1 Introduction

This paper deals with the design and comparative analysis of direct-driven type superconducting wind power generators according to MgB$_2$ and YBCO wires. The specifications of MgB$_2$ and YBCO wires were investigated, and the 4 MW superconducting generators using MgB$_2$ and YBCO wires were designed based on a rated line-to-line voltage of 3.3 kV and a rotational speed of 14 rpm. The magnetic field distributions of the generator were analyzed using a 3D finite element method program. The generator designs using MgB$_2$ and YBCO wires were compared by focusing on the size, weight, magnetic flux density, operation current value, and required length of the wire.

2 Superconducting wire for the generator

In the case of YBCO, the width and thickness were 4 and 0.15 mm, respectively and the critical current was approximately 198 A at an operating temperature of 22 K and a external magnetic flux density of 2.82 T. The width and thickness of the MgB$_2$ wire in the tape type were 3.0 and 0.7 mm, and the critical current was approximately 320 A at an operating temperature of 20 K and magnetic field of 1.4 T. The operating temperatures of superconducting generators using YBCO and MgB$_2$ wires were kept at around 20 and 30 K. Since large scale superconducting rotating machines require a superior performance at around 20 and 30 K.

3 Fundamental structure of the 4 MW superconducting generator

The material of vacuum shield is 304-stainless steel, which is nonmagnetic material, for reducing thermal conduction. The material of rotor body and stator body are M-27 24 Ga, which is a ferromagnetic material, to increase the magnetic flux density. A field coil is composed of double pancake coil wound with superconducting wire. A stator winding has double-layered, distributed three-phase winding methods, and the material of the stator winding is copper.

4 FEM analysis result of a 4 MW superconducting generator

The YBCO and MgB$_2$ wires were influenced by the perpendicular magnetic field because the shape of the wire was the tape type. The critical current density applied to the field coil depends on the magnetic flux density of the perpendicular direction. Therefore, the operating current is selected by the value of the perpendicular magnetic field.

5 Comparison of the Two superconducting generators

There were fewer of turns of the field coil using MgB$_2$ than the field coil using YBCO. However, the MgB$_2$ wire was 7 times thicker than the YBCO wire. Therefore, the field coil using the MgB$_2$ wire as larger than the field coil using the YBCO. As the size of the superconducting generator’s field coil increased, the volume of the surrounding structure increased. As a result, the outer diameter and weight of the generator increased.

6 Conclusions

This paper dealt with the design and comparative analysis of direct-driven type superconducting wind power generators according to MgB$_2$ and YBCO wires. The superconducting generators using MgB$_2$ and YBCO wires were compared by focusing on the diameter, weight, magnetic flux density, operation current value, and required length of the wire. As a result, Considering the weight and volume issues related to using superconducting generators, YBCO is more advantageous than MgB$_2$. Moreover, considering the cost issue, MgB$_2$ is more advantageous than YBCO. Therefore it is necessary to select appropriate superconducting wires considering cost, weight, and volume issues when designing superconducting generators.

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