Finite Element Analysis of a Novel Design of a Three Phase Transverse Flux Machine with an External Rotor

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Abstract – **The permanent magnet excited transverse flux machine is well suited in particular for direct drive applications of electric road vehicles. The 3D finite element model with completely independent rotor and stator parts includes only two poles of the machine with appropriate repeating periodic boundary conditions for the unknown degrees of freedom of the 3D magnetic vector potential. Consequently, the various angular rotor positions can be calculated by utilizing the sliding surface approach and a domain decomposition algorithm.**

I. Introduction

As shown in Fig. 1, the novel design with an external rotor consists of a three phase arrangement with a total number of 120 poles. The rotor parts of the three phases are arranged in line and carry the permanent magnets with an alternating magnetization in circumferential direction. On the other hand, the stator parts of the three phases carry the ring windings of the three phases and have an appropriate mechanical angular shift necessary for the three phase operation.

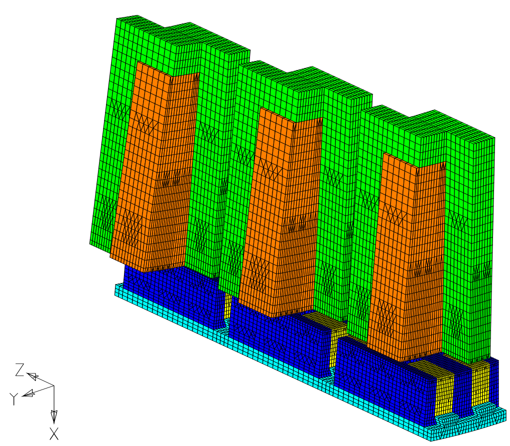

Fig. 1: Three phase transverse flux machine with inline rotor segments and inserted permanent magnets as well as shifted stator segments and ring windings, finite element model of two poles

II. Sample Analysis Results

Fig. 2 shows the load torque of the three phases and the entire machine with the rated stator current of $\hat{I} = 120\,\mathrm{A}$ as well as the load torque of the entire machine with various stator currents of $\hat{I} = 30\,\mathrm{A} \ldots 150\,\mathrm{A}$ according to a maximum electromagnetic torque. The three phases contribute to the electromagnetic torque independently with only little interaction. Due to the appropriate electrical shift of the three phase currents, the resulting shaft torque is comparatively as smooth as for conventional three phase induction machines. Nevertheless, the electromagnetic torque shows higher harmonics with in particular a significant 6^{th} harmonic component.

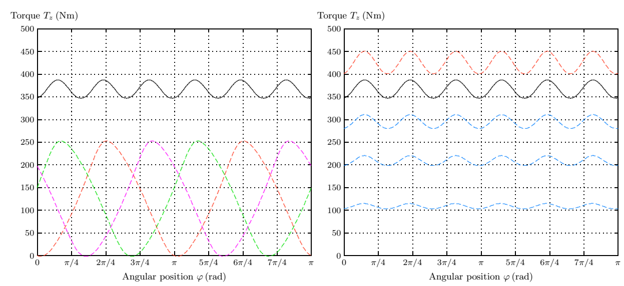

Fig. 2: Load torque of the entire machine and the three phases with rated stator current of $\hat{I} = 120\,\mathrm{A}$ (left), load torque of the entire machine with stator currents $\hat{I} = 30\,\mathrm{A} \ldots 150\,\mathrm{A}$ (right)

Fig. 3 shows both no-load voltages as well as short-circuit currents of the three phases for the rated speed of $n = 400\,\mathrm{rpm}$. Caused by the high level of saturation, the three phase voltages have a significant 3^{rd} harmonic component resulting in a non-vanishing sum of the three phase voltages as additionally drawn. On the other hand due to the low level of saturation, the three short-circuit currents of the Y-connected stator are nearly sinusoidal with respect to time.

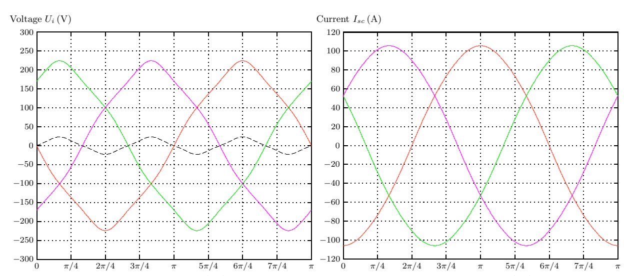

Fig. 3: No-load voltages (left) and short-circuit currents (right) of the three phases, rated speed of $n = 400\,\mathrm{rpm}$

With an intent of basic design studies for an optimization, the full paper will additionally discuss a comparison of using isotropic and anisotropic materials with either the stator or rotor parts.

References

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