Metamodeling Approach for Comparison of Linear Flux-Switching and Permanent Magnet Synchronous Machines for Electric Aircraft Propulsion

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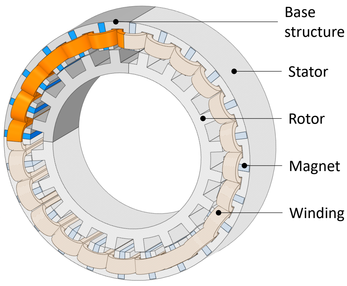
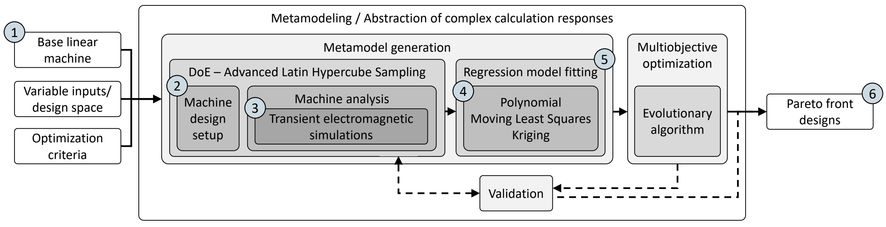
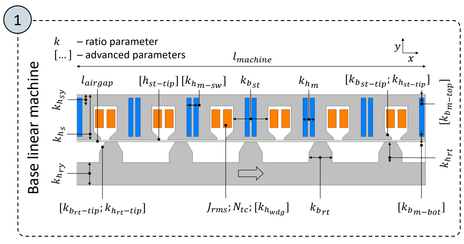
Motivation

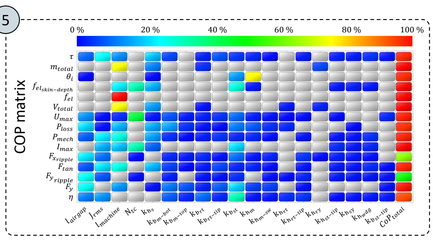
- Linear machine investigation - base structure as scalable unit
- Metamodel technique for optimization process shortening
- Flux-switching machine - alternative to common PMSM due to:
  - High shear stress, power density and efficiency
  - Robust rotor and PM demagnetization resistance
  - Common control strategy

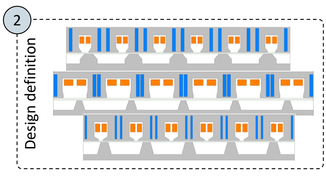


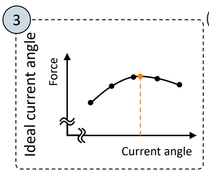
Methodology

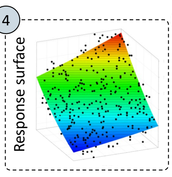


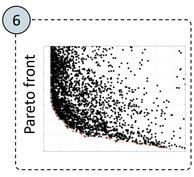










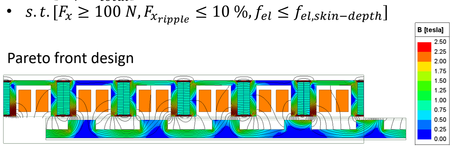


Results from flux-switching machine investigation

Example optimization without advanced parameters

- $\min[-\eta, m_{total}]$
- $s.t.\,[F_x \geq 100\ N, F_{x_{ripple}} \leq 10\ \%, f_{el} \leq f_{el,skin-depth}]$

Pareto front design



Parameter	Value (Metamodel)	Value (FEM)
$l_{model},]_{rms}$	$200\ mm, 7\ A/mm^2$	
m_{total}	4.4 kg	4.3 kg
f_{el}, θ_i	508 Hz, 97°	499 Hz, 94°
$F_x, F_{x_{ripple}}$	100 N, 10 %	97 N, 38 %
η	93.7 %	93.1 %

Conclusion

- **Fast and adaptive multiobjective machine optimization** using FEM-based models and metamodeling approach
  - Optimization using 10k designs:
    FEM-based: >**30 d**, Metamodel-based: **5-30 min**
- Machine topology comparison and **identification of the potentials** of flux-switching machines

Outlook

- **Extended consideration** of electromagnetic, thermal and mechanical effects
- **Pre-sizing and derivation of design recommendations** by transferring translational into rotational motion