# A Novel Flux Reversal Claw Pole Machine with Soft Magnetic Composite Cores

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MT 26 International Conference on Magnet Technology
Vancouver, Canada | 2019

**Paper ID: Mon-Af-Po1.22-07[105]**

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## 1. Introduction

- This paper proposes a novel flux reversal claw pole machine (FRCPM) with soft magnetic composite (SMC) cores, the proposed FRCPM has both the advantages of flux reversal permanent magnet machine (FRPMM) and claw pole machine (CPM).
- the FRCPM can be operated under relatively high rotate speed since there is no winding or PMs on rotor, and the weak PMs, ring winding and SMC stator cores are encapsulated together as a whole part.
- Moreover the adopted 3D magnetic flux path can bring FRCPM with relatively high torque ability, and the adopted SMC cores can bring FRCPM with low core loss at the high speed operation.

## 2. Description for FRCPM

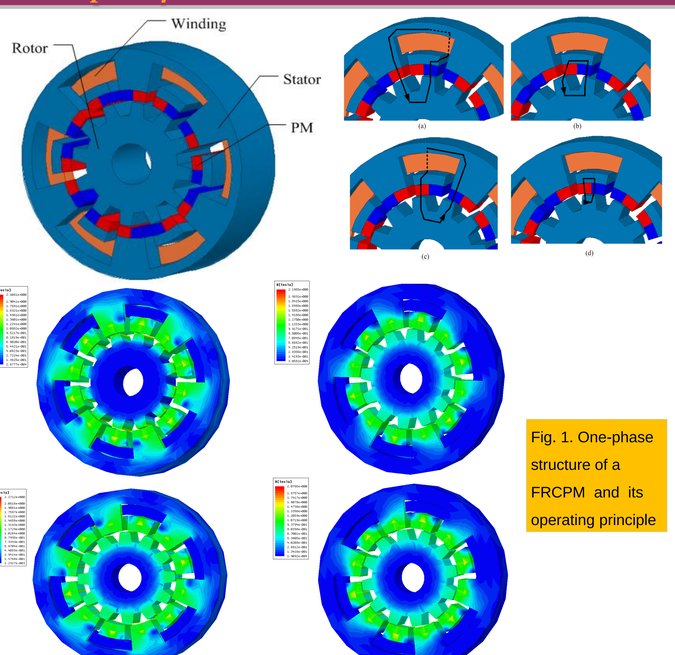


Fig. 1. One-phase structure of a FRCPM and its operating principle

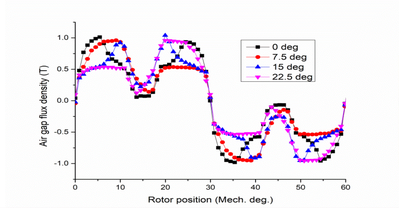


Fig. 2Typical no load flux density of FRCPM, (a) 0 deg, b) 7.5 deg, (c) 15 deg and (d) 22.5 deg

## 3. Main dimension for FRCPM

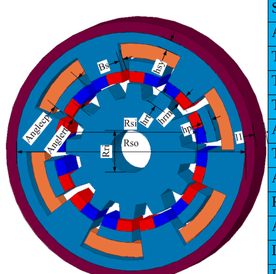


Fig. 3. Main dimensions of FRCPM

| Parameter | Symbol | value | unit |
|---|---|---|---|
| Stator outer radius | Rso | 33.5 | mm |
| Stator inner radius | Rsi | 22.5 | 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 | Anglecp | 24 | deg |
| Thickness of PM | hrm | 3 | mm |
| Air gap length | g1 | 0.5 | mm |
| Rotor outer radius | Rro | 19 | mm |
| Angle of rotor teeth | Anglert | 12 | deg |
| Length of rotor teeth | hrt | 4 | mm |
| Rotor inner radius | Rri | 6 | mm |
| Number of winding turns | Ncoil | 100 | |
| Stator core material | SMOLAY 500TM | | |
| PM material | Br=1.15 T, ur=1.05 | | |

## 4. Parameter and Performance Analysis for FRCPM

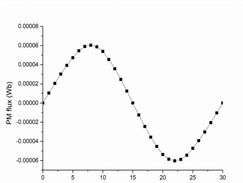


Fig. 4. PM flux linkage

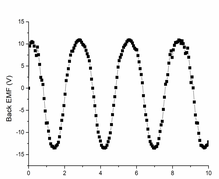


Fig. 5. Back EMF

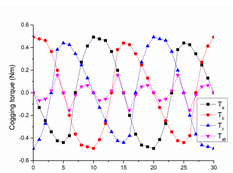


Fig. 6. Cogging torque

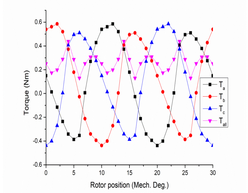


Fig. 7. EM Torque

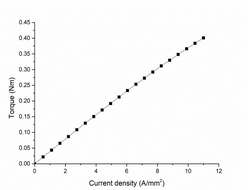


Fig. 8. EM Torque vs current

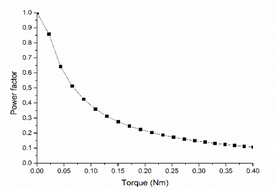


Fig. 9. Power factor

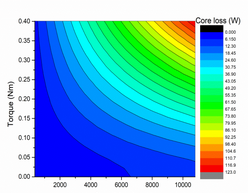


Fig. 10. Core loss

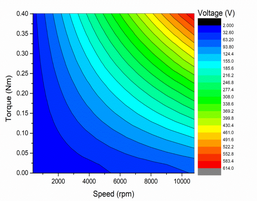


Fig. 11. Voltage

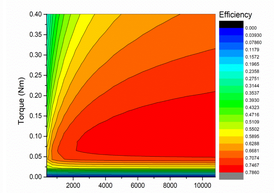


Fig. 12. Efficiency

The main electromagnetic parameter of FRCPM 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 FRCPM 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 FRCPM can be used for some special applications.

## 5. Conclusion

1) A novel FRCPM is proposed in this paper, it has combined the merits of CPM and FRPMM, it has the 3D magnetic flux and global ring windings, thus its torque coefficient is quite high, it has no winding or magnets on rotor cores, thus it can be operated for the high speed operation.
2) The proposed FRCPM can be a good candidate for the high performance drive application.

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