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Design and Performance Analysis of a Novel PM Assisted Synchronous Reluctance Machine

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➢1. Introduction

- ❖ This paper proposes a novel permanent magnet assist synchronous reluctance (PMAREL) machine and assembly using grain oriented silicon steel (GOSS), the GOSS is used to replace some part of the stator teeth.
- ❖ The rolling direction of the GOSS is along the radial direction of the machine, thus the advantage of higher permeability and higher kneel point in this material can be used to release the flux saturation problem of the stator teeth.
- ❖ The electromagnetic and mechanical performance are compared in novel and traditional PMAREL machine. It can be seen that the proposed PMAREL machine has higher torque ability and wider constant torque operation region.

➢2. Description for PMAPEL

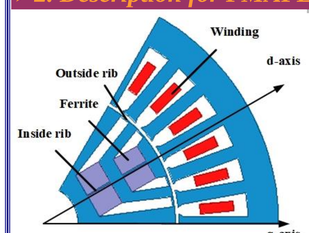


Fig. 1. Topology of traditional PMAREL machine

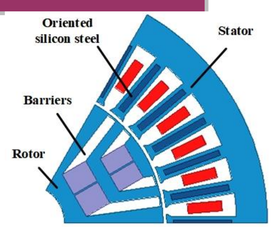


Fig. 2. Topology of novel PMAREL machine

➢3. Main dimension for PMAREL

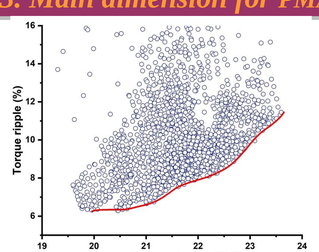


Fig. 3. Optimization results of traditional PMAREL machine

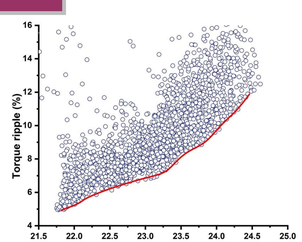


Fig. 4. Optimization results of novel PMAREL machine

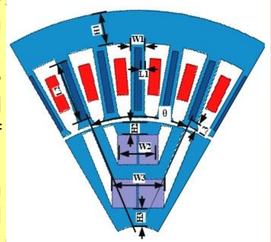
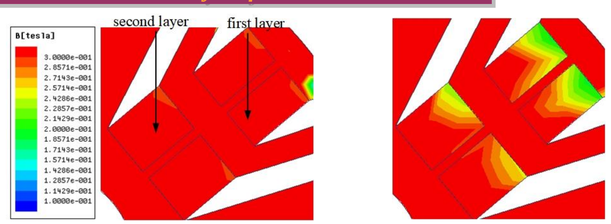


Fig. 5. Main dimensions of PMAREL

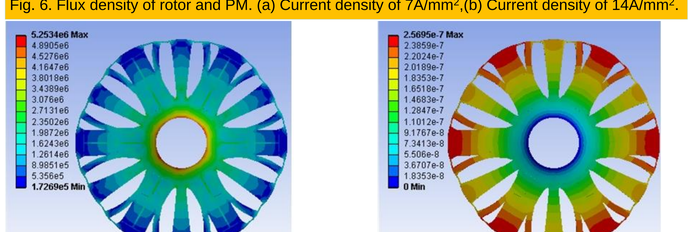
Parameter	value	unit	Parameter	value	unit	Traditional PMAREL		Novel PMAREL	
Stator outer radius	140	mm	Slot fill factor	55	%	H_1	8.5	8	mm
Stator inner radius	80	mm	Rated current density	7	A/mm^2	H_2	3	5	mm
Stack length	63	mm	Max current density	14	A/mm^2	H_3	5	5	mm
Air gap length	1	mm	Rated speed	3000	rpm	W_1	4.1	3.8	mm
Inside rib length	0.8	mm	Maximum speed	6000	rpm	W_2	11.6	10	mm
Outside rib length	0.5	mm	PM remanence	0.4	T	W_3	12.2	13.6	mm
						θ	45.7	46	deg
						L_1	-	1	mm
						L_2	-	18	mm
						L_3	-	1	mm

➢4.Demagnetization and stress Analysis for PMAREL



(a) 7A/mm^2 (b)14A/mm^2

Fig. 6. Flux density of rotor and PM. (a) Current density of 7A/mm^2,(b) Current density of 14A/mm^2.



(a) (b)

Fig. 7. Distributions of (a) Mechanical stress. (b)Mechanical deformation.

➢5. Performance Analysis for PMAREL

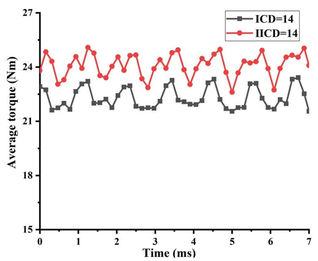


Fig. 8. Torque versus current density

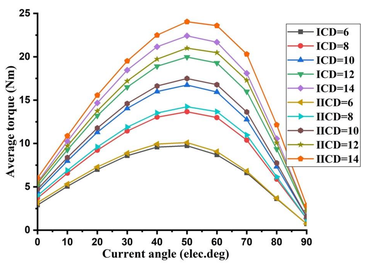


Fig. 9. Torque versus current angle

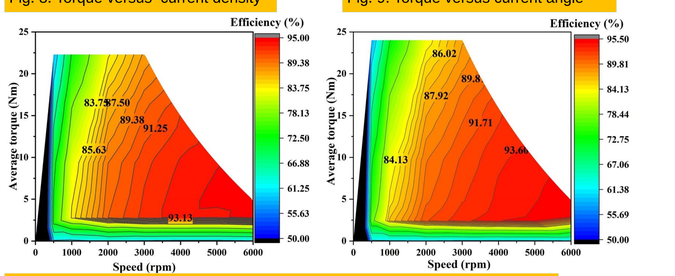


Fig. 10. Efficiency counter maps. (a) traditional and (b) novel PMAREL machine

The main electromagnetic and mechanical performance of traditional and novel PMAREL machine with the above dimensions has been calculated, which includes the demagnetization analysis, mechanical stress analysis when the rotor at the maximum speed, torque, efficiency.
Compared with the traditional PMAREL machine , the proposed machine can have higher torque ability and wider constant torque operation region.

➢5. Conclusion

1) Based on the unique properties of GOSS, a novel PMAREL machine is proposed in this paper. The novel PMAREL and the benchmark traditional PMAREL are analyzed and compared.
2) The saturation of stator teeth can be released by adding the GOSS in the teeth with the rolling direction along the radial direction of the machine.
3) The proposed PMAREL can be a good torque ability and wider constant torque operation region.