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

Wed-Mo-Po3.05-06 [33]

Research of Post-Assembly Magnetization of Large-Power Surface-Mounted Rare-Earth Permanent Magnet Machines with Integrated Magnetizing Windings

Q. J. Wang, H. F. Ding, H. Zhang, J. Zhou, Y. L. Lv, L. Li

Wuhan National High Magnetic Field Center， Huazhong University of Science and Technology, Wuhan, China， 430074

I. Introduction

Permanent magnet (PM) motors are widely used in industry because of their excellent performance. For large power PM motors, the assembly process is very complicated and risky, and the maintenance process for irreversible demagnetization fault is very complex and high-cost.

A Post-assembly magnetization method for large-power surface-mounted permanent magnet (SPM) is proposed. The finite element model is established to analyze the eddy current effect and temperature rise. Two SPM motors of 50 kW and 900 kW are selected as prototypes. Corresponding magnetization schemes are designed. Simulation results show that the motors can be fully magnetized by the designed magnetization schemes.

II. Design Criteria

- Saturated magnetization energy

$$E_s = (1/2)CU^2$$ • Energy of capacitor bank

$$E_t = (1/2)B_sH_s(V_m + V_s + V_r)$$ • Energy for saturated magnetization

- Design of integrated magnetizing winding (Thermal demagnetization effect)

$$I_{pulse}{}^2 R_{coil}\Delta t = c_{cu}m_{cu}\Delta T$$ • Heat conduction formula

$$R_{coil} = 4n\rho_{cu}(l_0 / s_0)$$ • Resistance of magnetizing winding

$$\rho_{cu} = \left(-3.41e^{-9} + 7.2e^{-11}T\right)\Omega / m$$ • Resistivity of copper Conductor

$$\mathrm{I} = \left(\sqrt{(1e^5\alpha\Delta T)/(\beta n + 0.13)}\right)\mathrm{A}$$ • Relationship between coil turns and magnetizing current

III. Magnetizing Scheme with Integrated Winding

TABLE I. PARAMETERS OF PROTOTYPES

Parameters	Machine A	Machine B
Power	50 kW	900 kW
Stator OD	269.24 mm	1430 mm
Rotor OD	160.4 mm	1250 mm
Motor length	83 mm	800 mm
Pole	8	60
Slot	48	183
PM material	NdFeB(N36)	NdFeB (N42SH)
PM thickness	8 mm	24 mm
Pole arc	31.5 degree	3.75 degree

TABLE II. MAGNETIZING COILS

Parameters	50 kW	900 kW
Number of coils	4	8
Wire size	2 mm × 3 mm	2 mm × 4 mm
Maximum turns	16	20
α	3.669	6.5226
β	0.00363	0.0142

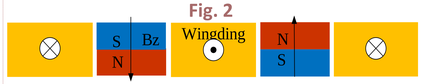
50 kW SPM

900 kW SPM

- Layout of Magnetizing Coils

Fig. 1

Fig. 2



During the magnetization progress of the 900 kW SPM motor, the parts of the core close to the poles to be magnetized are locally saturated, resulting in asymmetry of magnetic circuits of the poles to be magnetized.

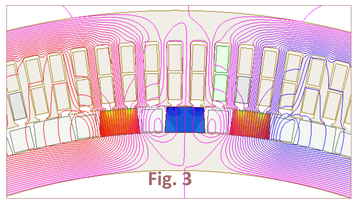


Fig. 3

- The relationship between coil turns and magnetizing current

The coil temperature rises in an approximately adiabatic process during magnetization. In order to avoid the thermal demagnetization of PM, the temperature rise of the magnetizing coil is limited to no more than 100 K.

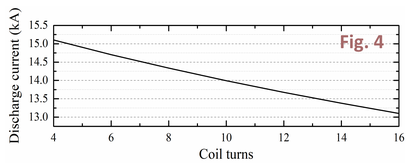


Fig. 4

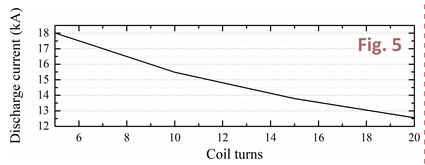


Fig. 5

- Parametric analysis of initial discharge voltage and number of coil turns

The magnitude of the magnetizing field with determined discharge circuit depends on initial discharge voltage of the capacitor and number of turns of the magnetizing coil.

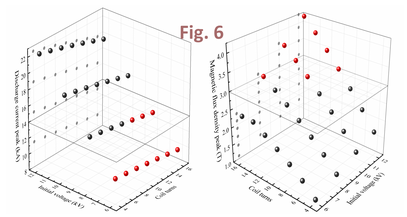


Fig. 6

When initial voltage is 8 kV, number of coil turns is 16, a 3 T magnetizing field is generated with a temperature rise less than 100 K.

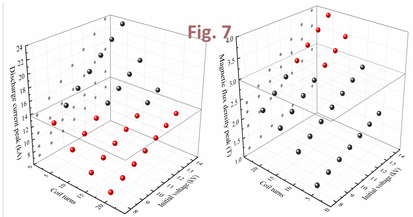


Fig. 7

Initial voltage	Number of coil turns
11 kV	20
12 kV	15

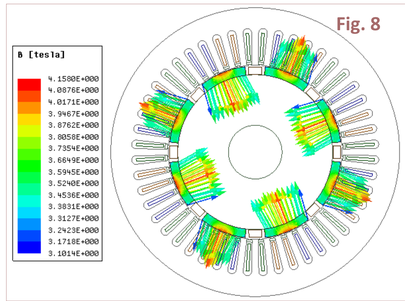


Fig. 8

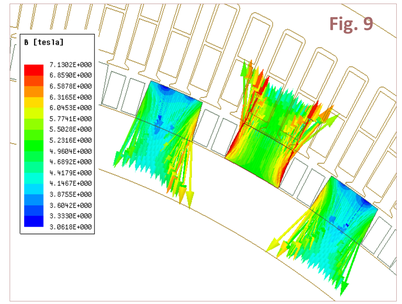


Fig. 9

IV. Integrated Winding combing with stator winding

For the 50 kW motor, when the initial discharge voltage is 7 kV and the magnetizing coil is 10 turns, a magnetizing field with both amplitude and direction satisfying the requirements can be generated.

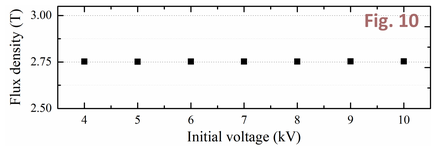


Fig. 10

For the 900 kW motor, the stator windings barely have contribution to the magnetizing field

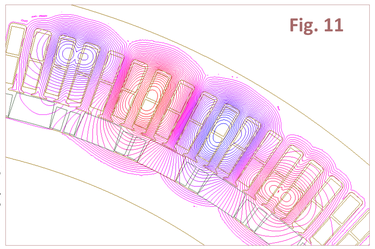


Fig. 11

V. Conclusion

- The 50 kW motor can be successfully magnetized with the integrated winding when the initial voltage is 8 kV and the number of turns of magnetizing winding is 16. If the stator winding is utilized in series with the integrated magnetizing winding, the initial voltage can be reduced to 7 kV and the number of turns of magnetizing winding can be reduced to 10.
- For the 900 kW motor, only integrated magnetizing windings can be used for magnetization. When the initial voltage is 12 kV and the number of turns of magnetizing winding is 15, the motor can be fully magnetized.

References

1. G. W. Jewell, D. Howe. IEEE Trans. Magn., 28(5), 3036-3038, 1992.
2. M. F. Hsieh, Y. C. Hsu, D. G. Dorrell. IEEE Trans. Ind. Electron, 57(10), 3376-3384, 2010.
3. W. N. Fu ; Y. D. Chen. IEEE Trans. Appl. Supercond, 26(4) , 2016.