Optimisation of the Slot Dimensions of a Large Air-gap Linear Synchronous Motor

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Introduction: The thrust force of a 10-pole/9-slot large air-gap linear synchronous machine is maximized by optimising the slot geometry while keeping the amount of heat produced by the windings constant. The thrust force (*F*) produced by a linear permanent-magnet synchronous motor is a function of three key quantities—the magnetic loading (*B*) the specific electrical loading (*Q*) and the surface area of the air-gap (*A*).

$$F = BQA$$

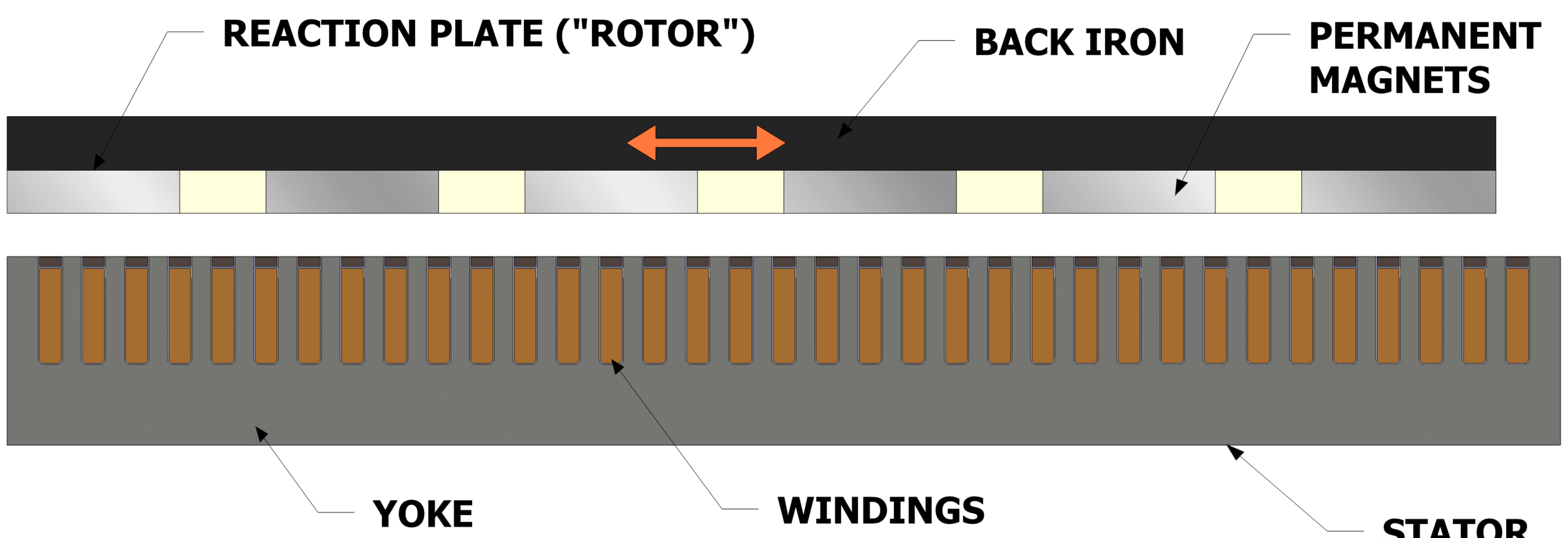

Figure 1. Linear synchronous motor components

Methodology: A 2-dimensional model with 'Magnetic Fields' physics and a 'Stationary' solver is used for the parametric sweep of the slot-width-to-tooth-width ratio. The geometry is parameter driven and six multi-turn coil domains are used to simulate the double-layer, concentrated winding.

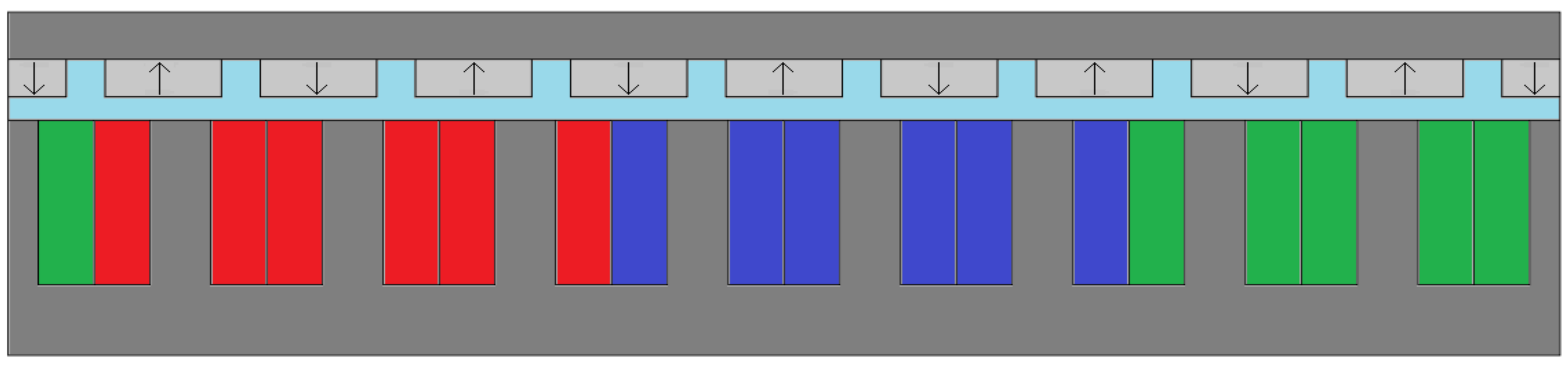

Figure 2. FEA geometry

Results: The slot-width-to-tooth-width ratio is shown to affect the thrust force, magnetic loading, specific electrical loading and peak tooth flux density.

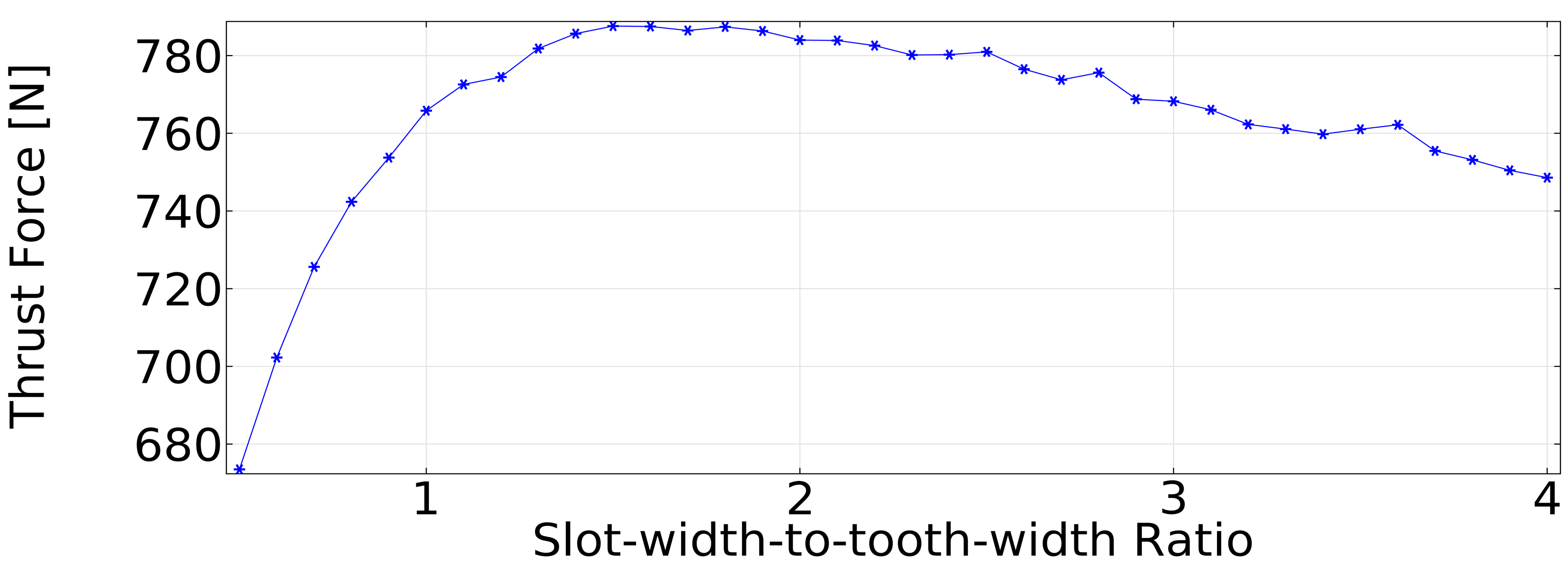

Figure 3. Thrust force

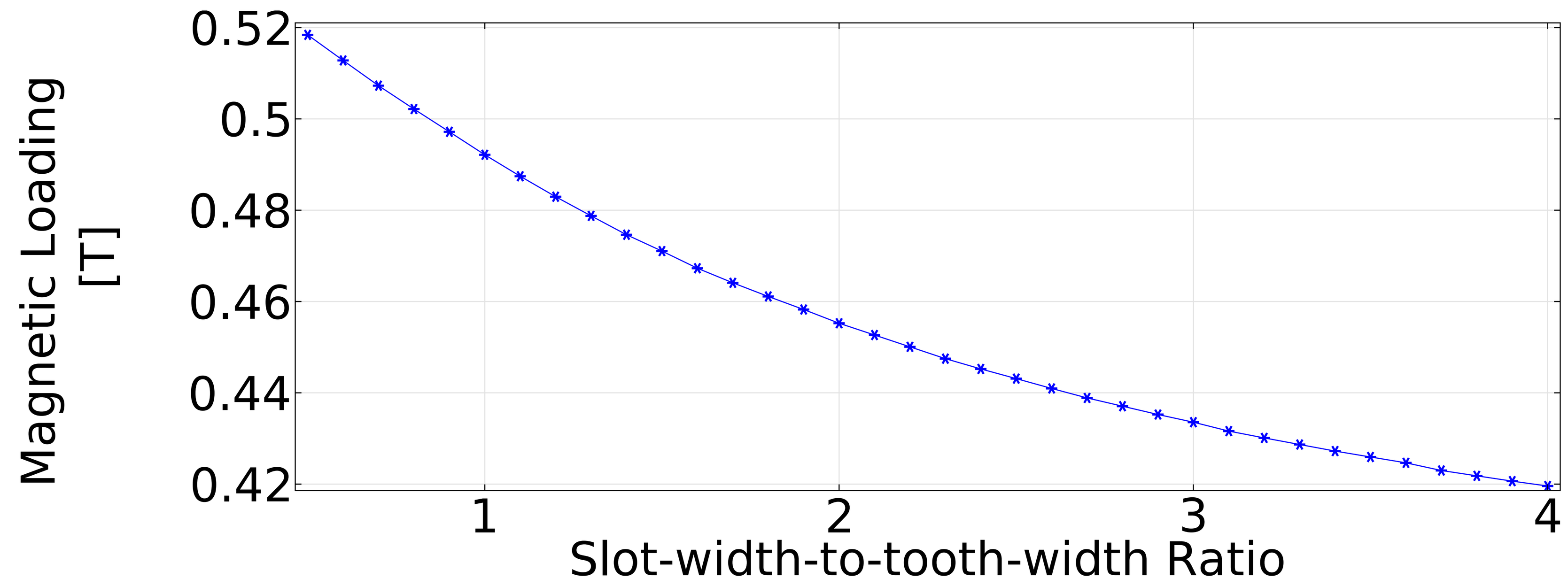

Figure 4. Magnetic Loading

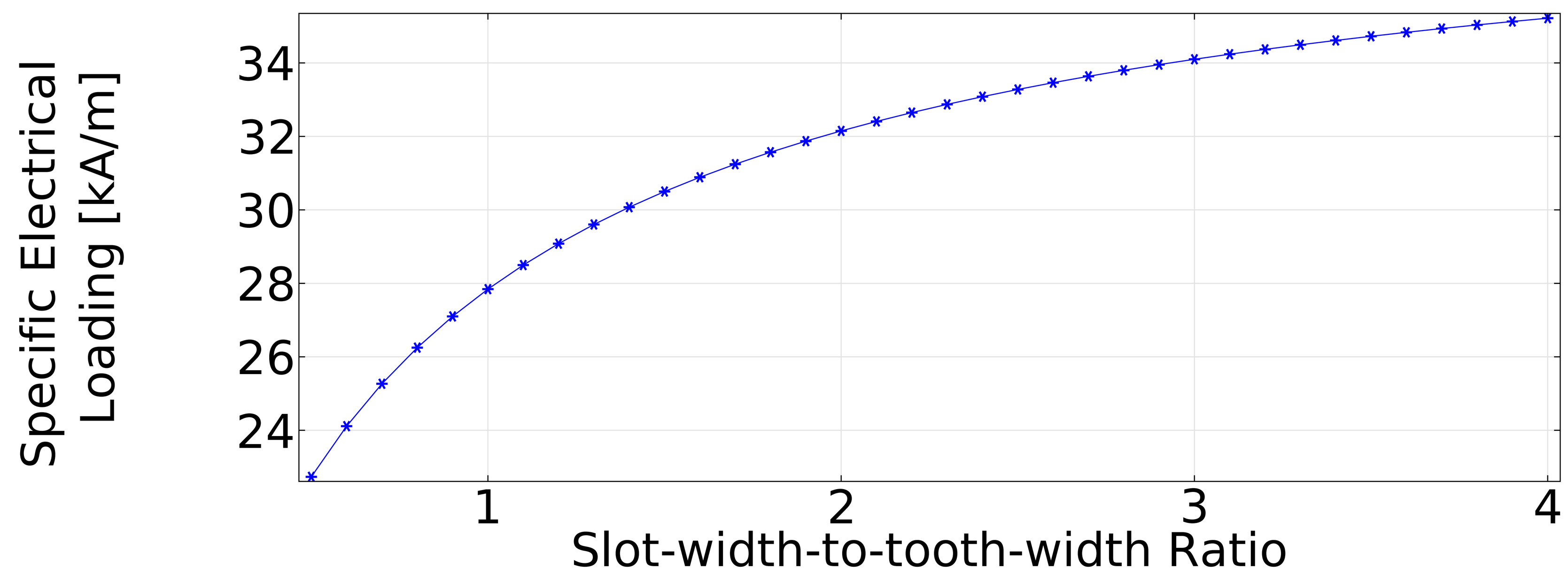

Figure 5. Electrical loading

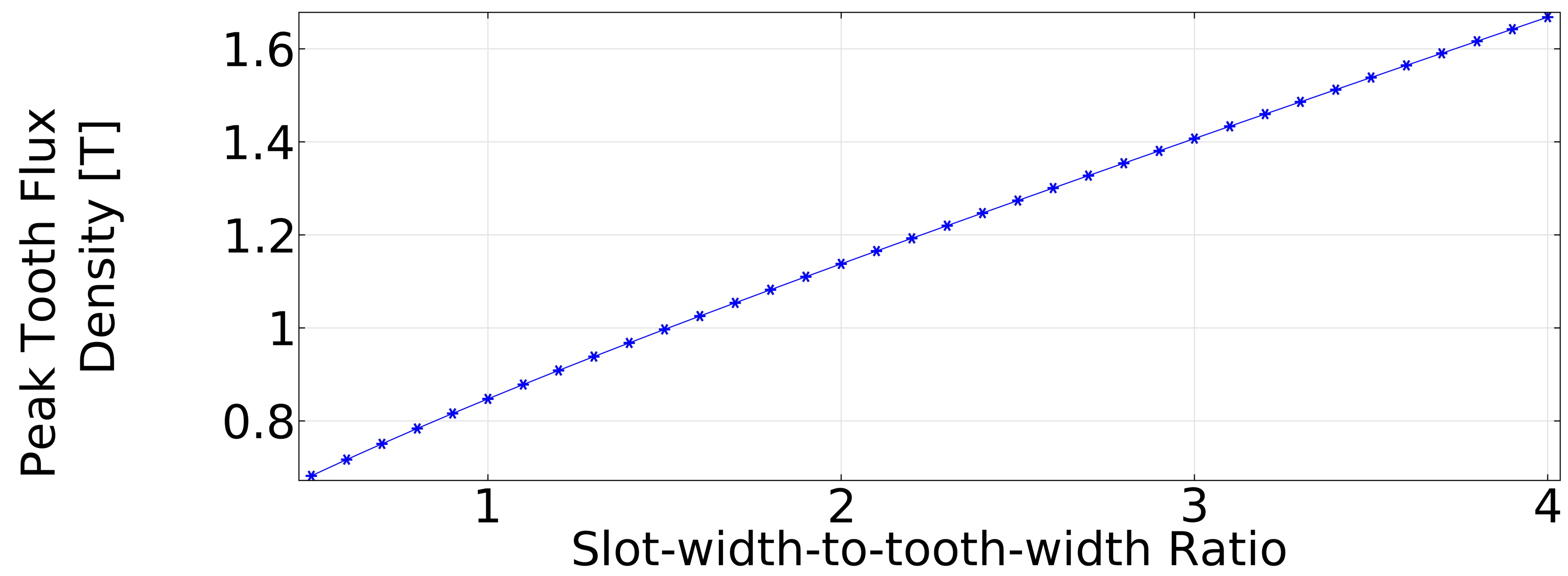

Figure 6.Tooth flux density

The peak force occurs where the best compromise between the magnetic and electrical loading is achieved for a particular air-gap surface area. Larger slots allow more copper to be accommodated and, consequently, the electrical loading is higher for the amount of heat produced. In contrast, the effective air-gap increases and so the magnetic loading reduces.

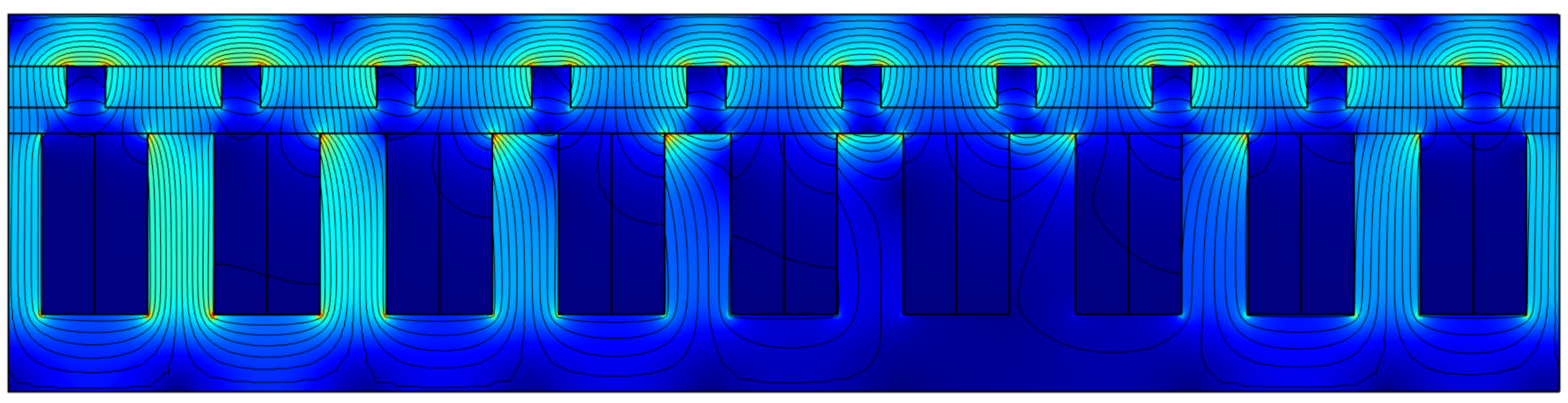

Figure 7. Magnetic flux distribution

Conclusion: The maximum force is achieved when the slot-width-to-tooth-width ratio is between 1.4 and 2. Other factors (such as the magnitude of the cogging force) should be considered to further refine the results and find the optimum slot dimensions.

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