Thu-Mo-Po4.08-03 [55]

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

Magnetization Loss Analysis of Fully High Temperature Superconducting Synchronous Generators with Dual Field Windings

Myeonghee Lee[1], Sang Ho Park[1], Seyeon Lee, Gye-Won Hong[1], Woo-Seok Kim[1], Ji-Kwang Lee[2], Kyeongdal Choi[1]

1: Korea Polytechnic University, 2: Woosuk University

CASS center for advanced superconducting systems

KPU KOREA POLYTECHNIC UNIVERSITY

WOOSUK UNIVERSITY

1. Introduction

- ✓ Fully superconducting rotating machines might be smaller and have higher efficiency than the conventional superconducting ones.
- ✓ If we adopt HTS windings to the armature of the conventional HTS synchronous machine with HTS field windings, the magnetization loss is too high because of the big circumferential magnetic fields.
- ✓ We have suggested a fully HTS machine with dual field windings to reduce the high circumferential fields.
- ✓ We also suggested an armature winding structure that have 3 phase windings in 4 poles span to realize the installation of the HTS armature.
- ✓ We analyzed the magnetization losses of the fully HTS machines with various configurations.

2. Conventional HTS machine vs. Fully HTS one

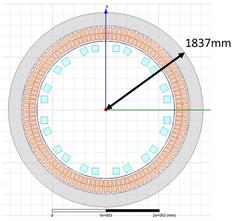


Fig1. Conventional HTS machine

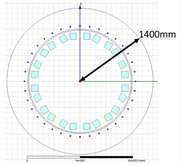
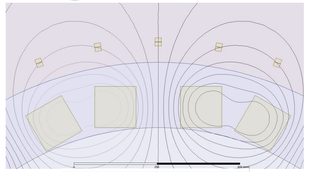
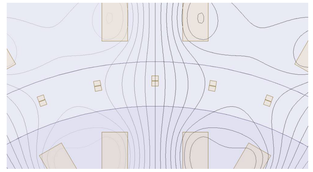


Fig2. Fully HTS machine

- ✓ The fully HTS machine might have a smaller volume and lighter weight than the conventional one.
- ✓ But the perpendicular field to the armature HTS tape is too high.

3. Single field vs. Dual fields





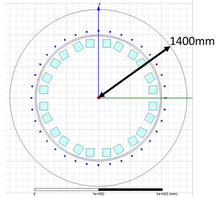


Fig3. Single field winding: structure & flux-line

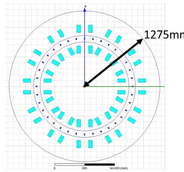


Fig4. Dual-field winding: structure & flux-line

- ✓ In case of the 10MW dual field windings, the perpendicular field to the HTS tapes in the armature can be drastically decreased.
- ✓ But the magnetization loss is still high for the commercial use.

4. 10 MW, 3 phase windings : 2 poles span vs. 4 poles span

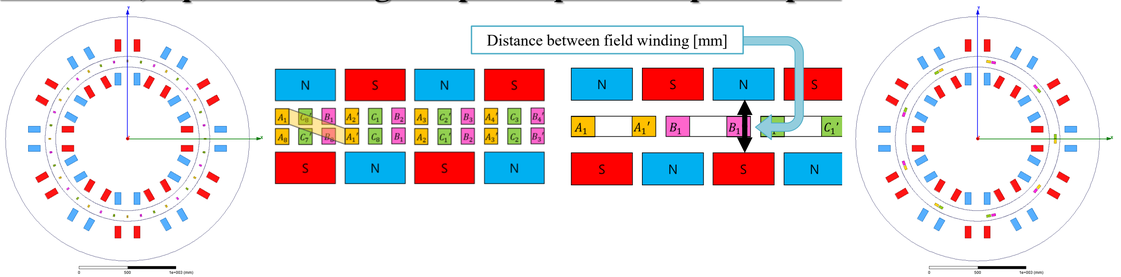


Fig5. 3 Φ in 2 poles dual field winding

Fig6. 3 Φ in 4 poles dual field winding

Gap between dual fields [mm]	3 Φ in 2 poles		3 Φ in 4 poles	
	Effective length[m]	AC Loss [kW]	Effective length[m]	AC Loss [kW]
125	1.01	14.9	0.83	21.2
145	1.08	14.5	0.91	22.3
165	1.16	14.1	1.00	23.7
185	1.25	13.9	1.10	25.4
205	1.35	14.3	1.22	27.7
225	1.46	14.4	1.38	27.9
245	1.58	14.8	1.55	35.1
265	1.71	15.4	1.75	39.3
285	1.85	16.2	2.05	41.9

Table1 AC-Loss by gap between dual fields

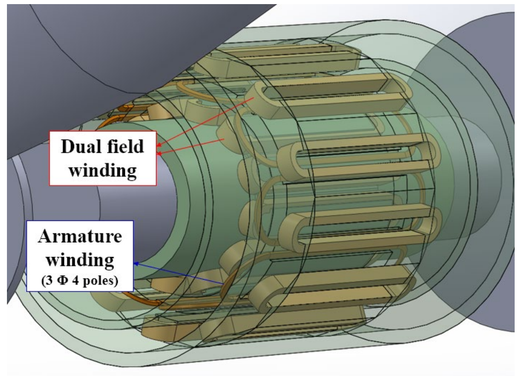


Fig7. 3 Φ in 4 poles dual field winding

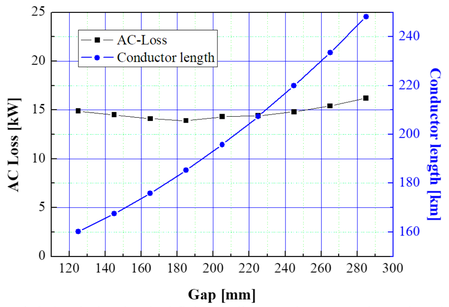


Fig8. 3 Φ in 2 poles dual field winding: AC loss & conductor length

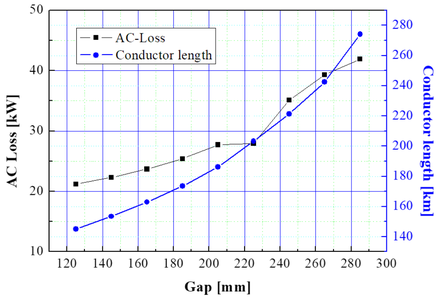


Fig9. 3 Φ in 4 poles dual field winding: AC loss & conductor length

- ✓ It is impossible to install the HTS windings in the shape of the copper armature windings because HTS tapes are stiff and need a cryogenic structure.
- ✓ We suggested a new configuration of the HTS armature windings. The concentrated 3 phase windings are separately installed in 4 poles span. The gap between the inner and outer fields effects the magnitude of the AC losses.
- ✓ The new configuration has a lager magnetization loss than the one of the normal configuration which is not possible to be realized

5. Variations of the shape of the armature

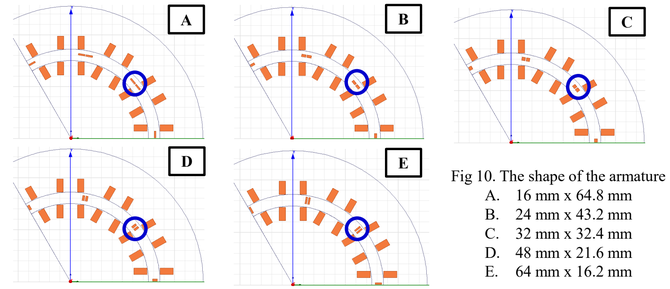


Fig 10. The shape of the armature
- A. 16 mm x 64.8 mm
- B. 24 mm x 43.2 mm
- C. 32 mm x 32.4 mm
- D. 48 mm x 21.6 mm
- E. 64 mm x 16.2 mm

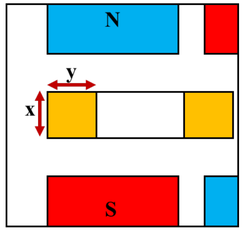


Fig11. The shape of the armature

Shape of the armature (x × y)	Effective length[m]	AC-Loss [kW]
16 mm × 64.8 mm	0.81	16.0
24 mm × 43.2 mm	0.83	21.2
32 mm × 32.4 mm	0.85	25.2
48 mm × 21.6 mm	0.86	28.7
64 mm × 16.2 mm	0.86	31.1

table2. AC-Loss by shape of the armature

- ✓ In the case of 3 phase windings in 4 poles span, not only the gap between dual fields but also the dimensions of the armature windings effect the total AC losses.
- ✓ If the cross-sectional areas are same for all cases, the thinner windings have the lower losses.
- ✓ It is because the circumferential field is lowest at the mid-point between the dual fields.

6. Conclusion

- ✓ We investigated the possibility of a fully high temperature superconducting synchronous machine.
- ✓ It is hard to be commercialized in case the fully HTS machine has the same structure of the conventional synchronous machine, because the perpendicular field to the HTS tapes in the armature is too high.
- ✓ We have suggested a fully HTS machine with dual field windings to reduce the AC losses.
- ✓ We also suggested a new configuration of the HTS armature which has 3 phase windings in 4 poles span. This configuration enables the HTS winding with cryostats to be installed.
- ✓ We analyzed the effects by the gap between dual fields and the dimensions of the armature windings.
- ✓ We will design a fully HTS machine based on this results in near future.