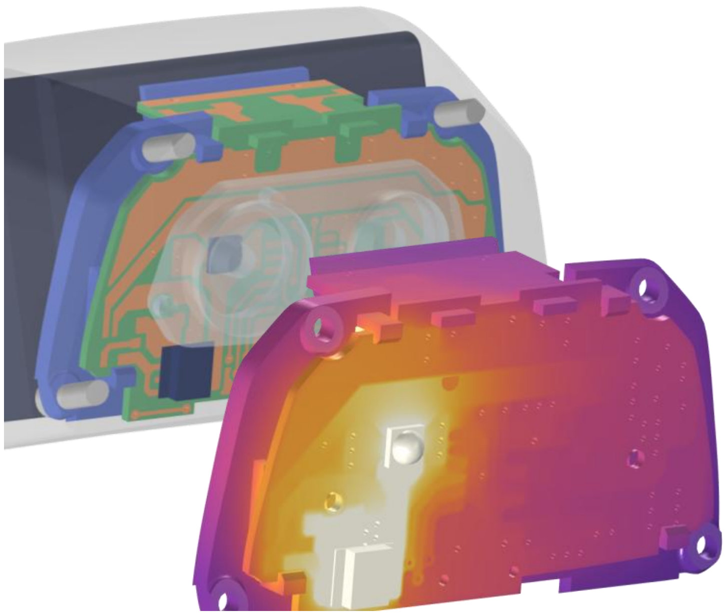
- French Numerical modelling consultancy
- Leader in France of the COMSOL Certified Consultants, key partner worldwide
- 9 members Eng.D. + Ph.D.
- Main partners:
  - big international companies
  - laboratories
- Involved in the Research projects like EU FP (SHARK, SisAl)/ PhD supervision

SHARK
INDUSTRIALISING LASER FUNCTIONAL TEXTURING

SisAl Pilot

COMSOL Certified Consultant

Case study 1: Heat dissipation in a head lamp



Modelling the Heat Dissipation of a Head Lamp within COMSOL Multiphysics®

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[1] SIMTEC, Grenoble (France)
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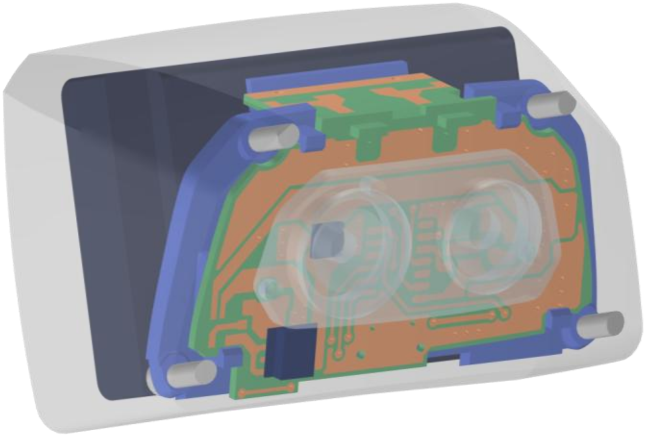
COMSOL Conference 2023 Munich publication link

This work has been founded by DECATHLON and made in a fruitful collaboration between DECATHLON and SIMTEC.

Extracted from « Modeling the Heat Dissipation of a Head Lamp within COMSOL Multiphysics® », COMSOL Conference 2023, Link.

Case study 1: Heat dissipation in a head lamp

Context and objectives



- Serial production of head lamps
- **Goal: reducing the environmental footprint**
- Employing other materials having other properties…
- … Requiring to redesign some parts

→ Thermal performance of new designs?

❑ No overheating of the electronic components
❑ No hot spots neat the user

→ Estimating the heat dissipation performances using a numerical model!

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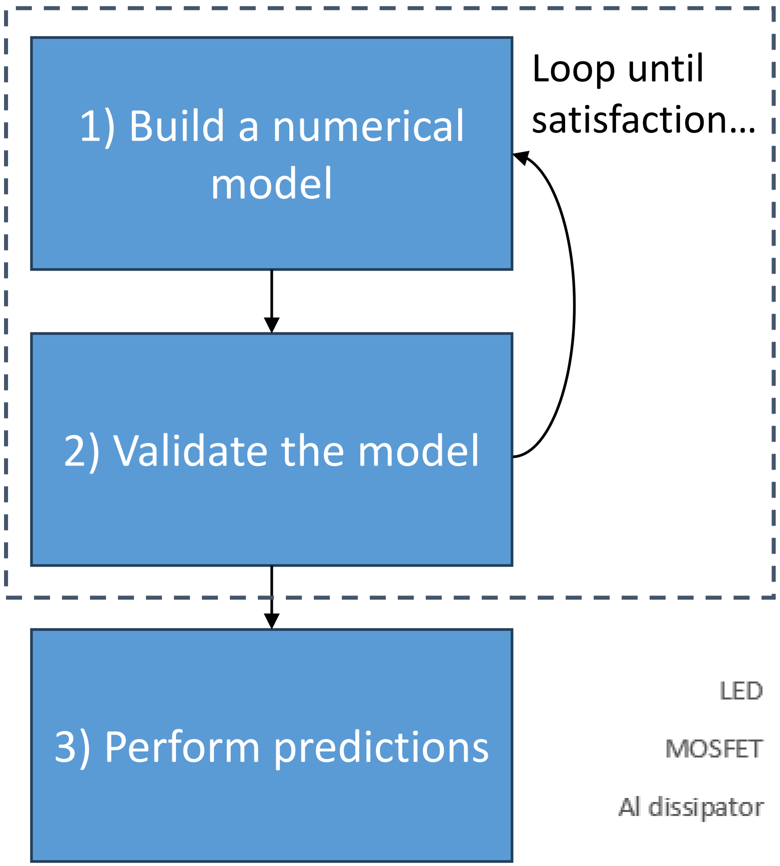
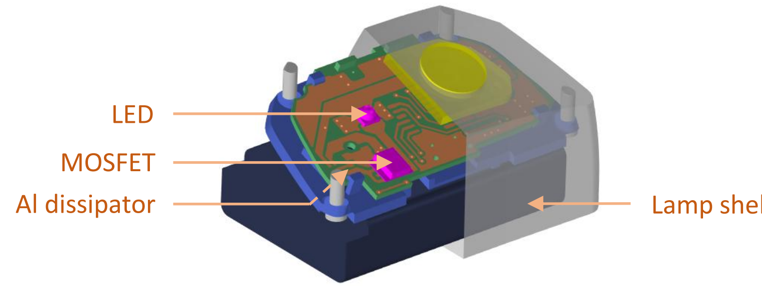
Case study 1: Heat dissipation in a head lamp

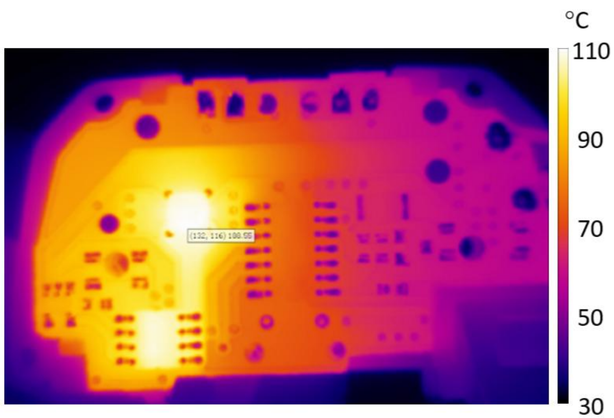
Context and objectives

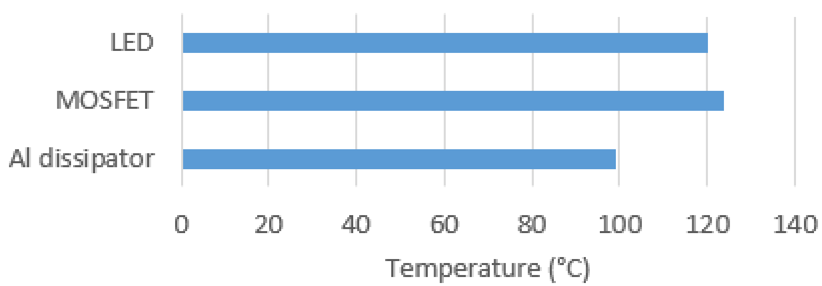


A few components of the lamp



Experimental temperatures: open lamp (no shell)





Experimental temperatures: closed lamp

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Case study 1: Heat dissipation in a head lamp

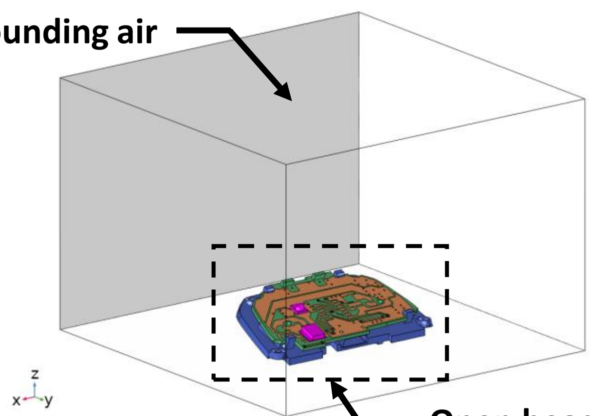
Modelling – Open lamp

Hypotheses:

- Main heat dissipation processes: **conduction** and **natural convection** (no radiation)
- **Laminar** natural convection (Grashof number)

Computational domain

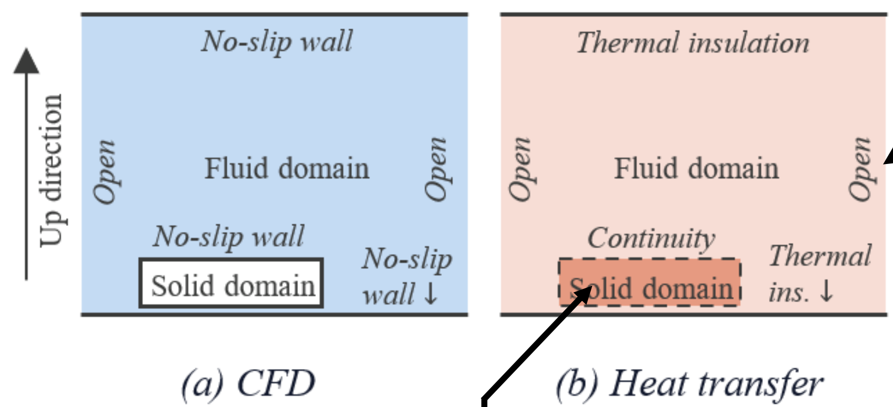
Surrounding air



Open head lamp

CFD ⟷ Heat transfer model

Cold source



Heat sources: LED and MOSFET

→ Solved at steady-state

→ **Conduction + Natural convection : very natural coupling in COMSOL Multiphysics!**

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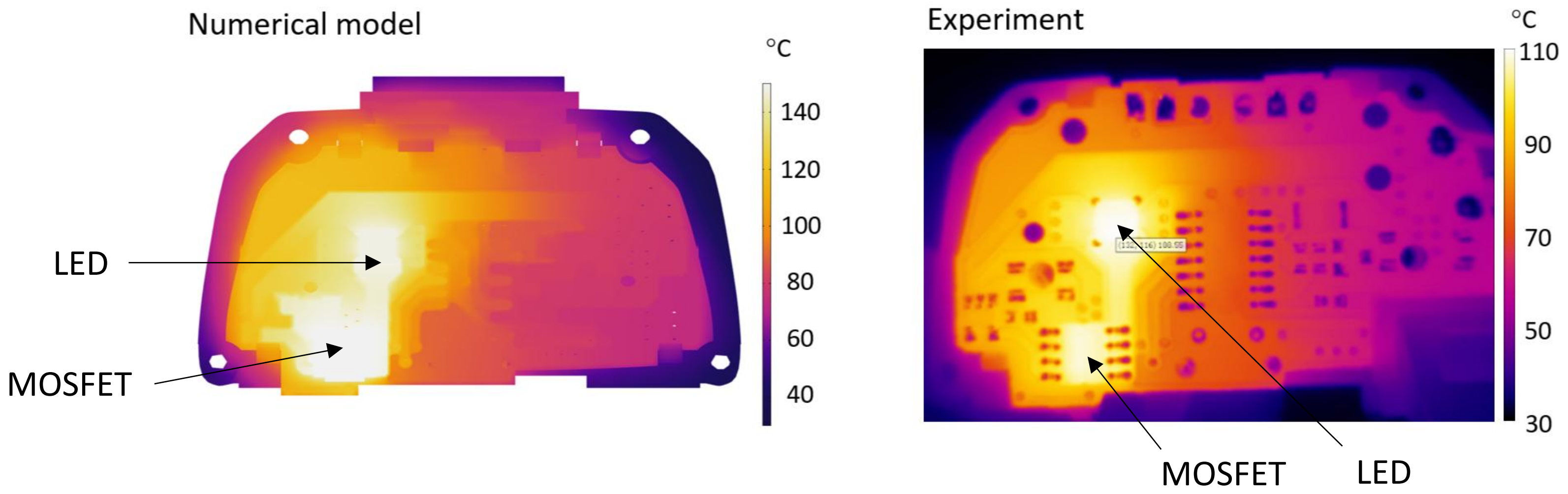
Case study 1: Heat dissipation in a head lamp

Results – Open lamp

Temperature cartography: numerical model vs. experiment



Qualitative agreement ✓

Quantitatively: numerical temperatures ≫ experimental temperatures

→ Very good first step!

→ But a dissipation process seems to be missing: radiative transfers

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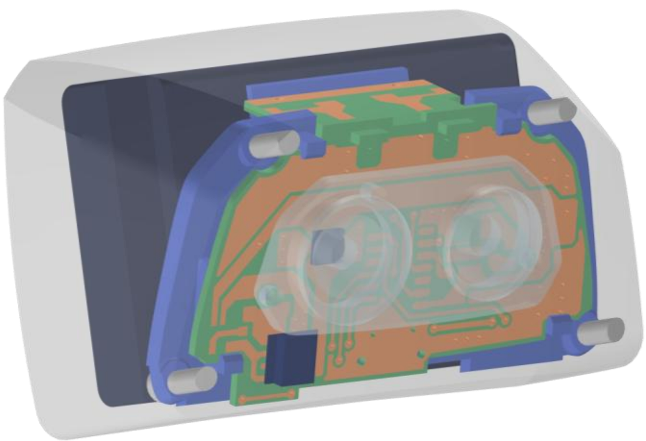
Case study 1: Heat dissipation in a head lamp

Modelling – Closed lamp

Hypotheses:

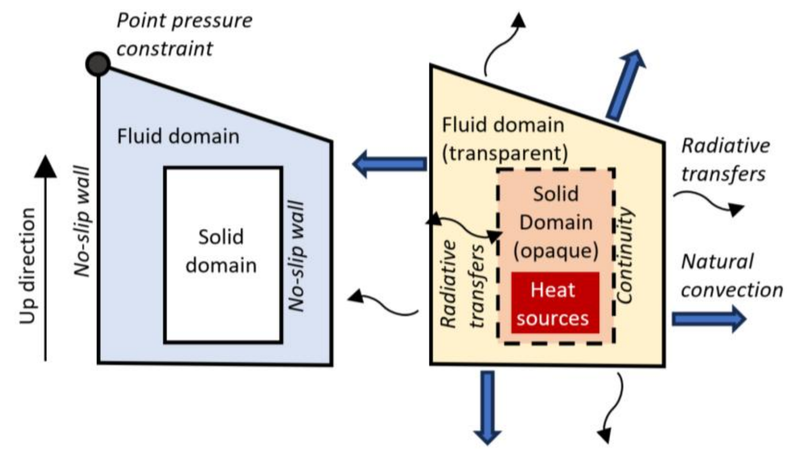
- ~~Main heat dissipation processes: **conduction** and **natural convection** (no radiation)~~
- **Laminar** natural convection (Grashof number)

Computational domain



Surrounding air is not explicitely represented

CFD ⟷ Heat transfer model



→ Solved at steady-state

→ **Conduction + Natural convection + Surface-to-surface radiation: still a very natural coupling in COMSOL Multiphysics!**

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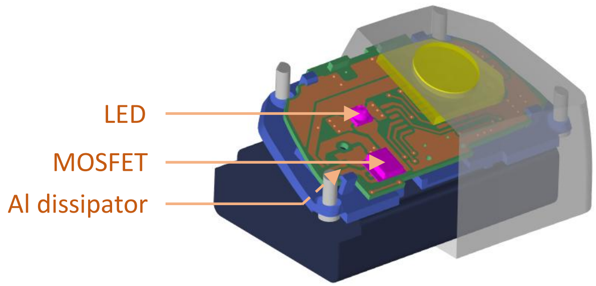
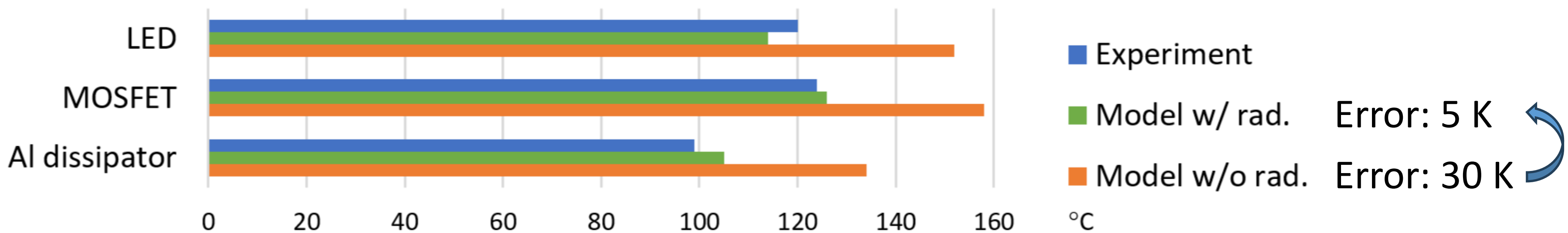
Case study 1: Heat dissipation in a head lamp

Results – Closed lamp

A few components of the lamp



Local temperature measurements: numerical model vs. experiment



In fact, we also simulated the closed without radiation!

→ By taking into account radiation: the model is far more accurate! ✓

→ Validated model: ready to make predictions and answer design issues! ✓

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Conclusions and Perspectives

→ Modelling is an iterative process:
1) We make simplifying hypotheses
2) We build models upon these
3) Whenever it's possible: we compare the model with experiments
4) We get back to step 1) until the model is accurate enough

→ COMSOL is a well adapted tool to efficiently address heat transfer issues in complex geometries:
- CAD imports and geometry operations
- Very natural couplings (physics, solvers…)

→ On this specific case study: we developed an accurate head lamp thermal model, making it possible to evaluate heat dissipation performance of new designs

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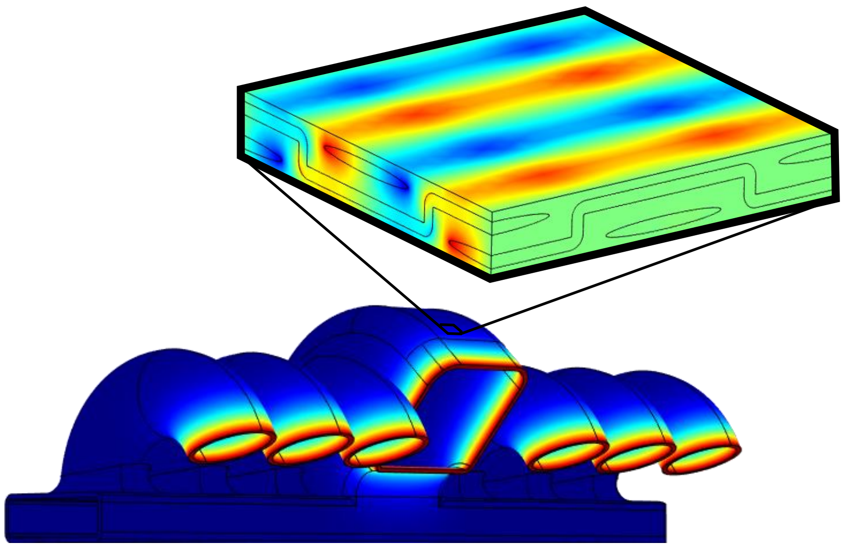
Case study 2: Thermal and mechanical multiscale modelling



Heat Transfers and Solid Mechanics in Microarchitectured Materials using Periodic Homogenization

F. Viry[1], J.-D. Wheeler[1], P. Namy[1]
[1] SIMTEC, Grenoble (France)

COMSOL Conference 2023 Munich publication link

Extracted from « Heat Transfers and Solid Mechanics in Microarchitectured Materials using Periodic Homogenization », COMSOL Conference 2023, Link.

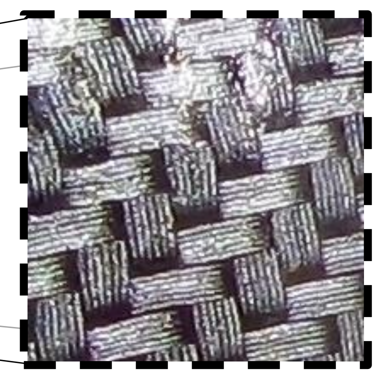
Case study 2: Thermal and mechanical multiscale modelling

Context and objectives

Microarchitectured materials

- Lightweight
- Resistant
- Insulating
- Other properties…

Intake manifold photo from Shutterstock



Carbon fiber pattern

→ **How to design and evaluate the performance of my part using such materials?**

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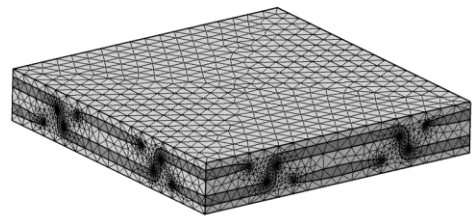
Context and objectives

What about direct FEA?

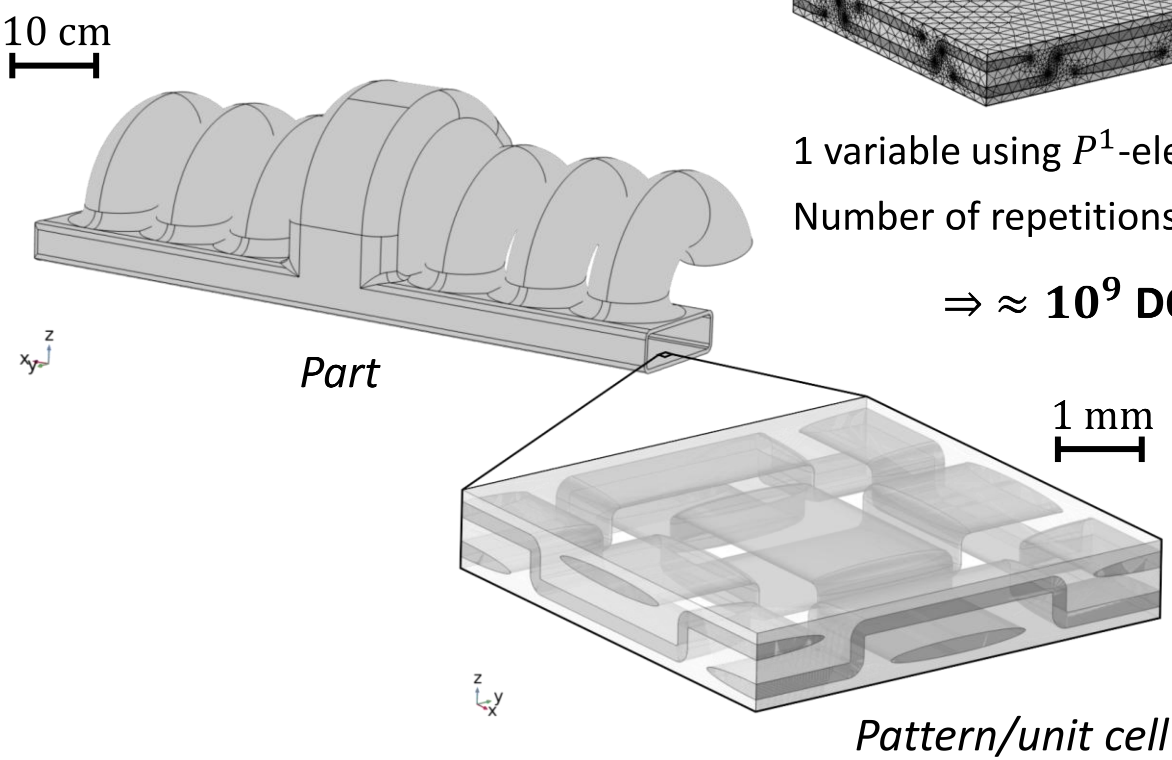


$\approx 100\ k$ nodes/cell

1 variable using P^1-elements $\Rightarrow \approx 100\ k$ DOF/cell

Number of repetitions of the unit cell : $\approx 10\ k$

$\Rightarrow \approx \mathbf{10^9}$ **DOF to solve for !!**



→ **We must rely on a more sophisticated approach: *e.g.* periodic homogenization method!**

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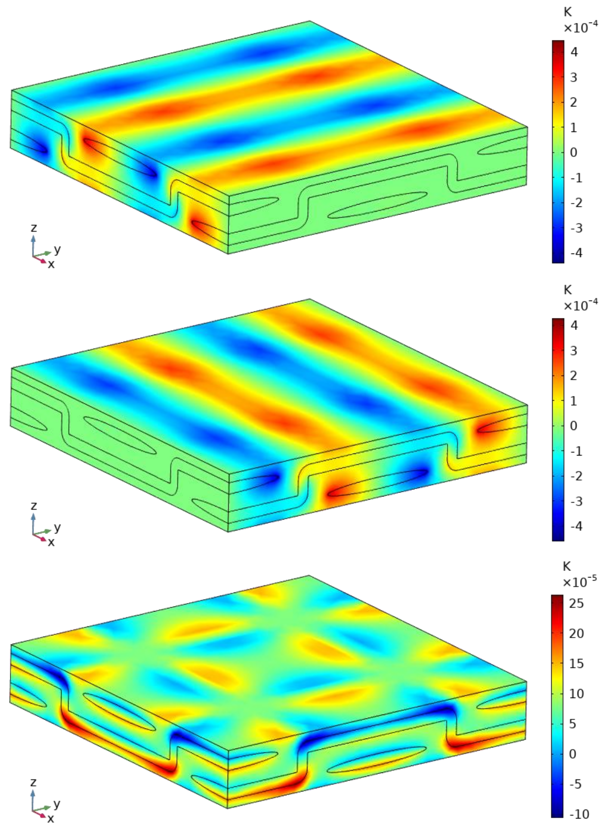
Case study 2: Thermal and mechanical multiscale modelling

Modelling – Principles of periodic homogenization

Step 1: submit the microstructure to unitary solicitations (FEM computations)

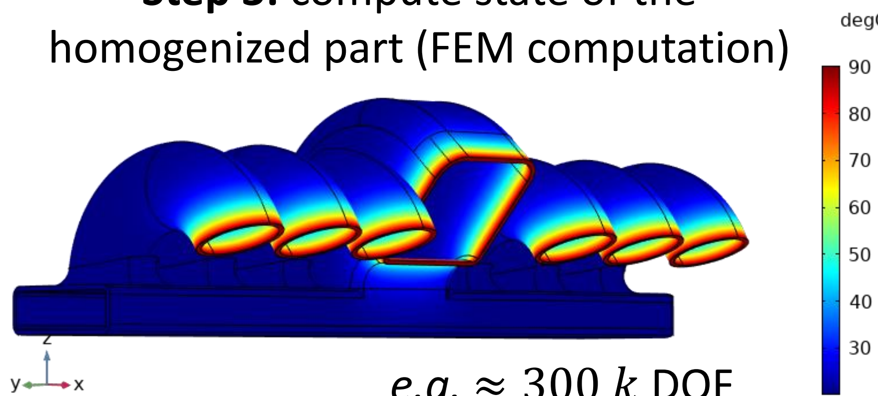


e.g. $\approx 100\ k$ DOF/computation

Step 2: compute homogenized properties (post-treatments)

→ *Conductivity matrix*
→ *Elasticity tensor*
→ …

Step 3: compute state of the homogenized part (FEM computation)



e.g. $\approx 300\ k$ DOF

Step 4: relocate → combine macroscopic and microscopic results to **get accurate results at microscale** (post-treatment)

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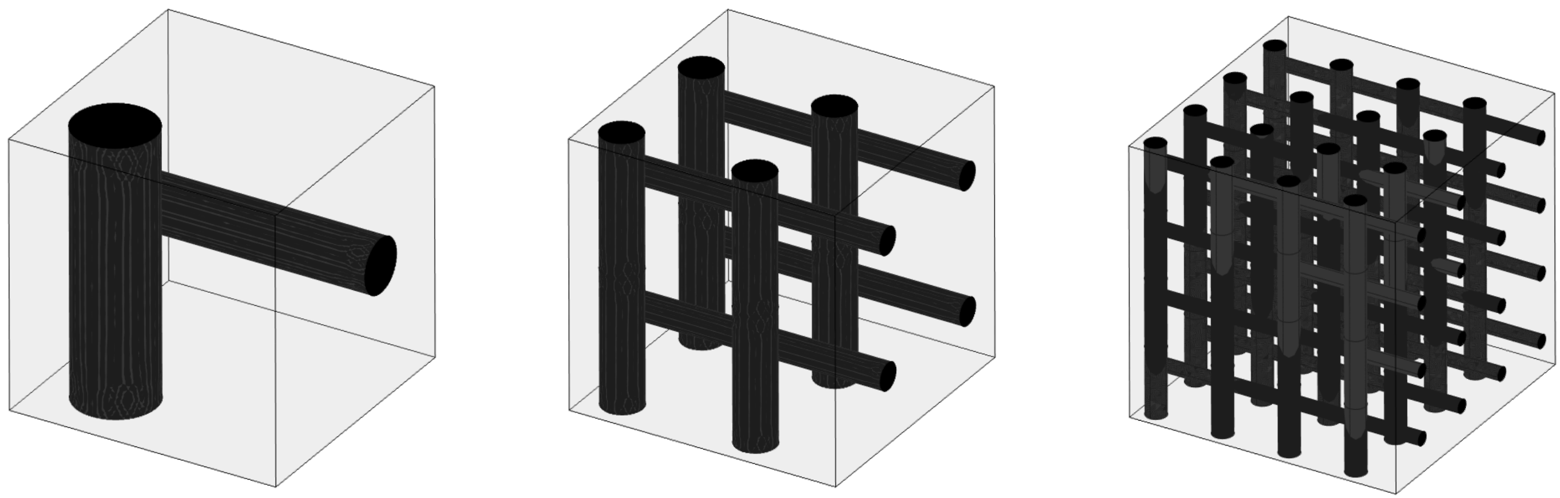
Case study 2: Thermal and mechanical multiscale modelling

Modelling – Theoretical results of periodic homogenization

\+ Size of the unit cell compared the system under study -



\- Accuracy of the method (theoretically guaranteed!) +

Identical computational cost !

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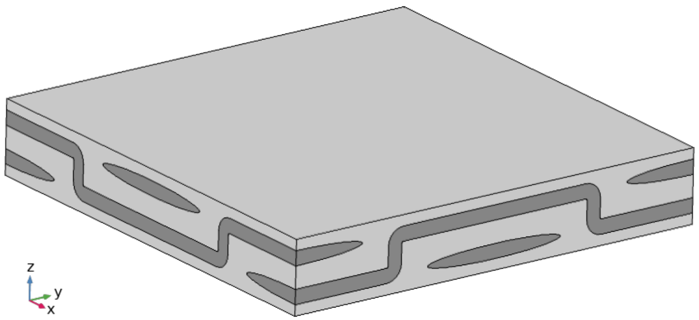
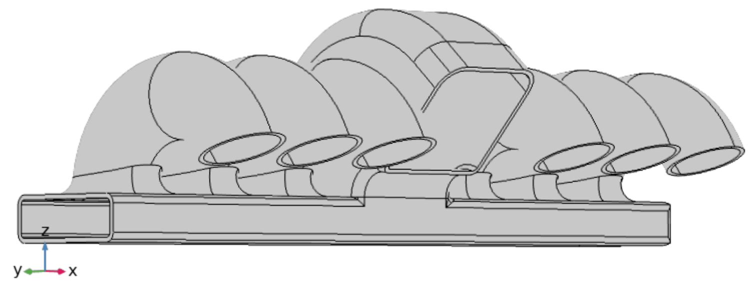
Case study 2: Thermal and mechanical multiscale modelling

Modelling – COMSOL implementation

Component 1: microstructure analysis



Component 2: macrostructure analysis



Non-exhaustive practical issues :

- ❑ Non-conventional system of PDEs
- ❑ Numerical care is needed: meshing, discretization orders…
- ❑ Automation required to implement *long* formulas

→ COMSOL Multiphysics® is flexible enough for that!

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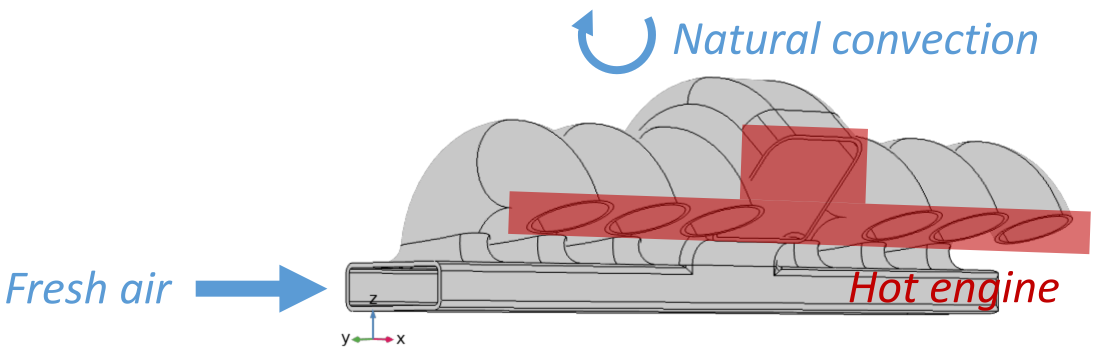
Case study 2: Thermal and mechanical multiscale modelling

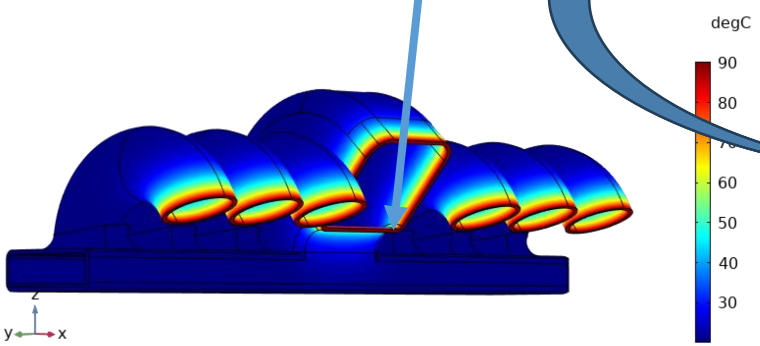
Main Results – Heat transfer study case



Goal: preventing delamination
→ maximal thermal gradient?

Apparent gradient

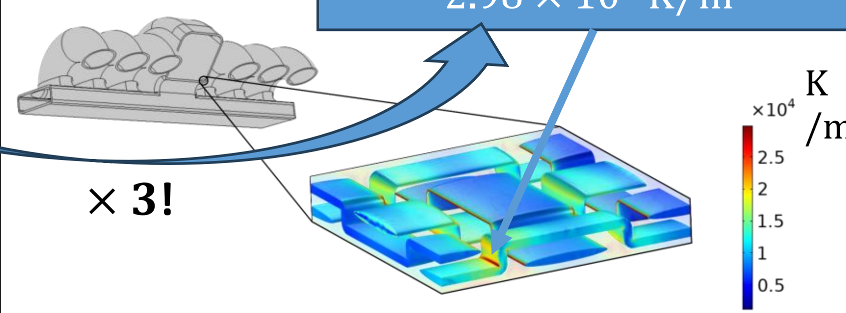
$\max \|\nabla T_{homogenized}\| = 1.02 \times 10^4\ \mathrm{K/m}$



Microscopic gradient

Local $\max \|\nabla T_{relocalized}\| = 2.98 \times 10^4\ \mathrm{K/m}$

$\times$ **3!**



→ **Only looking at homogenized variables may not be sufficient!**

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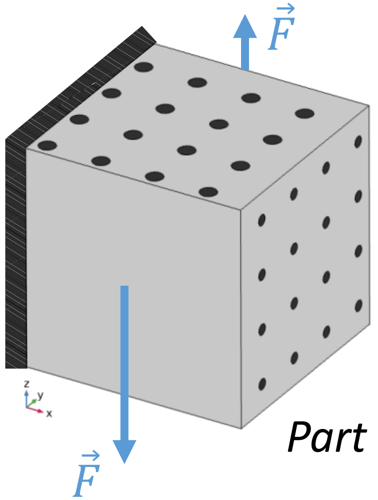
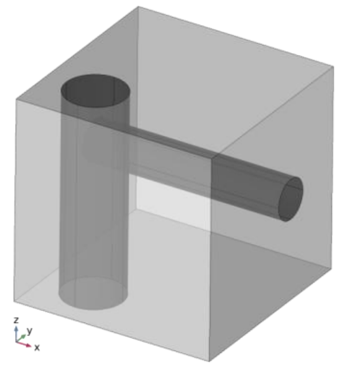
Case study 2: Thermal and mechanical multiscale modelling

Main Results – Solid mechanics study case



Part

= repetitions of



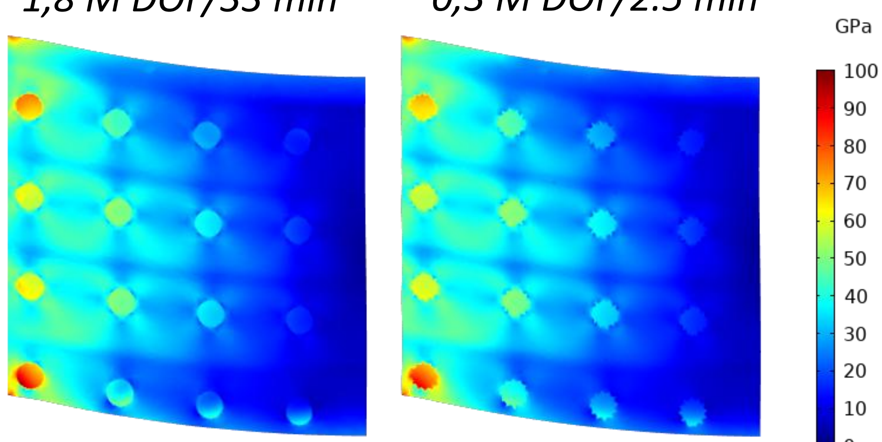
Unit cell

→ Mechanical stress within the part?

Von Mises stress within a cut plane

Direct FEA
1,8 M DOF/33 min

Periodic homogenization
0,3 M DOF/2.5 min



→ **The method is very accurate!**

→ **The method is very efficient!**

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Case study 2: Thermal and mechanical multiscale modelling

Conclusions and Perspectives

→ Understanding and predicting the microscopic behavior of parts made of microarchitectured materials is important to design them

→ Periodic homogenization is one of the techniques making the numerical analysis affordable and accurate

→ **Major contribution:** generic implementation within COMSOL Multiphysics® for:
- ❑ Heat transfers by conduction
- ❑ Solid mechanics

→ What about next steps?
- ❑ Handling more physics
- ❑ Dealing with nonlinearities
- ❑ Applying the method to more industrial cases!

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Q&A session

Thank you!

Q&A?

Our question: Who would like to try on our models? ☺









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