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Study of A Post-Assembly Magnetization Method of a V-Type Rotor of Interior Permanent Magnet Synchronous Motor for Electric Vehicle

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I. Introduction

Interior permanent magnet (IPM) synchronous motor is widely used in electric vehicles. Rotors with V-type, U-type and other shaped poles can improve the motor performance but the pole structure is more complicated. The assembly process of permanent magnet (PM) blocks is time consuming, with high device complexity and a risk of damage to the PM blocks.

Post-assembly magnetization method has the advantages of simple installation, low cost and high safety, which is very suitable for applying to the design and manufacture of PM motors for electric vehicles.

II. Design Guidelines

- Capacitor bank is used as pulsed power supply.
- The saturated magnetization magnetic flux density of NdFeB PM is 3 T.
- The permeability of the silicon steel sheet approximates unity in the magnetization progress.
- Strong eddy currents are generated in PM blocks and the cores of the rotor and magnetizing device which will weaken the magnetizing magnetic field.
- The power system parameters are corrected considering the influence of saturation effect and eddy current effect in preliminary design stage.
- The finite element method is used to analyze the post-assembly magnetization process of the rotor.

III. Design of magnetization system

A. Preliminary Design of Magnetizing Device

- Device schematic diagram
The outer diameter of the device is the same as the stator. The pole number is the same as the rotor, the pole length is the same as the stator teeth, the pole width is the same as the rotor pole. And the air gap is the minimum that can be achieved in engineering.

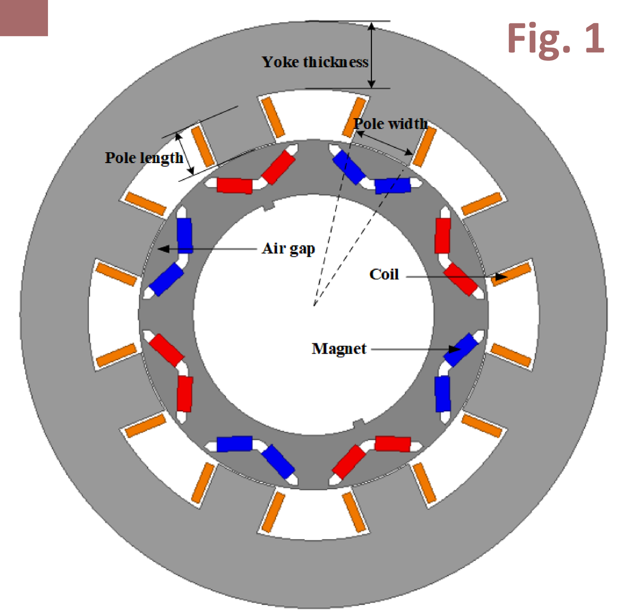

Fig. 1

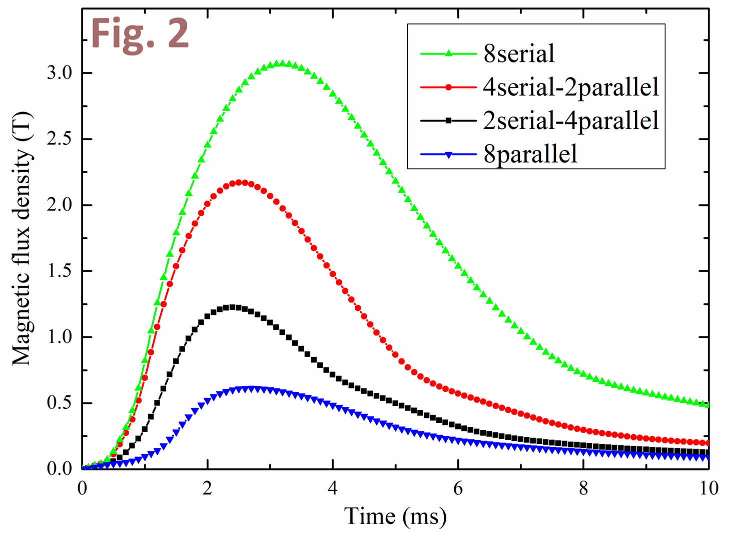

Fig. 2

- Connection modes of magnetizing coils
The peak values of the magnetizing current and magnetizing field produced by eight coils connected in series are the largest.

TABLE I. PARAMETERS OF PROTOTYPE

Parameters	Value
Power	50 kW
Stator OD	269.24 mm
Rotor OD	160.4 mm
Motor length	83 mm
Number of poles	8
Number of slots	48
PM material	NdFeB (N36)
Magnet thickness	6.48 mm

TABLE II. PRELIMINARY DESIGN

Parameters	Value
Coil layers	5
Single layer turns	7
Pole length	35.53 mm
Pole width	25.2 degree
Yoke thickness	18.14 mm
Air gap	0.5 mm
Outer diameter	134.62 mm
Inner diameter	80.95 mm

- Saturation effect
It is feasible to set the permeability of the silicon steel sheet as unity when finite element method is used to calculate the magnetizing field.

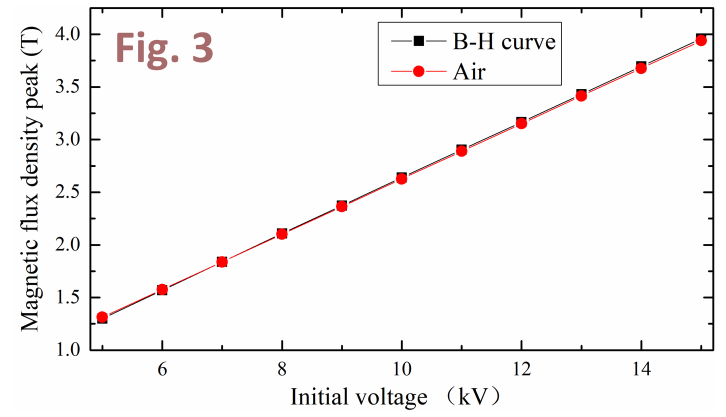

Fig. 3

- Eddy current effect
The eddy current effect will weaken the magnetizing field to a certain extent.
A 3 T magnetizing field can be obtained if the initial discharge voltage is increased from 10 kV to 12 kV.

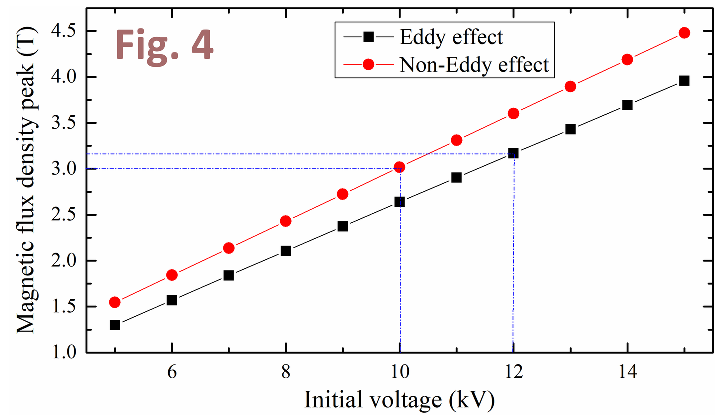

Fig. 4

B. Optimal Design of Magnetizing Device

- The number of turns of the magnetizing coil is related to the dimensions of the device. The pole width affects the number of layers, and the pole length affects the number of turns of a single layer.

$$\partial_{PW} = \left(45 - 2\left(450 l_s / \left(80.95\pi\right)\right)\right) degree$$ • Pole width

$$l_{pl} = \left(4.5 n_0 + 0.05\right) mm$$ • Pole length

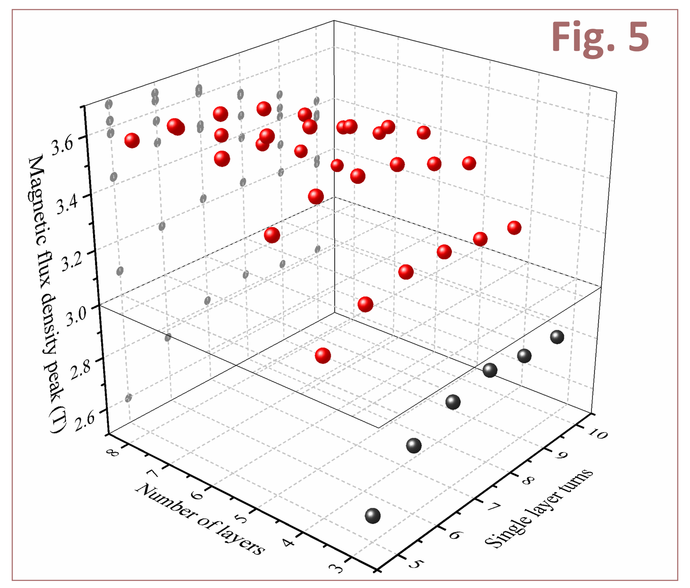

Fig. 5

- When the initial discharge voltage is set to 12 kV, a magnetizing field of 3 T can be obtained combination of 4 layers and 5 turns of a single layer using the minimum number of turns. The maximum magnetizing field is generated when the coil parameters is 7 layers and 5 turns of a single layer.

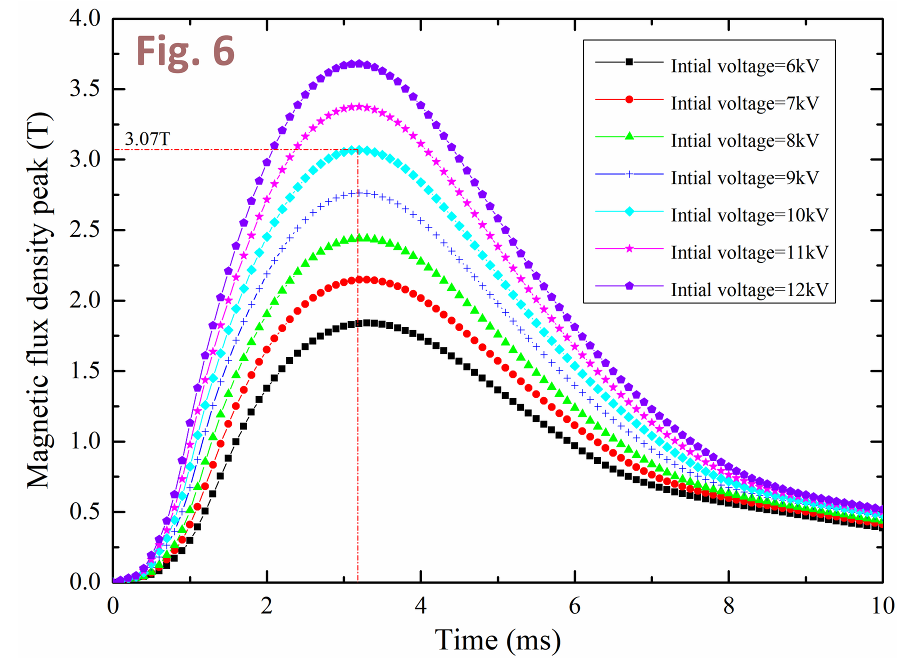

Fig. 6

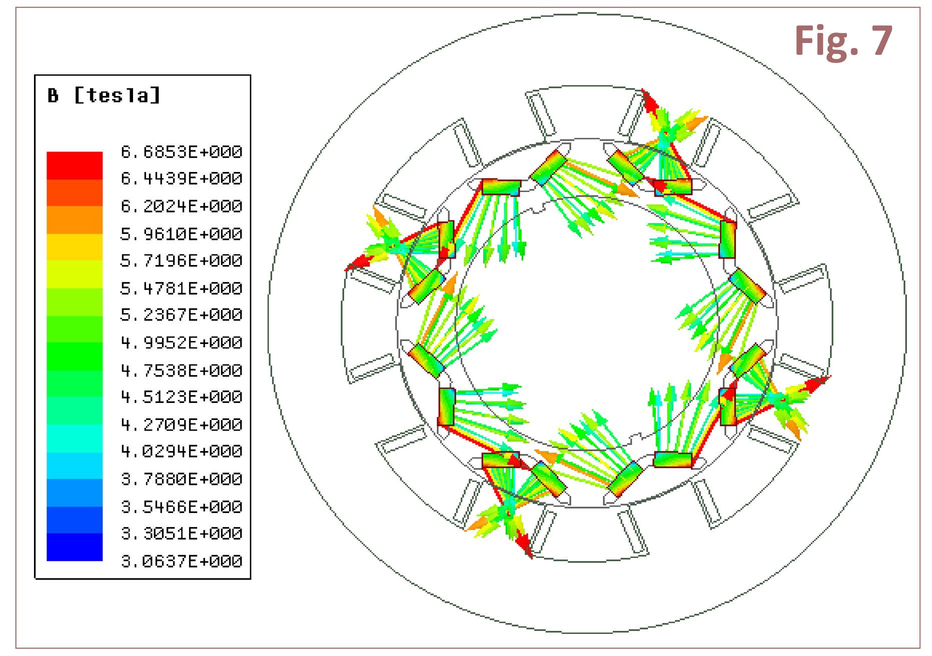

Fig. 7

- A 3 T magnetizing field is obtained when the initial discharge voltage is 10 kV using the combination of 7 layers and 5 turns

TABLE III. OPTIMAL DESIGN

Parameters	Value
Coil layers	7
Single layer turns	5
Pole length	22.55 mm
Pole width	20.23 degree
Yoke thickness	31.12 mm
Air gap	0.5 mm
Outer diameter	134.62 mm
Inner diameter	80.95 mm

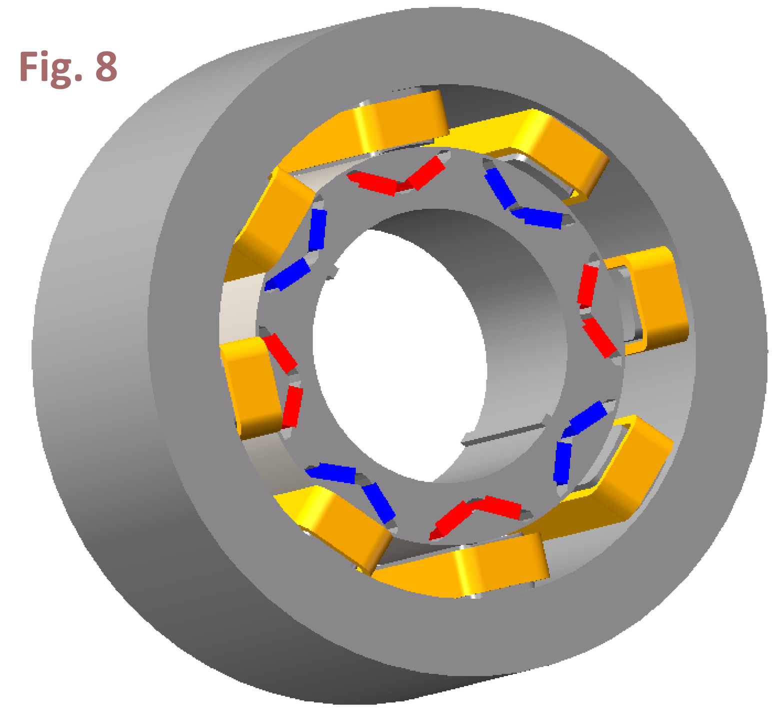

Fig. 8

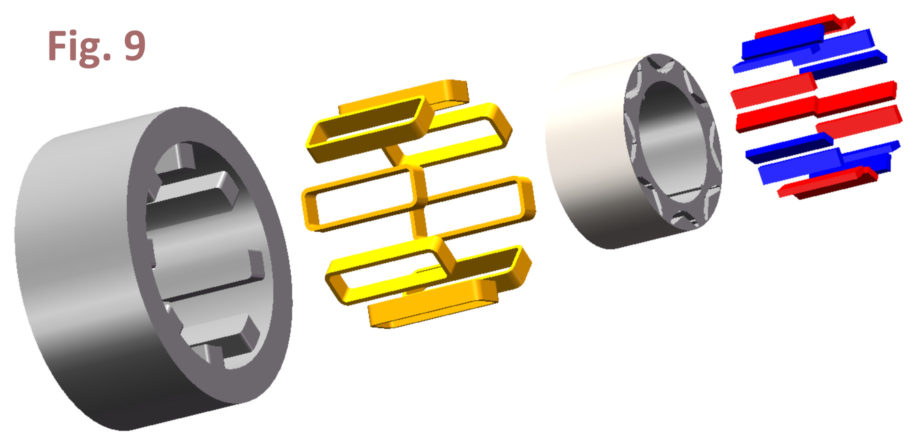

Fig. 9

V. Conclusion

➢ A post-assembly magnetization method of a V-type rotor of an IPM motor is proposed. In the preliminary design, a 3 T magnetizing field is obtained when the initial discharge voltage is 12 kV. In the optimal design, where the coil parameters are 7 layers and 5 turns, a 3 T magnetizing field is obtained when the initial discharge volt-age is 10 kV. The energy consumed of the optimal design is reduced.

References

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