Future Flexible Operation of Power Generation Systems

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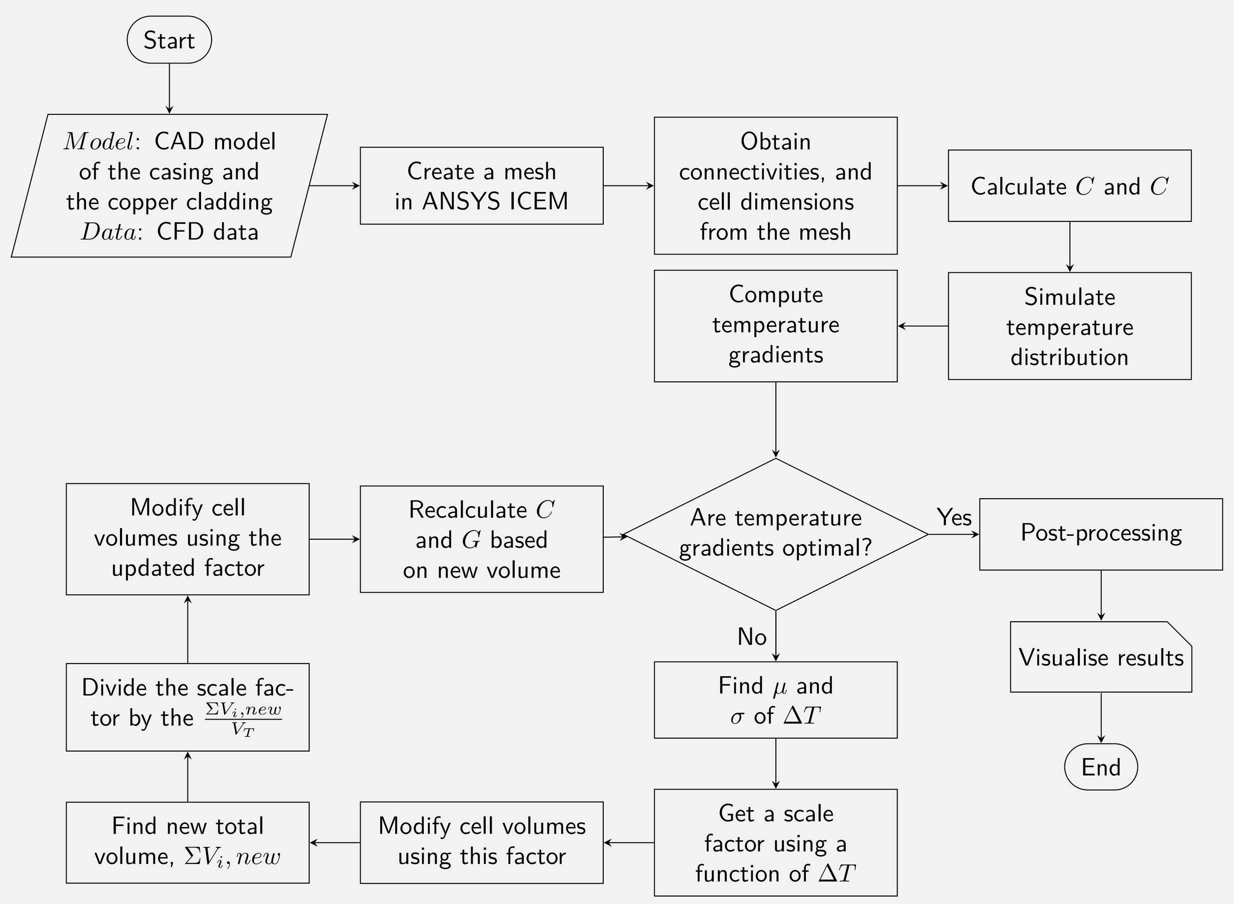
Overview

- Steam turbine casing is subjected to high thermal stresses due to temperature gradients during operation, potentially leading to material fatigue and failure.
- This study investigates the use of high thermal conductivity material cladding as a passive control method to reduce thermal stresses in steam turbine casings.
- Optimization of cladding thickness and placement is conducted using computational fluid dynamics simulations and thermal network models.
- The research aims to enable the flexible operation of steam turbines, facilitating the integration of variable renewable energy sources into the power grid.

Key findings

- Analysed the heat transfer inside steam turbines using CFD simulations to identify areas with high thermal gradients.
- Designed cladding sections using high thermal conductivity materials, strategically placing them in areas experiencing the most thermal stress.
- Optimized cladding thickness using TNMs to improve computational efficiency in the optimization process.
- Advanced optimization techniques are employed to identify the optimal cladding design that minimizes thermal stresses while satisfying constraints related to turbine performance, material usage, and manufacturing costs.

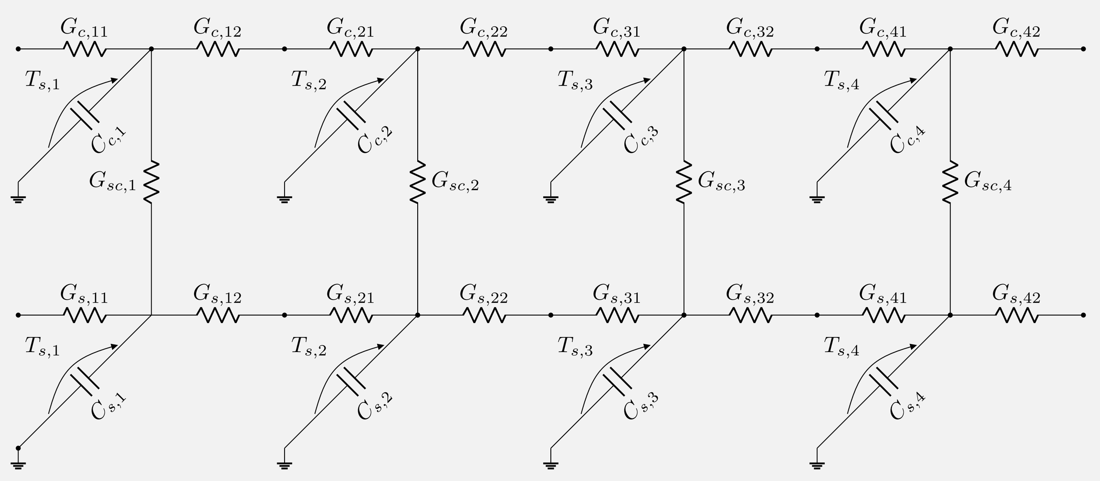
The optimisation process:



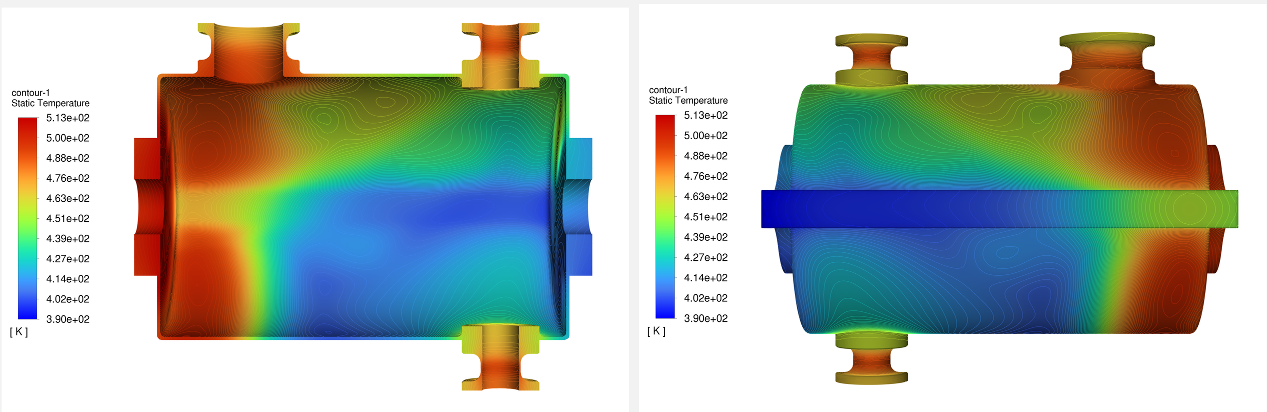
Methodology

- TNMs are used to efficiently optimize cladding thickness, requiring less computational time than FEA simulations.
- The model is constructed based on a mesh with cells representing material properties such as density, specific heat capacity, and thermal conductivity.

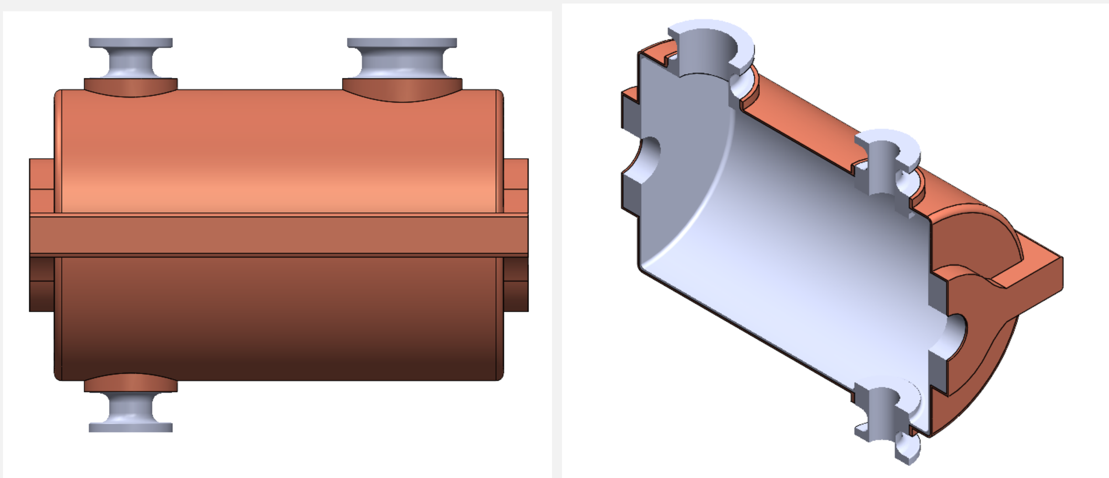
An example of thermal network:



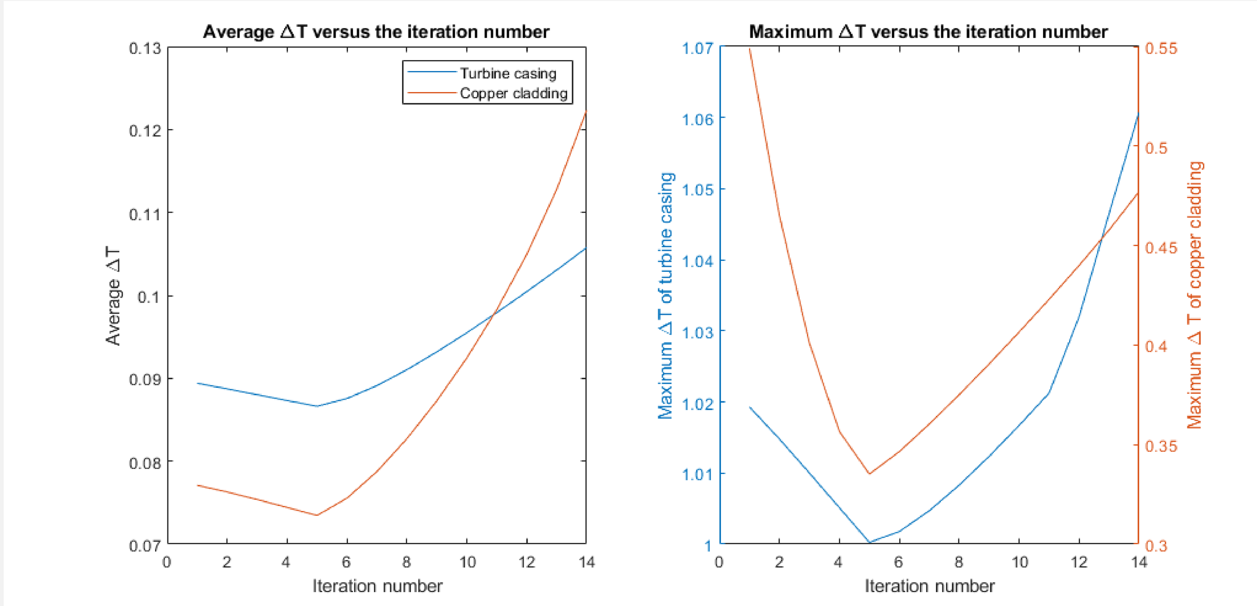
The temperature profile before adding cooper:



The CAD model of copper cladding is designed:



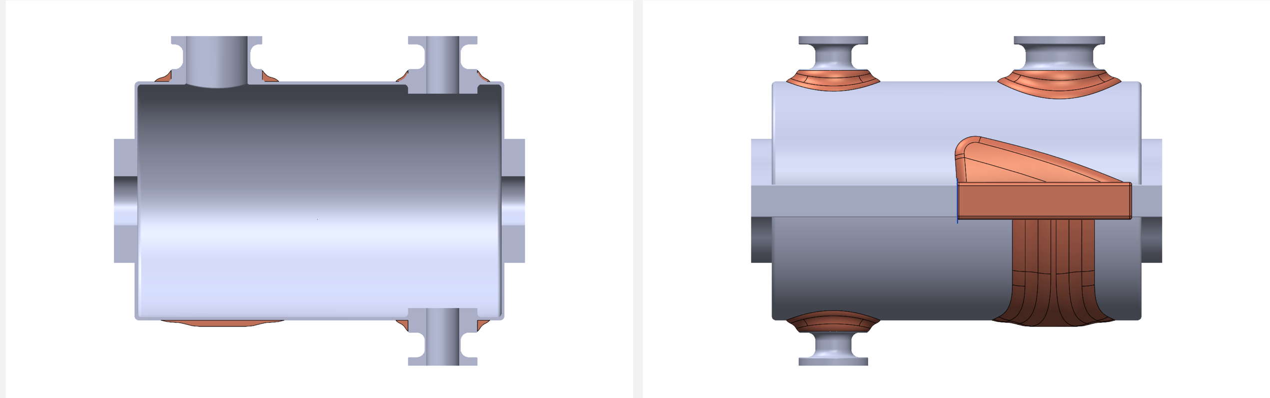
Copper thickness is then optimised:



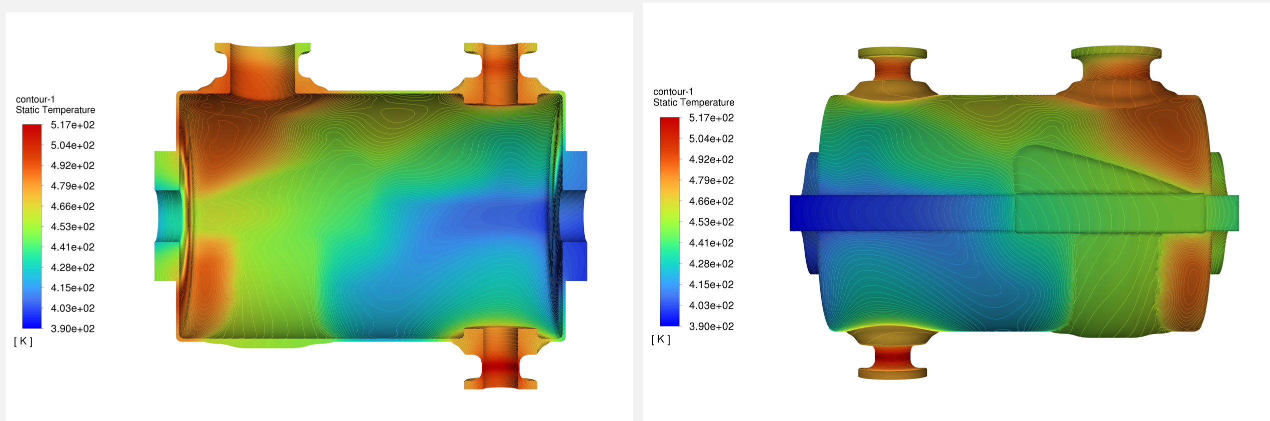
Results

The optimisation provides the following copper distribution:

The optimised copper cladding is built:



This results in the following profile:



Conclusion

- This study demonstrates the potential of high thermal conductivity material cladding as an effective solution for reducing thermal stresses in steam turbine casings.
- Optimized cladding design contributes to the flexible operation of steam turbines by reducing thermal stresses, mitigating material fatigue and failure risks.
- Efficient cladding design and optimization promote the integration of variable renewable energy sources into the power grid, supporting clean energy generation and grid stability.

References

[1] Mariusz Banaszkiewicz. Multilevel approach to lifetime assessment of steam turbines. *International Journal of Fatigue*, 73:39–47, 2015.