Impact of Flux Barrier Shape and Design Strategy in Synchronous Reluctance Machine Optimisation

Paper #36

UCLouvain

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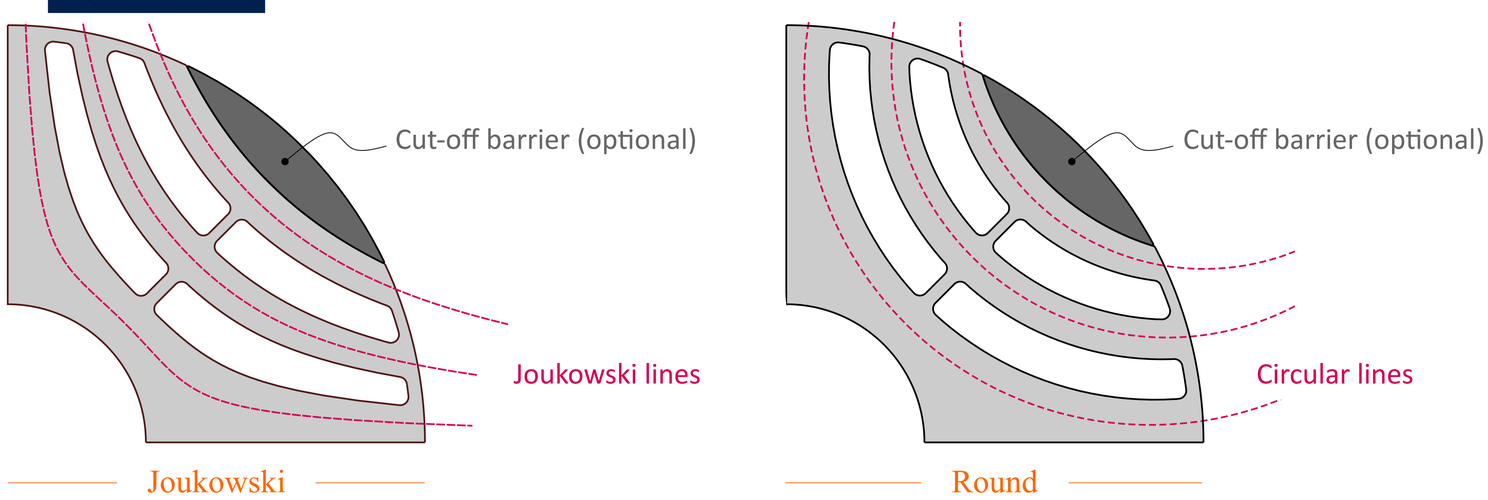
Context

When **maximising the mean torque** under a **torque ripple constraint,** while **ensuring the structural integrity**:

- Does adding a **cut-off barrier** improve the performance?
- Does the **shape of the flux barriers** matter?
- Can the **optimisation time** be **reduced**?

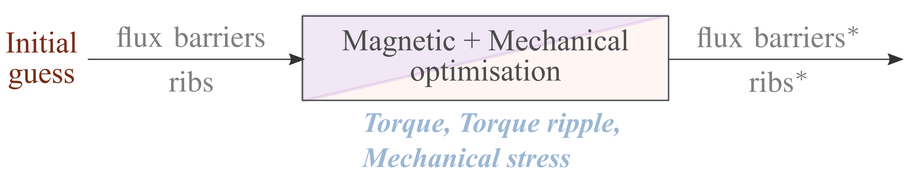
→ **Comparison** of optimised rotor geometries with **Joukowski** and **Round** flux barriers, **with and without cut-off** barrier, using two **different design approaches**.

Geometries



Design approaches

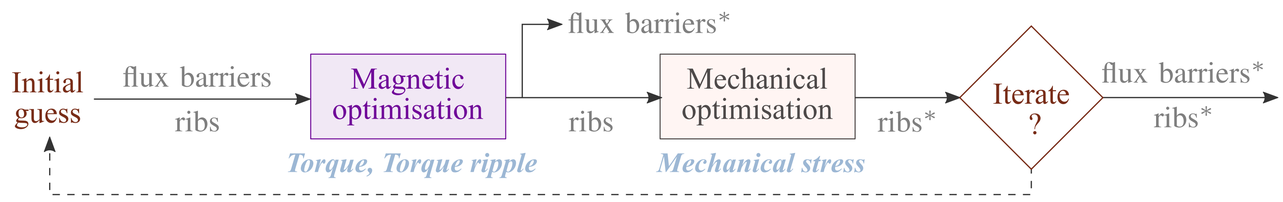
Approach 1



A **single optimisation** is performed on all the parameters together.

Global optimum is expected, at the cost of a **high optimisation time.**

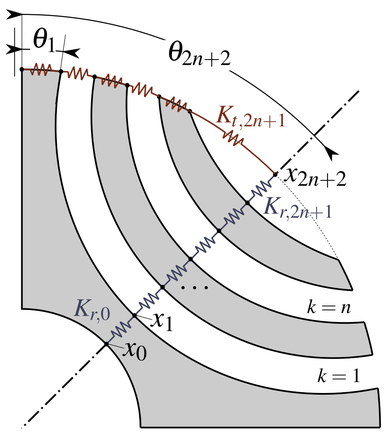
Approach 2



Two **successive optimisations** are performed on subsets of the design space:

- The **flux barriers** are optimised to maximise the **mean torque** under the **torque ripple** constraint,
- The **ribs** are optimised to comply with the **structural integrity** constraint.

Parametrisation



Position and thicknesses of the flux barriers are determined **by solving sitffness networks**:

$$x_i = x_{i-1} + \frac{K_i}{\sum_{k=0}^{2n+1} K_k} L$$

Removing the cut-off consists in imposing:

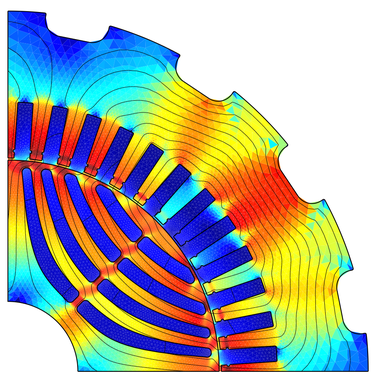
$$K_{t,2n+1} = K_{r,2n+1} = 0$$

Radial and tangential ribs are then added, parametrised **by thicknesses and fillets radii.**

*Joukowski flux barriers only require one stiffness network, instead of two.

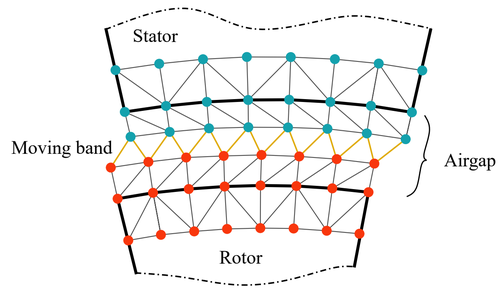
Evaluation

Performed by Finite Element Analysis, using **Gmsh** mesh generator and **GetDP** solver.

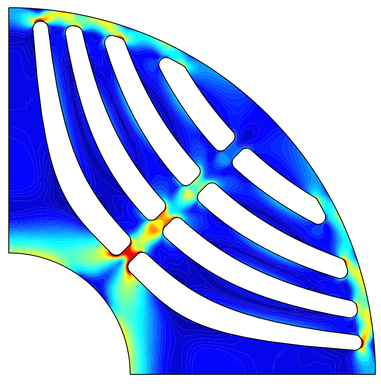


Magnetic model

2D nonlinear magneto-quasi-static



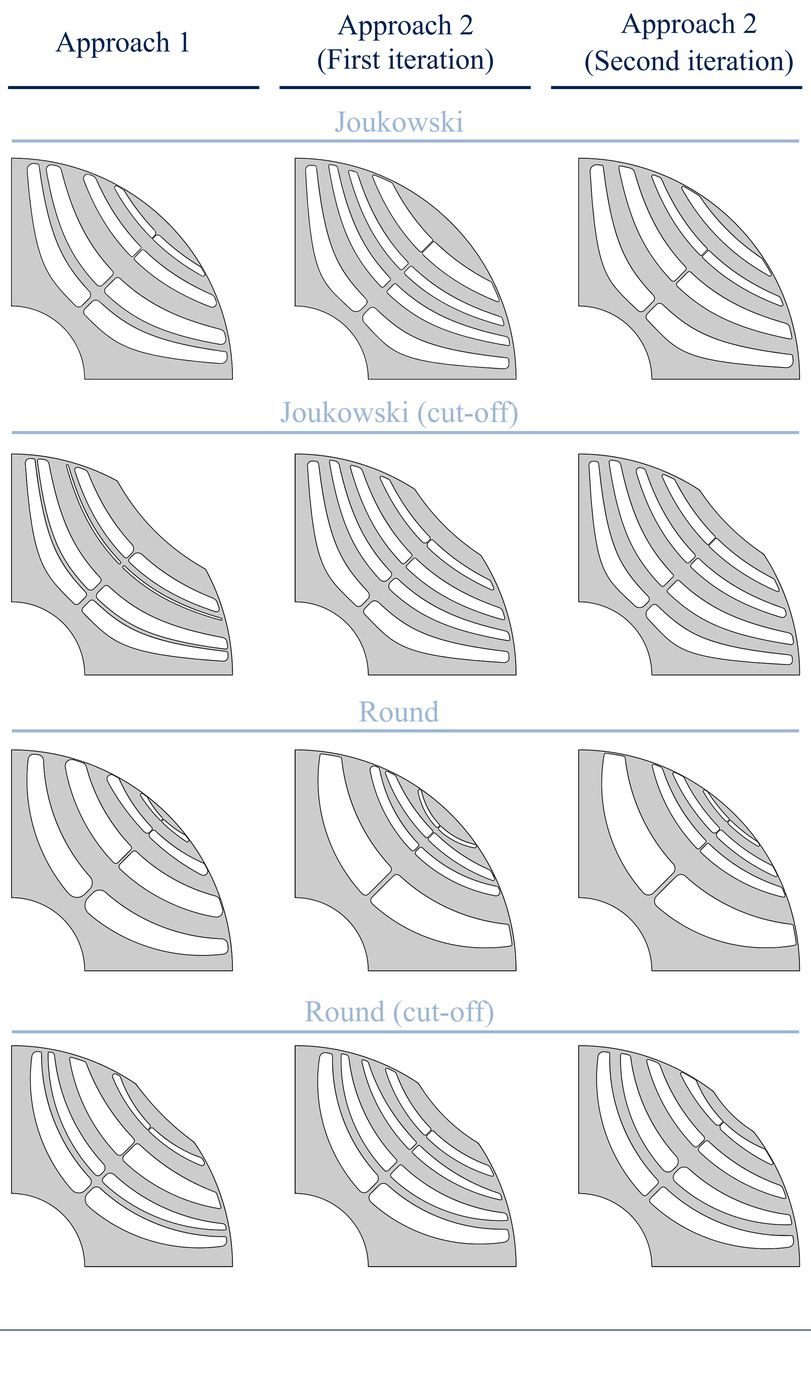
Use of moving band technique to speed up the resolution

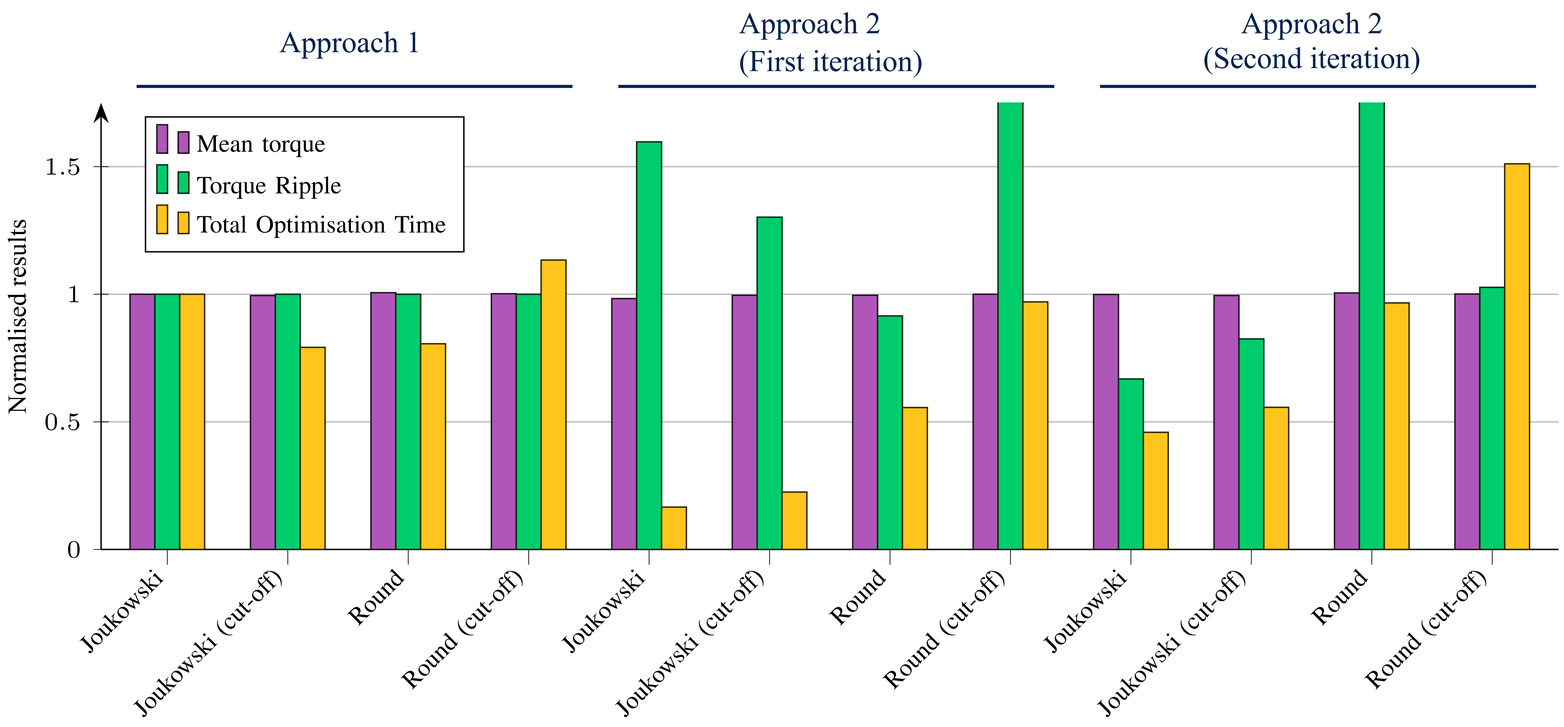


Mechanical model

2D linear elasticity

Results





- Carrying a **single optimisation** lead to geometries outputting the **same mean torque**, with no significant differences in the **total optimisation time**.
- Carrying **successive optimisations drastically reduces the optimisation time** for all the geometries, at the cost of a **higher torque ripple.**
- **Iterating** on this approach **lowers the torque ripple** but **increases the total optimisation time**.
- Nonetheless, the total optimisation time is **still halved for Joukowski flux barriers**. This approach is not as interesting for round flux barriers.

Conclusion

- There are **no real benefits of adding the cut-off** barrier.
- **Round** and **Joukowski** flux barriers output the **same mean torque**.
- **Total optimisation time** can be **halved for Joukowski** flux barriers when carrying successive optimisations.