This project concerns an investigation in the use of superconductors in electric generators. The reason to use superconductors in wind turbines is that they have a resistance of almost 0Ω at low temperatures. This means they have lower power dissipation and thereby a higher current density which reduces the size and weight of the wind turbine generator. The loss reduction due to superconductors improves the efficiency of the wind turbine at all operation speeds.

Introduction

Why? The reason to use superconductors in wind turbines is that they have a resistance of almost 0Ω at low temperatures. This means they have lower power dissipation and thereby a higher current density which reduces the size and weight of the wind turbine generator. The loss reduction due to superconductors improves the efficiency of the wind turbine at all operation speeds.

Small Scale Generator

Process? In order to test the behavior of a generator with superconductive wire a small scale model has been built and tested.

The red line shows the air gap flux density at room temperature. The superconductor acts as a normal copper conductor giving a maximum current of 1A. The maximum air gap flux generated at 1A is 1.8 mT. The blue line shows the air gap flux density at 50A and with the temperature at 77 K. At this state a much higher air gap flux density can be obtained.

Super Conducting Wind Turbine

The type of magnets used in Siemens 3 MW permanent magnet, direct drive generator are the rare earth NdFeB. Using Siemens design as inspiration a 10 MW permanent magnet generator would require 2.9 ton NdFeB.

The blue line shows the flux density [B] as a function of current in the superconductor. It is seen that when increasing the current the flux density will also increase.

The red line shows that with increasing current the flux density has to be reduced to maintain the superconducting properties. From the curves it can be concluded that the superconductor is able to reach a maximum of 75A.

The red line shows the air gap flux density at room temperature. The superconductor acts as a normal copper conductor giving a maximum current of 1A. The maximum air gap flux generated at 1A is 1.8 mT. The blue line shows the air gap flux density at 50A and with the temperature at 77 K. At this state a much higher air gap flux density can be obtained.

Due to the higher flux density (B) and higher current (i) the torque increases.

The red line shows the torque at room temperature with one amp.

The blue line shows the torque at 50A and at a temperature of 77 K. The torque is increased by a factor of 10 by using superconductors.

The blue line shows the flux density [B] as a function of current in the superconductor. It is seen that when increasing the current the flux density will also increase.

The red line shows that with increasing current the flux density has to be reduced to maintain the superconducting properties. From the curves it can be concluded that the superconductor is able to reach a maximum of 75A.

The red line shows the air gap flux density at room temperature. The superconductor acts as a normal copper conductor giving a maximum current of 1A. The maximum air gap flux generated at 1A is 1.8 mT. The blue line shows the air gap flux density at 50A and with the temperature at 77 K. At this state a much higher air gap flux density can be obtained.

Due to the higher flux density (B) and higher current (i) the torque increases.

The red line shows the torque at room temperature with one amp.

The blue line shows the torque at 50A and at a temperature of 77 K. The torque is increased by a factor of 10 by using superconductors.