A Novel Flux Switching Claw Pole Machine with Soft Magnetic Composite Core

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1. INTRODUCTION

- A novel flux switching claw pole machine (FSCPM) with soft magnetic composite (SMC) cores is proposed in this work. The proposed FSCPM has both advantages of flux switching permanent magnet machine (FSPMM) and claw pole machine (CPM) with SMC cores.
- The mechanical robust ability of FSCPM is quite good due to there is no windings or PMs on rotor core. The core loss of FSCPM at high operation frequency is relatively low for the SMC material has lower core loss properties at high frequency compared with silicon steels. As well as the torque density of this machine is very high due to its good flux concentrating structure.The topology and operation principle of FSCPM are explained.

2. Description for FSCPM

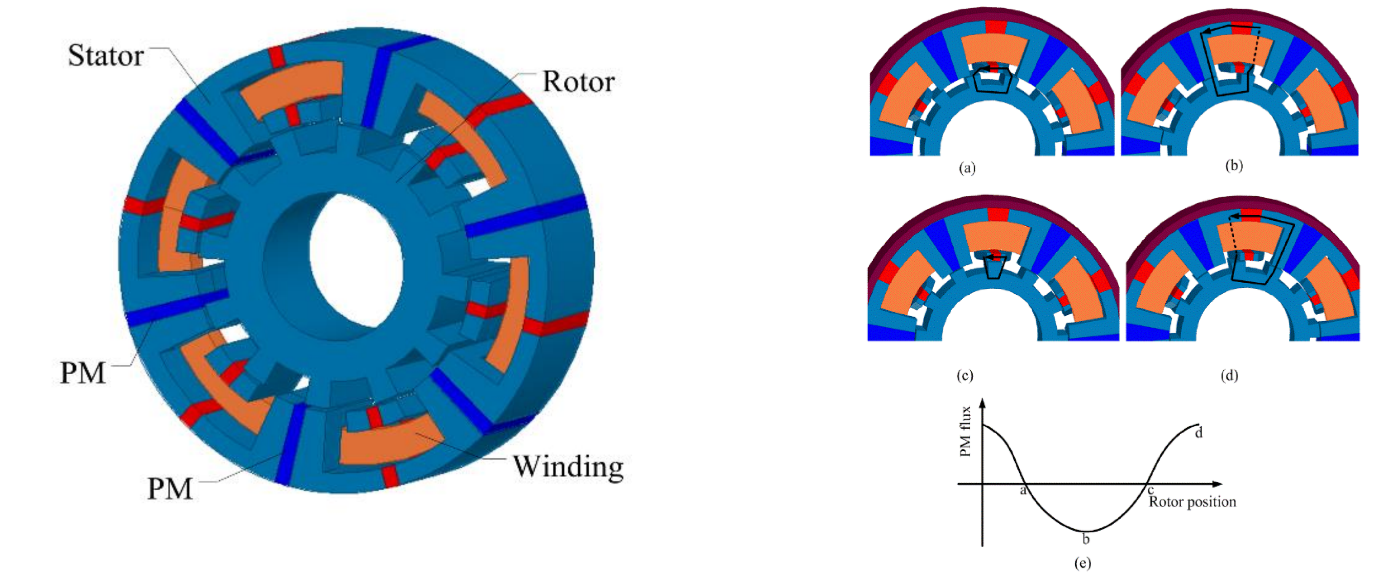
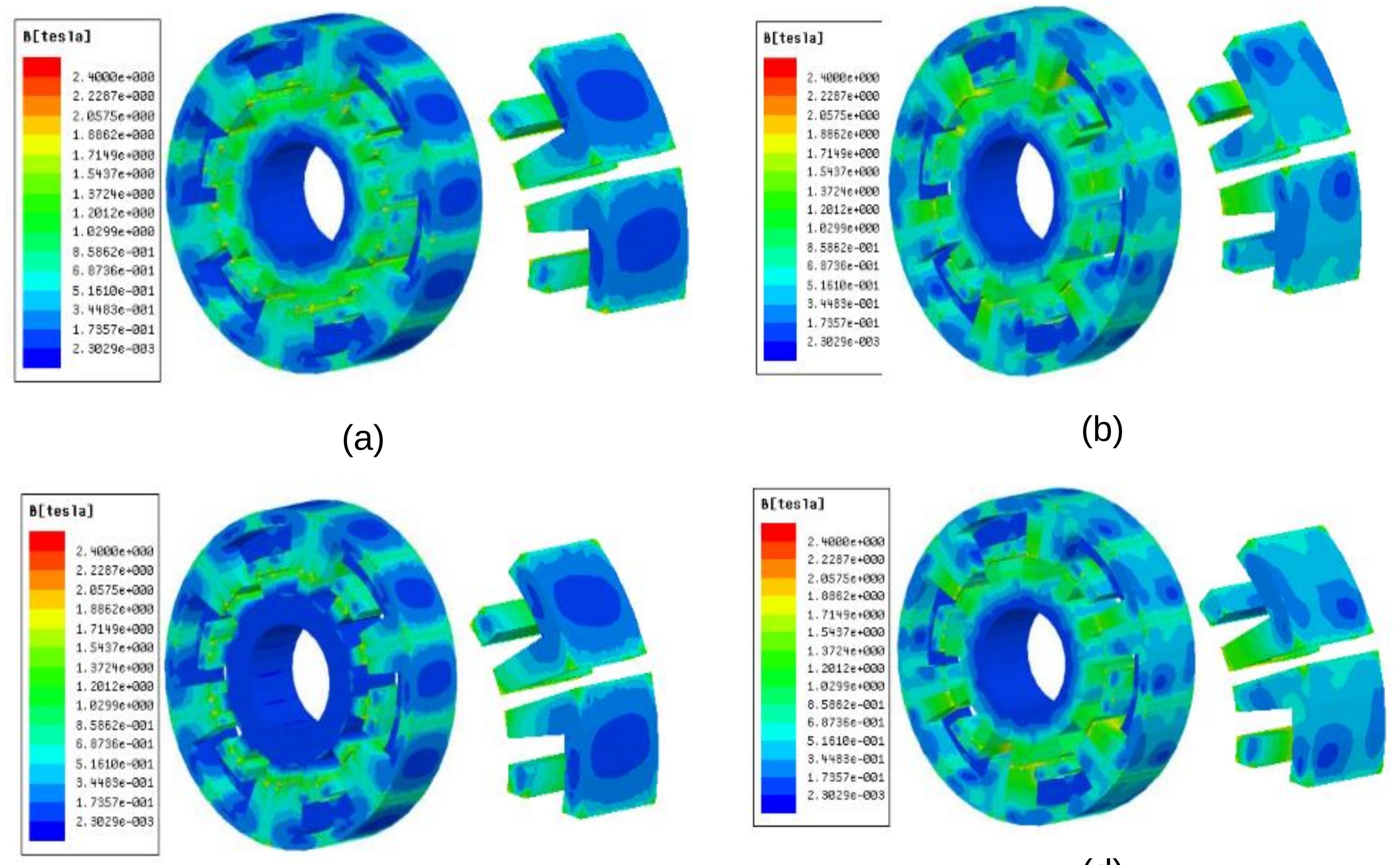


Fig. 1. One-phase structure of a FSCPM and its operating principle



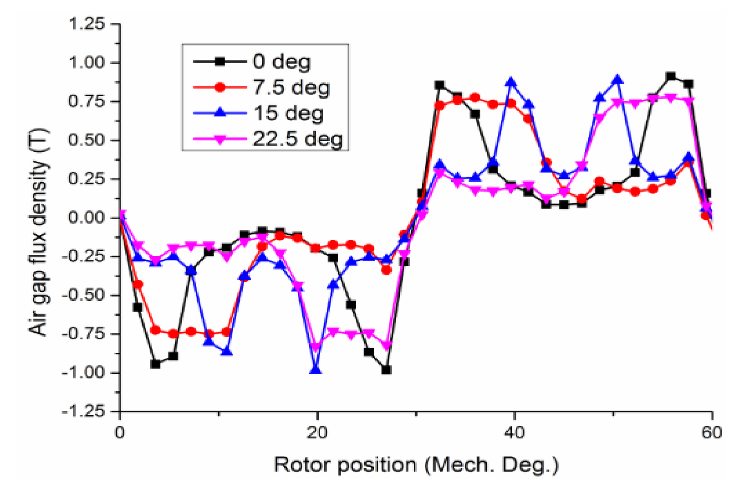


Fig. 2Typical no load flux density of FSCPM,
(a) 0 deg, (b) 7.5 deg, (c) 15 deg and (d) 22.5 deg

3. Main dimension for FSCPM

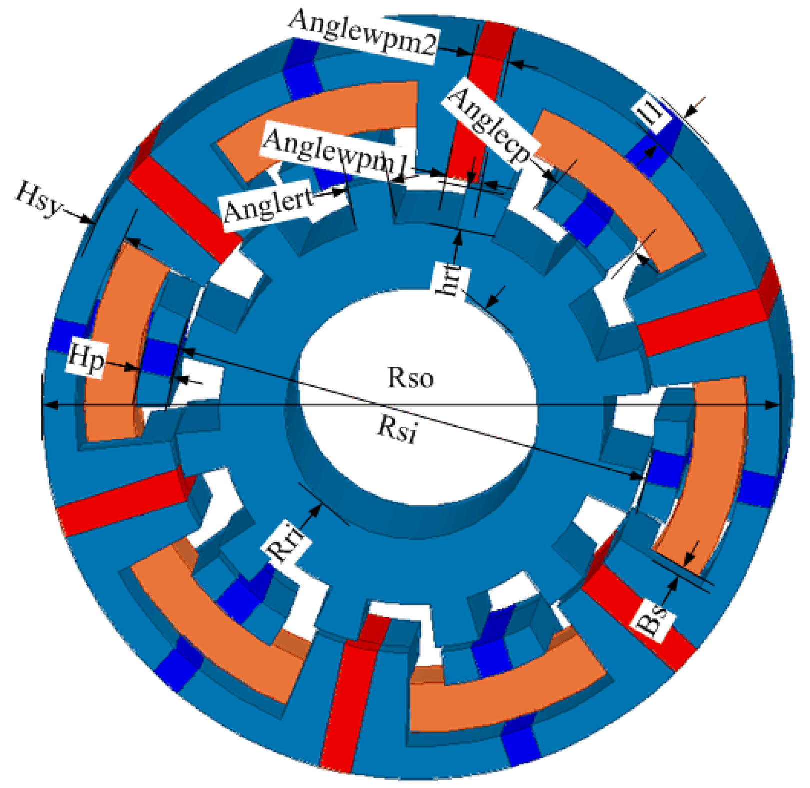


Fig. 3. Main dimensions of FSCPM

Parameter	Symbol	Value	Unit
Stator outer radius	Rso	33.5	mm
Stator inner radius	Rsi	22	mm
Axial length per stack	L1	18.2	mm
Thickness of stator wall	Bs	4	mm
Thickness of stator claw pole	Hp	3	mm
Thickness of stator yoke	Hsy	3	mm
Angle of stator claw pole include PM	Anglecp	22	deg
Angle of PM close to outer radius	Anglewpm1	8	deg
Angle of PM close to inner radius	Anglewpm2	5	deg
Air gap length	g1	0.5	mm
Angle of rotor teeth	Anglert	11	deg
length of rotor teeth	hrt	4	mm
Rotor inner radius	Rri	11.5	mm
Number of winding turns	Ncoil	50	
Stator core material	SMOLAY 700TM		
PM material	B_r=1.15 T, u_r= 1.05		

4. Parameter and Performance Analysis for FSCPM

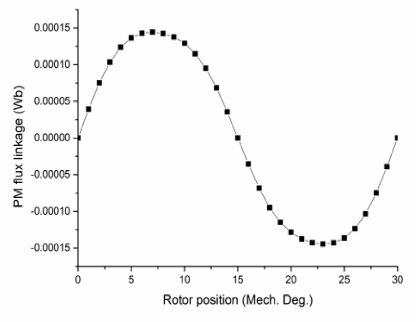


Fig. 4. PM flux linkage

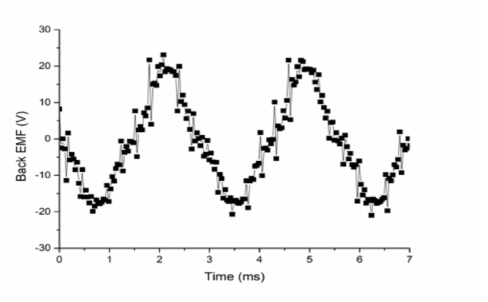


Fig. 5. Back EMF

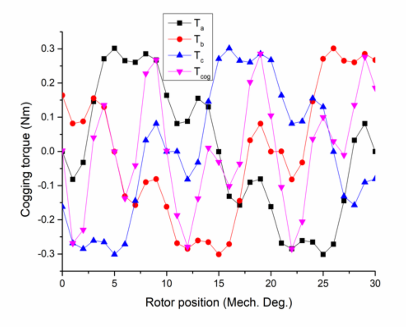


Fig. 6. Cogging torque

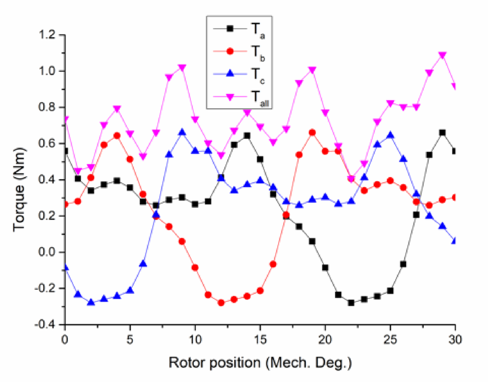


Fig. 7. EM Torque

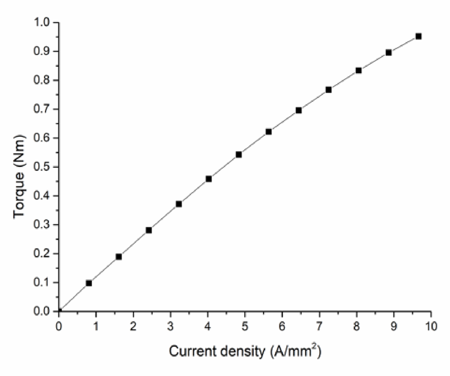


Fig. 8. EM Torque vs current

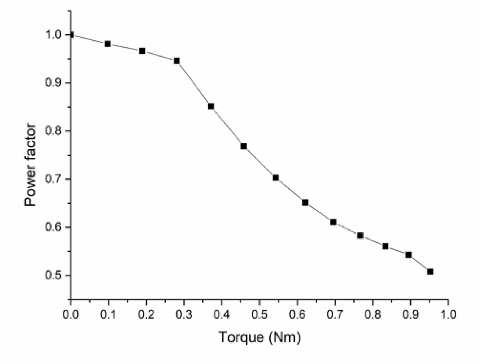


Fig. 9. Power factor

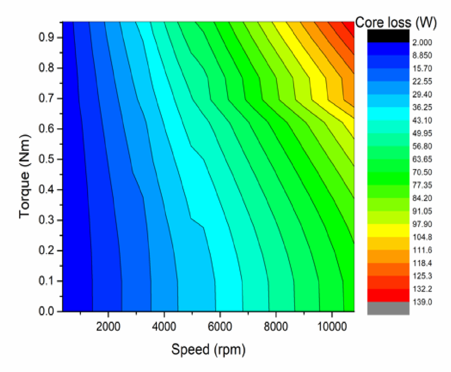


Fig. 10. Core loss

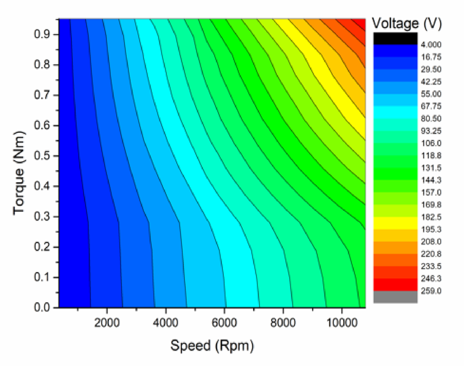


Fig. 11. Voltage

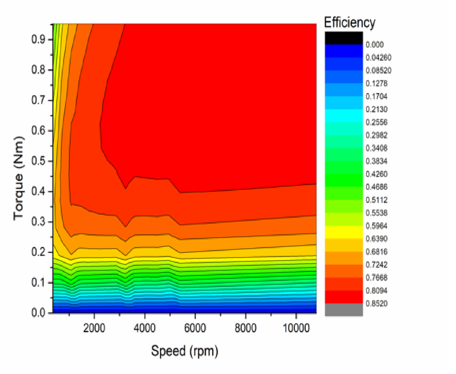


Fig. 12. Efficiency

The main electromagnetic parameter of FSCPM with the above dimensions has been calculated, which including the PM flux linkage, back EMF, cogging torque, EM torque and power factor.
Based on the above analysis results, the main performance of the FSCPM has been presented. Compared with the benchmark machine CPM, the proposed machine can have higher torque ability and efficiency. Moreover with no magnets and windings on the rotor core, the proposed FSCPM can be used for some special applications.

5. CONCLUSIONS

1) A novel FSCPM with SMC cores was proposed to integrate the merits of both FSPMM and CPM with SMC cores. It can be seen that the proposed FSCPM has the benefits of high torque ability, high power factor, high efficiency and good mechanical robustness.
2) The proposed FSCPM can be a good candidate for the high performance drive application.

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[2] C. Liu, G. Lei, T. Wang, Y. Guo, Y. Wang, and J. Zhu, “Comparative study of small electrical machines with soft magnetic composite cores,” *IEEE Trans. Ind. Electron*., vol. 64, no. 2, pp. 1049–1060, Feb. 2017.
[3] B. Ma, G. Lei, J. Zhu, Y. Guo and C. Liu, "Application-oriented robust design optimization method for batch production of permanent-magnet motors," *IEEE Trans. Ind. Electron*., vol. 65, no. 2, pp. 1728-1739, Feb. 2018.