Design and analysis of a 12 MW superconducting wind power generator

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Recently, large-scale offshore wind turbines have been preferred due to higher wind quality and better wind speed compared with land. Above all, floating offshore wind turbines for deep water and direct-drive type generators are being actively developed due to gearbox reliability.

However, heavy top heads of the wind turbines are big issues. Therefore, many companies have tried to develop wind power generators with larger capacity, smaller size and lighter weight. A high-temperature superconducting generator could be a key technology used to achieve these issues. The superconducting generator draws much attention for incorporating intolarge-scale offshore wind turbines.

This papercompares the design and analysis of a 12 MW superconducting wind power generator against a conventional generator.Weight trends of each component of wind turbines are investigated, and a fundamental design of 12 MW offshore wind turbine is suggested. The rotor, which supports superconducting field coils, consists of an air-core material to reduce heat loss at low temperature. An iron-core material like laminated silicon steel applies to the stator,which supports the copper armature coil at room temperature to reduce the total length of superconducting wire required.

Using the 3D finite element method, the generator isanalysed and conformed in terms of magnetic field distribution, torque performance, and efficiency. The torque ripple of the generator is reduced by changing the combination of pole and slot numbers.

The costs of the superconducting generator and conventional generator are estimated by considering key factors such as the weights of the materials used in the generator and supporting structure and also the losses of generator. The tophead weights of 12 MW offshore wind turbines by each generator type are compared.

As a result, the output performances such as torque ripple, total harmonic distortion of output voltage, and efficiency of the superconducting generator are improved. The weight of the superconducting generator is less than ahalf of the conventional generator. Moreover, the top head weight of 12 MW offshore wind turbine with the superconducting generator is estimated to be equivalent to an 8 MW wind turbine with conventional generator.The designed 12 MW superconducting generator and the estimated weight of the offshore wind turbine can effectively be utilized to develop large-scale offshorewind power systems.