Thermal Error Reduction by Topology Optimization

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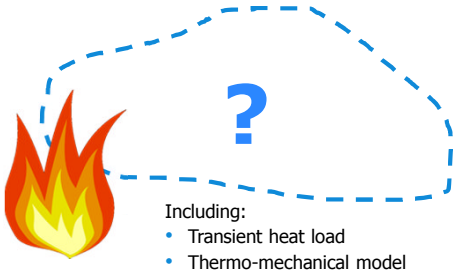
Thermal error

Undesired displacements due to temperature fluctuations

Thermal error reduction

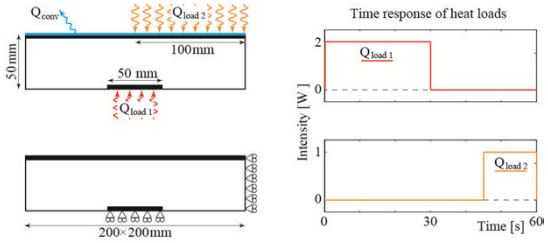
by topology optimization:



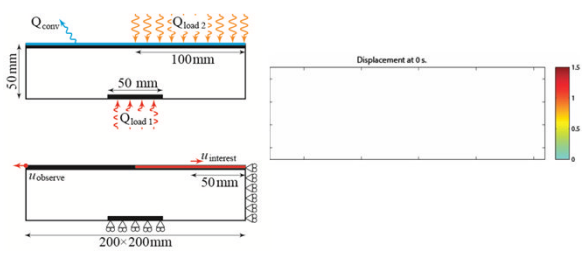
Including:
- Transient heat load
- Thermo-mechanical model

Test case

Aluminium block:

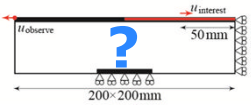


Response initial design



Optimization problem

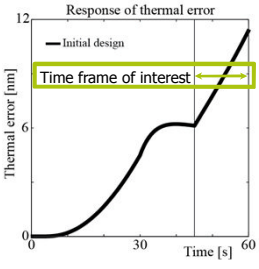
Reduction of the thermal error:



Thermal error

$$\min f = \int_{t_1}^{t_2} w_t \left(\boldsymbol{u}_I(t) - \boldsymbol{u}_R(t) \right)^2 dt$$

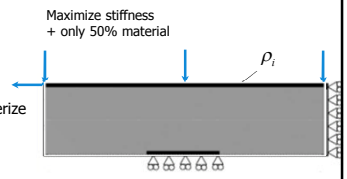
weighted average



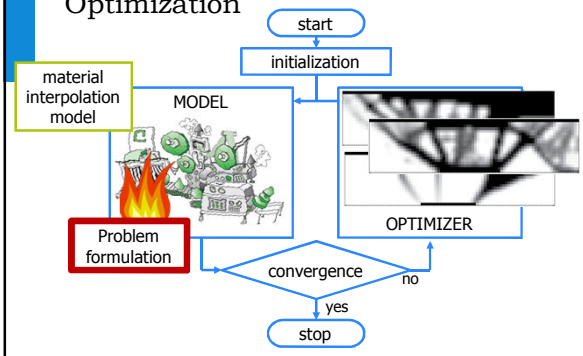
Density-based topology optimization

The basic principle

1. **Define** problem:
   - Desired performance?
   - Restrictions?
2. **Discretize** and parameterize material distribution
3. **Optimize** material distribution for best performance
4. **Evaluate** / fine-tune result (postprocessing, shape optimization)



Optimization



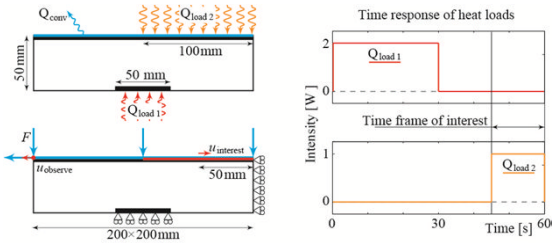
Topology optimization of thermal error

Minimize thermal error
+ only 50% material

➔ No material is a solution to a thermal load !

Optimization problem

Solution: additional mechanical load case



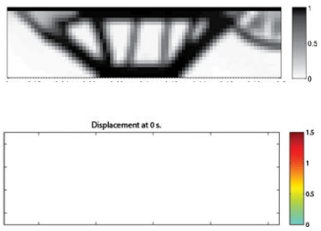
Topology optimization of thermal error

Minimize thermal error
+ only 50% material
+ **minimal stiffness to mechanical load case**

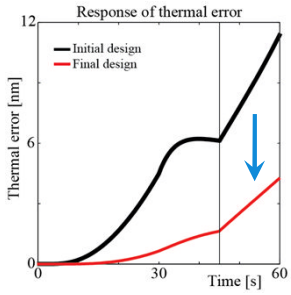
Topology optimization of thermal error

Maximize stiffness to mechanical load case
+ only 50% material
+ **maximal thermal error**

Response final design



Thermal error reduction



Conclusion

- Topology optimization can be used for transient thermal error reduction
- Optimization formulation:
  - need of an additional mechanical stiffness constraint
  - Maximize stiffness of mechanical load case + for maximal thermal error

Thank you for your attention

Acknowledgements:

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