A New Structure for the Coaxial Magnetic Gear with HTS Bulks

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WED-PO2-507-02

27th International Conference on MAGNET TECHNOLOGY
November 15-19, 2021, Fukuoka, Japan
Hybrid Conference: On-site and On-line

Background

In order to improve the torque density of the contact gear, it is necessary to design the shape of the gear, or to improve the material and processing technology. Although the research and improvement in this area play a certain role, in terms of its own contact transmission structure constraints, the improvement result is very limited. So far, the topological structures of various magnetic gear have been proposed successively. However, these structures of magnetic gears have a large torque ripple or not sufficiently high in torque density to meet the growing demands of the industry. Therefore, it is necessary to research on the magnetic gear with high torque density.

Objectives

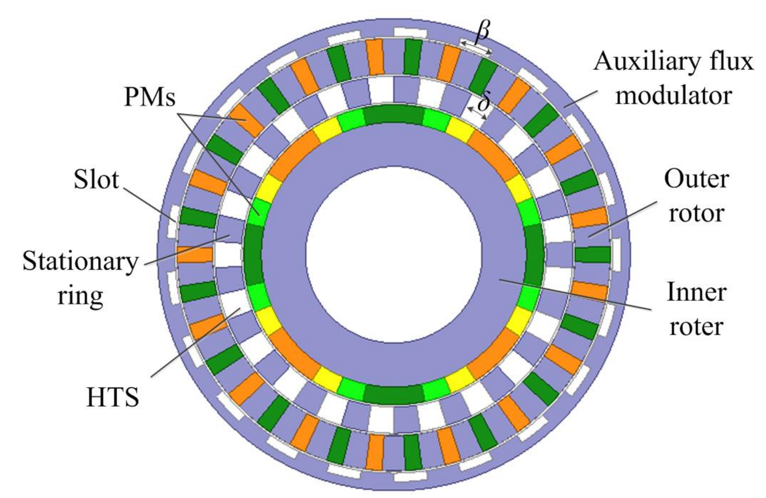
- The GA was used to optimize the parameters of proposed CMG to obtain maximum torque.
- An auxiliary flux modulator is added to the outermost layer to reduce magnetic flux leakage.

Conclusion

- A novel coaxial magnetic gear with auxiliary flux-modulator and HTS bulks has been presented and analyzed, which has a good flux modulation effect, and also can suppress magnetic flux leakage.
- The uneven block of PMs on the inner rotor can make the irregular air gap, so it is easy to get sinusoidal magnetic flux waveform.
- The GA was used to optimize the parameters of proposed CMG. The output torque of proposed CMG increased from 113.88N·m to 330.14N·m.

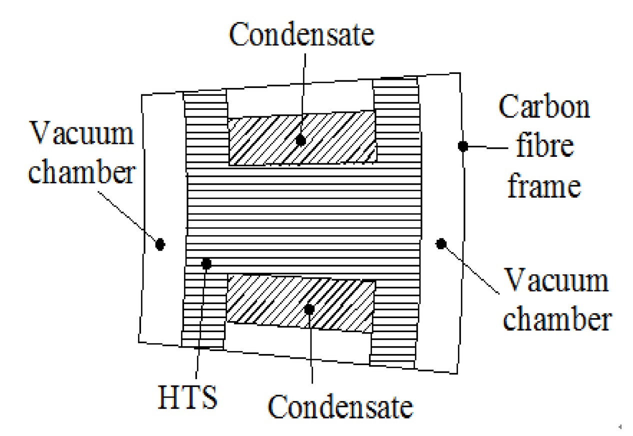
Structure

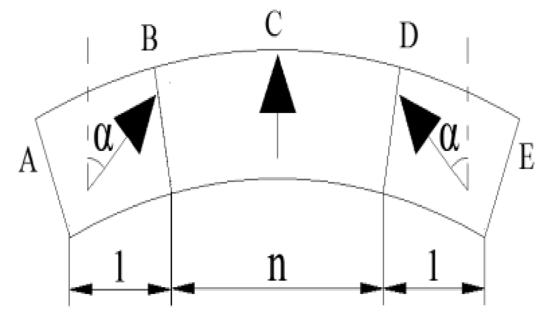
Model and magnet pole geometry



The proposed CMG introduces a stationary auxiliary flux modulator located outside of the ST-CMG. The pole-piece angle of the auxiliary flux modulator β is equal to that of the main flux modulator δ. The proposed CMG and the ST-CMG have the same volume size, but the amount of PMs decrease a lot.

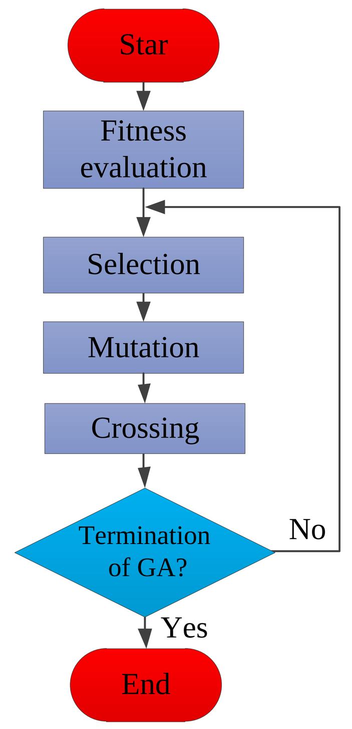
Structure of HTS and uneven block





The bulk HTS is mainly composed of carbon fibers frame, superconducting material, condensate and vacuum chamber. The block ratio of PMs is 1:n:1. The PMs with a middle ratio of n adopts radial magnetization, while the PMs with a ratio of 1 on both sides of the left and right adopts sinusoidal magnetization, and α is 60° .

GA flow and Parameters

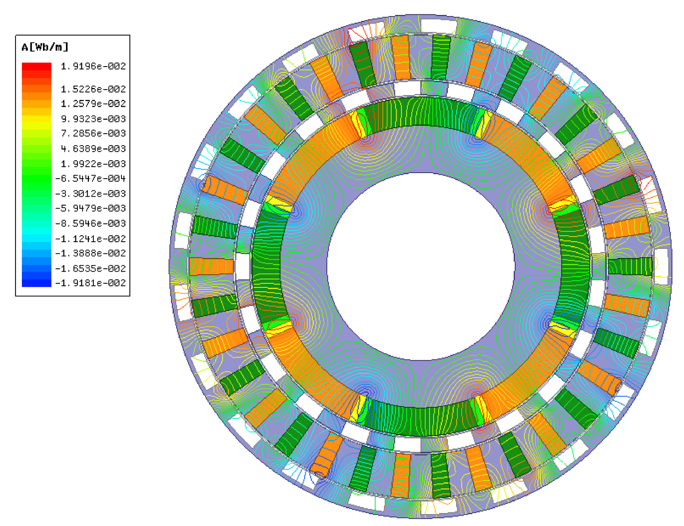


Flow chart of GA.

Parameters of proposed CMG

Parameters	Values
Inner radius of inner rotor core/(mm)	40
Outer radius of inner rotor core/(mm)	60
Inner radius of stationary ring/(mm)	72.02
Thickness of stationary ring /(mm)	5.93
Inner radius of outer PM /(mm)	78.85
Inner radius of outer PM /(mm)	98.45
The inter radius of iron yoke /(mm)	99.45
The outer radius of iron yoke /(mm)	107
Remanence of PMs/(T)	1.1
Axial length /(mm)	40
The thickness of the air gap /(mm)	1
α/(°)	60

Results



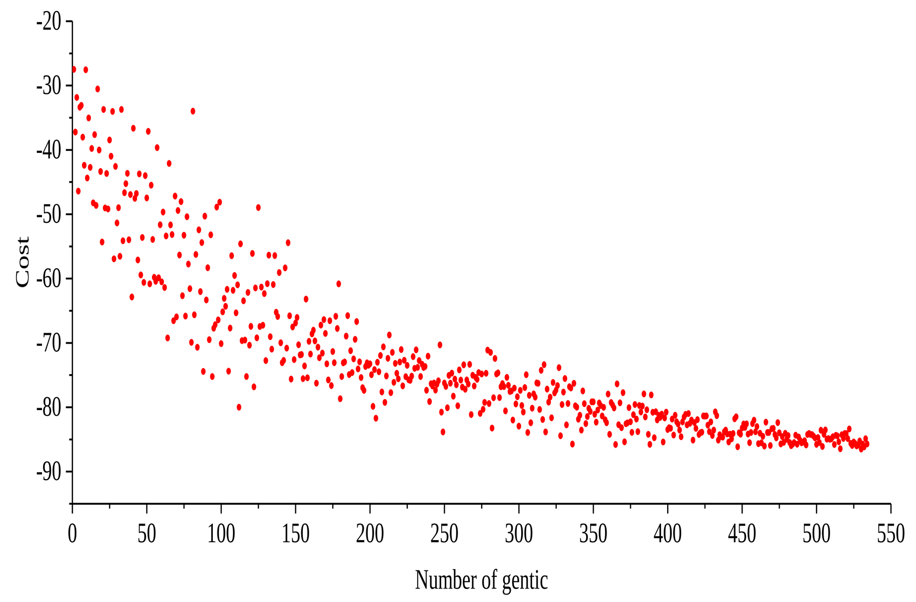
The flux distribution.

The corresponding rotational speed of the space harmonics can be expressed as,

$$\omega_{m,j,k} = \frac{mp\omega_r + jn_p\omega_p + kn_s\omega_s}{mp + jn_p + kn_s}$$

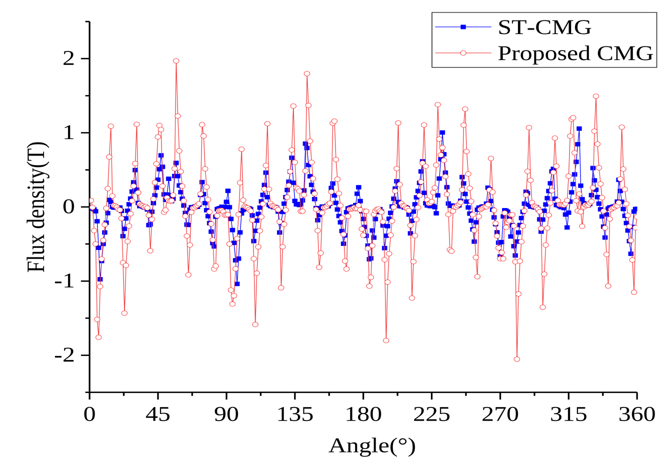
According to the Maxwell Stress tensor, the electromagnetic torque is expressed as follows,

$$T_{em} = \frac{L_{ef}R_e}{\mu_0}\int_0^{2\pi} B_r B_t d\theta$$

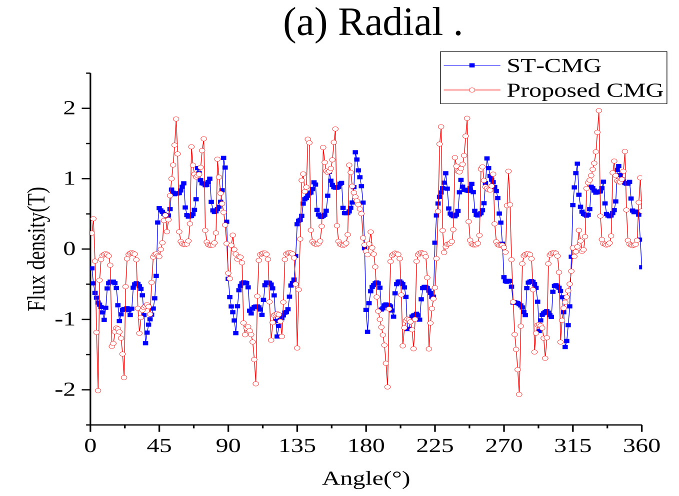


Objective function value change of GA optimization.

The smaller the cost function is, the better the solution is. As can be seen from the figure, the 318th iteration reached the minimum value of -83.852.

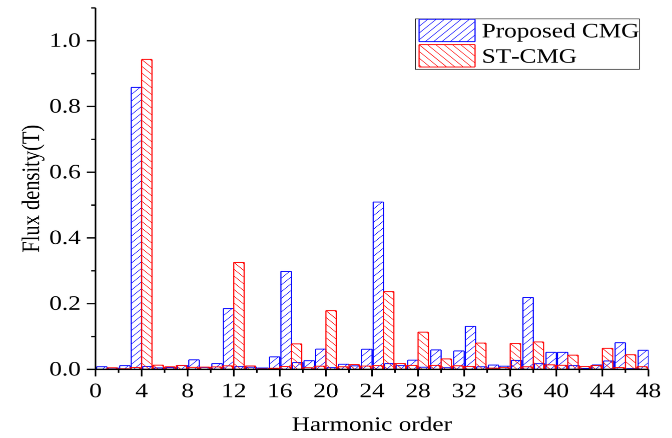


(a) Radial .

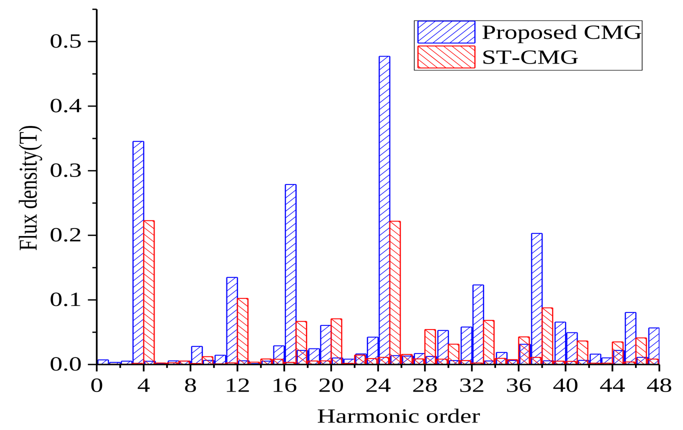


(b) Tangential.

Flux density distribution in the inner air gap.

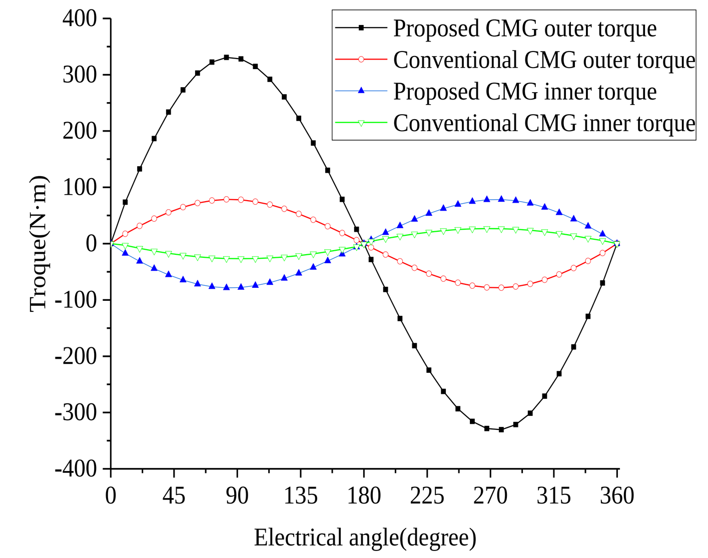


(a) Radial.

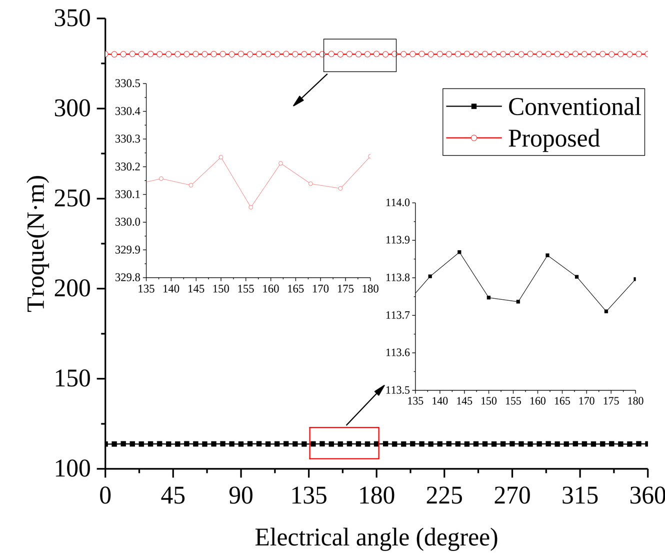


(b) Tangential.

Harmonic order.



Static torque.



Output torque.

Quantitative Comparison Among Two MGs

Quantity	Conventional	Proposed
MG volume	$1.237*10^{-3}m^3$	$1.237*10^{-3}m^3$
PMs weight	2.9kg	1.5kg
Outer torque	113.88N·m	330.14N·m
Torque density	92.06 kN·m/m³	266.89 kN·m/m³