



A Novel Magnetic Gear with Unequal Halbach Array and Non-uniform Air Gap

Libing Jing¹, Junlin Chen¹, Qian Wang², Ronghai Qu²

1. China Three Gorges University, Yichang, China

2. Huazhong University of Science and Technology, Wuhan, China



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

ID: 623

Tue-Af-Po2.25-10

1. Introduction

In order to improve the torque density and transmission stability of magnetic gears, more and more scholars have paid attentions to MG. a novel CMG with unequal Halbach arrays of inner rotor and non-uniform air gap is proposed in this paper. According to the principle of magnetic field modulation and “one-sided flux” structures, the unequal Halbach arrays could augment the magnetic field in the inner air gap. Moreover, the permanent magnets (PMs) of eccentric structure could obtain non-uniform air gap, which is helpful to enhance the flux-modulation effect. The proposed CMG topology with 4 inner and 17 outer pole pairs is established. The topology performance is assessed and verified by finite element analysis (FEA).

2. Basic Theory and Topology of Magnetic Gear

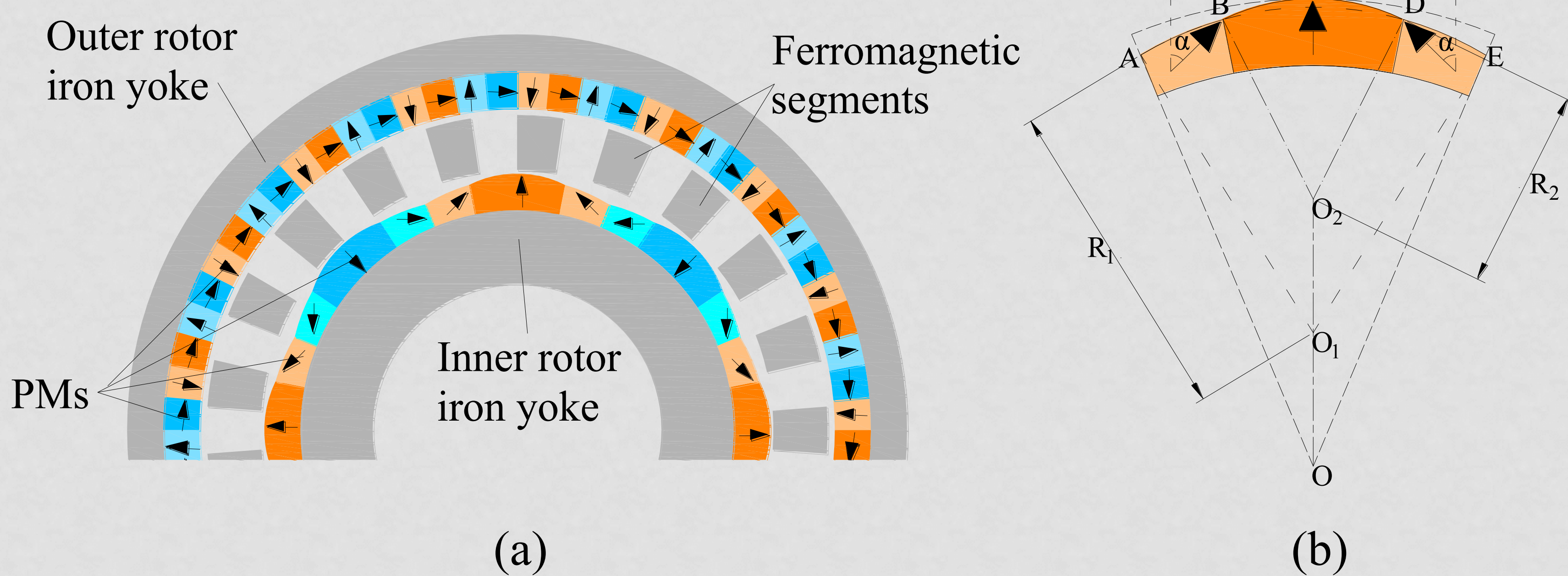


Fig. 1. MG topology: (a) Proposed model, (b) Eccentric structure of PMs.

The magnetization direction in each PM segment is given by:

$$\vec{M} = M_r \vec{r} + M_\theta \vec{\theta}$$

where M_r and M_θ are

$$M_r = \sum_{n=1,3,5}^{\infty} M_{rn}(n) \cos[np(\theta - \theta_0)] \quad M_\theta = \sum_{n=1,3,5}^{\infty} M_{\theta n}(n) \sin[np(\theta - \theta_0)]$$

where M_{rn} and $M_{\theta n}$ are

$$M_{rn}(n) = \frac{4B_r}{\mu_0 \pi n} \sin\left(\frac{n\pi}{2m}\right) \cdot \left\{ 1 + \sum_{k=2}^m \cos\left[\frac{(k-1)\pi}{m}\right] \cos\left[\frac{(k-1)n\pi}{m}\right] \right\}$$

$$M_{\theta n}(n) = \frac{4B_r}{\mu_0 \pi n} \sin\left(\frac{n\pi}{2m}\right) \cdot \left\{ \sum_{k=2}^m \sin\left[\frac{(k-1)\pi}{m}\right] \sin\left[\frac{(k-1)n\pi}{m}\right] \right\}$$

3. Application Example

TABLE I PARAMETERS OF PROPOSED MG

QUANTITY	Value
Radius of the inner rotor yoke	40mm
Outer radius of inner rotor yoke	60mm
The radius of arc AB(R_1)	48.74mm
The radius of arc BCD(R_2)	30mm
Thickness of stationary ring	15mm
The length of outer air gap	1mm
Thickness of PMs on the outer rotor	10mm
Inner radius of the outer rotor yoke	87mm
Axial length	40mm
Remanence of PMs	1.1T
PM segments per pole on the inner rotor	3
PM segments per pole on the outer rotor	2

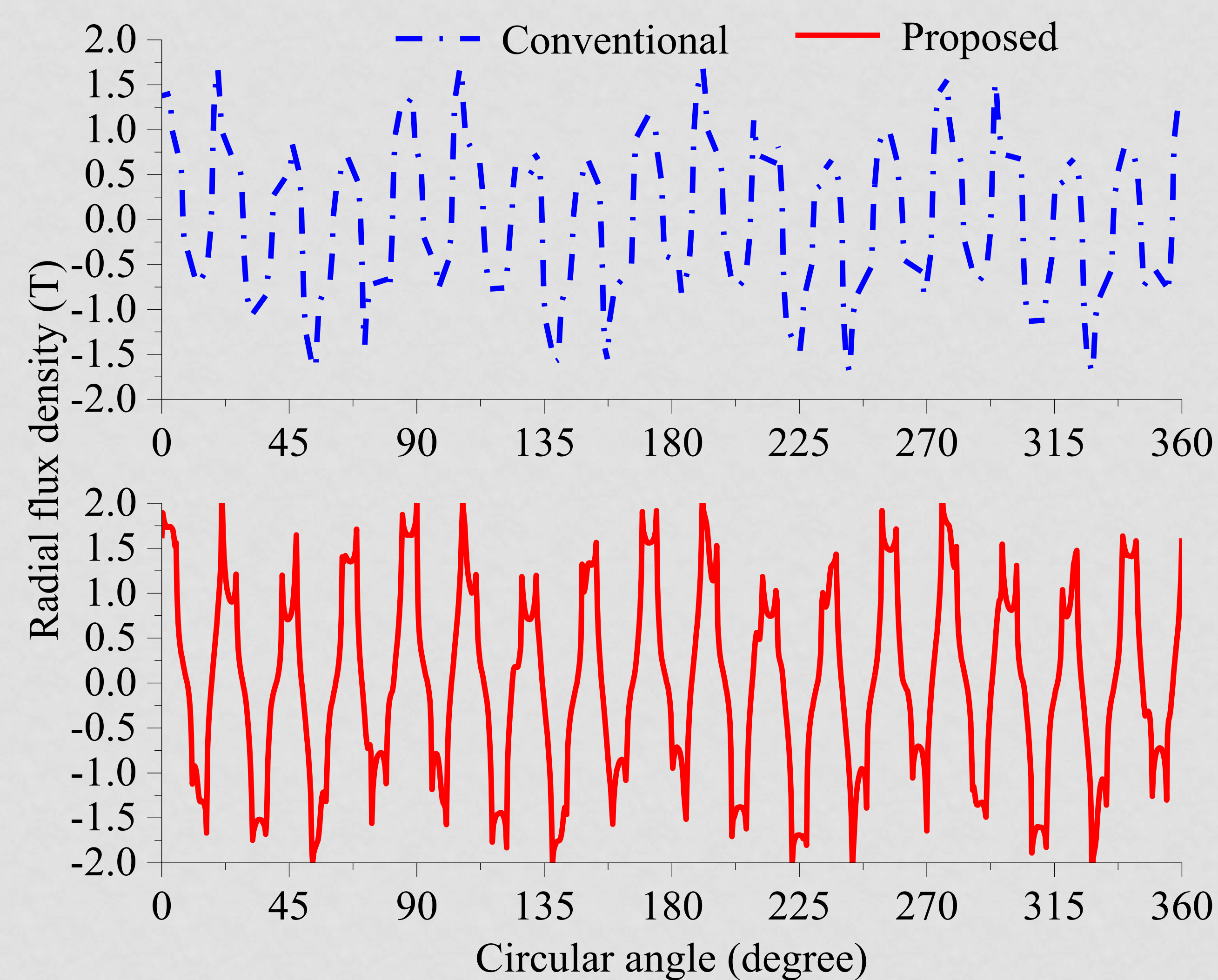


Fig. 2. Radial flux density distribution in the outer air gap

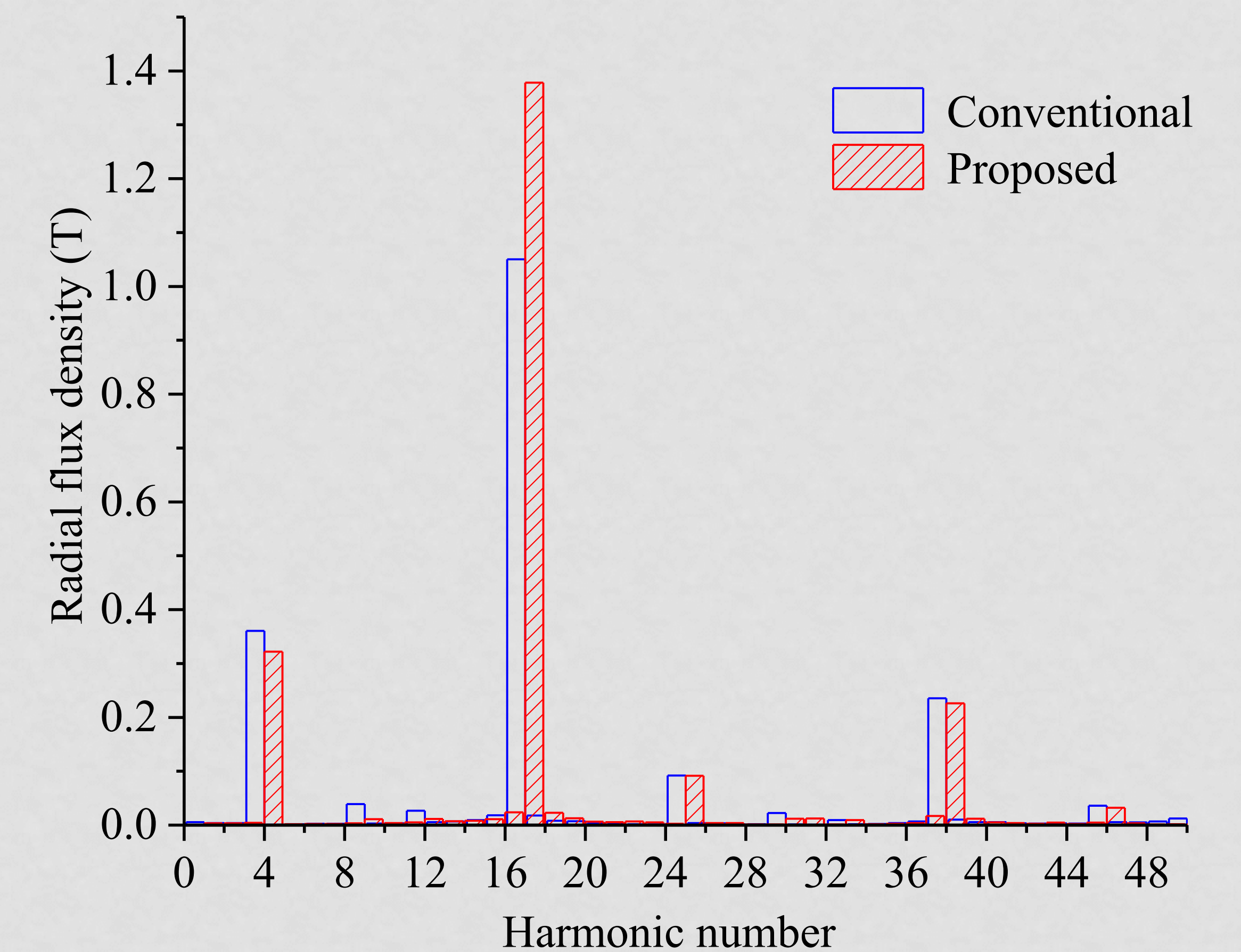


Fig. 3. Radial harmonic spectra in the outer air gap

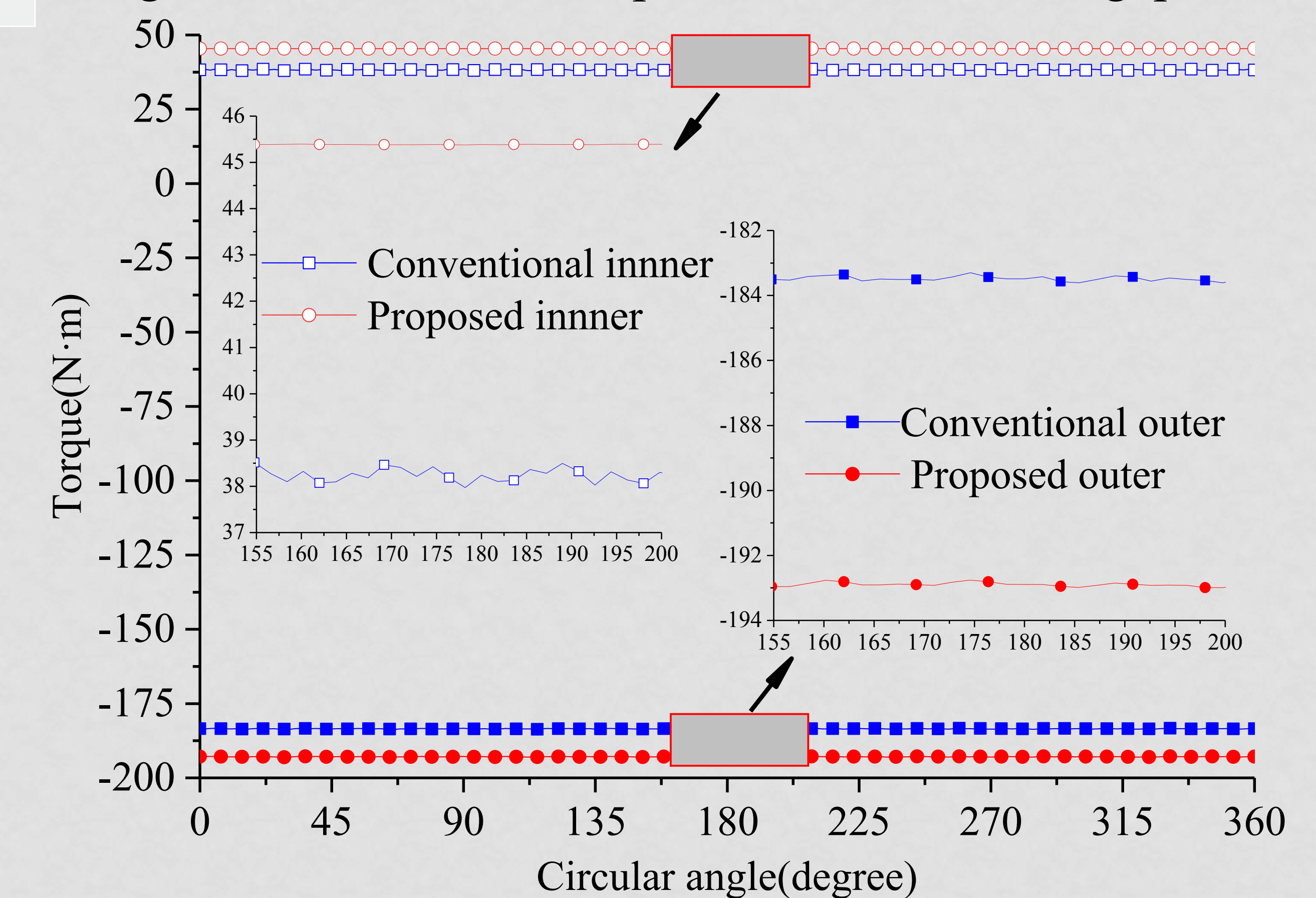


Fig. 4. Torque-angle curves

4. Conclusion

A Novel MG with unequal Halbach arrays of inner rotor and non-uniform air gap has been proposed. A sinusoidal flux density waveform can be obtained by the unequal Halbach arrays on the inner rotor. Flux density and torque of the proposed MG have been calculated by FEA. The proposed MG can offer at least 18.6% higher torque and up to 0.04% lower torque ripple than the conventional MG.