Abstract

The motivation for the work originates from the demand of clean and eco-friendly energy by designing a Novel generator for wind power application. The permanent magnet synchronous generator (PMSG) is quite attractive type for this application because of high power density, high efficiency and robustness. The first objective of this thesis is to find a novel configuration of PMSG for wind application. Another objective is to develop and validate, a new model based on improved magnetic circuit approach for the analytical design of PMSG.

This thesis presents a novel dual stator permanent magnet synchronous generator for the direct drive wind power application. The stators consist of five phase fractional slot double layer winding in the inner and outer stator. The five phase windings enhance the fault tolerant capability and make the generator compact. The novelty is done in the structure of the rotor for perfect magnetic coupling of fluxes between both the airgaps. This coupling of fluxes enhances the airgap flux density which improves the power density of the generator. For this, the annular shape of rotor is segmented into eight equal parts which enhances the main airgap flux and reduces the local leakage fluxes. The combination of both the advantages namely magnetically coupling and multi-phase enable the distinct features like high power density, high reliability, and compact size.

For the electromagnetic analysis, the improved magnetic circuit (IMC) is proposed for the prediction of electromagnetic characteristic of two radial flux generator namely single stator single rotor PMSG (SSFP-PMSG) and Novel magnetically coupled dual stator Five phase PMSG (MCDSFP-PMSG). Since the airgap flux is the building block for the design of a generator so analytical expression is developed in terms of material properties and design

parameters. By using the air gap flux density expression, it becomes easier to optimize the design parameters in short duration. The structure of segmented rotor is also optimized to make the proposed machine light in weight and cost effective. With the optimized design, the magnetic field distribution, cogging torque, generated voltage and electromagnetic torque are computed. The designed generator is modelled analytically and analyzed. These results are compared with finite element method (FEM) and found in good agreement.

For the validation of the electromagnetic performances for both the generators SSFP-PMSG and MCDSFP-PMSG, the prototypes have been developed. The predicted electromagnetic performances from the improved circuit model (IMC) are found in close agreement with experimental results.

The thermal modeling has also been developed for both SSFP-PMSG and MCDSFP-PMSG. The lumped parameter model technique is adopted for this purpose. For the SSFP-PMSG, a simple model has been discussed which do not consider the radiation and axial flow of heat. The radiation and axial flow of heat are included in the thermal model of MCDSFP-PMSG. Thermal model is used to identify the requirement of suitable grade of PM material, winding insulation, and insulation of iron core laminations.