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Energy Procedia 34 (2013) 26 – 49

Energy Procedia

10th Eco-Energy and Materials Science and Engineering (EMSES2012)

Characteristic Requirements of a Small Scale Squirrel Cage Induction Generator for Effective Electricity Generation from Wind Energy

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Abstract

This paper proposes characteristic requirements of a small scale squirrel cage induction generator for effective electricity generation from wind energy. These characteristics are obtained from modeling and testing results. Investigation into comparative performances between Standard and high efficiency induction generators is given in order to find out the characteristic requirements of a suitable induction generator. Performances of various features of the machine structure are given. The suitable design of the induction generator based on empirical rules is also included. The investigation of power loss of the induction machine both in theory using FEM (Finite Element Method) and tests has been made. In addition, static var (Volt-Ampere reactive power) compensator using power electronic control to keep terminal voltage of a self-excited induction generator constant is explained. These results can be guidelines for machine development and control method for effective electricity generation.

Selection and peer-review under responsibility of COE of Sustainalble Energy System, Rajamangala University of Technology Thanyaburi (RMUTT)

Keywords: Squirrel cage induction generator; self-excited induction generator; static var compensator

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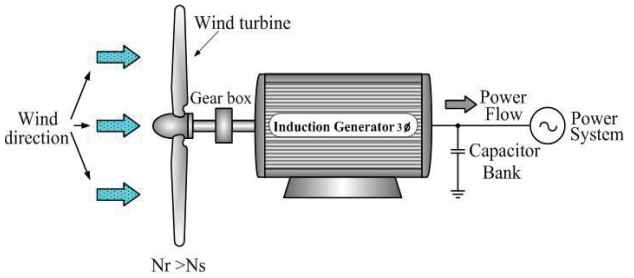
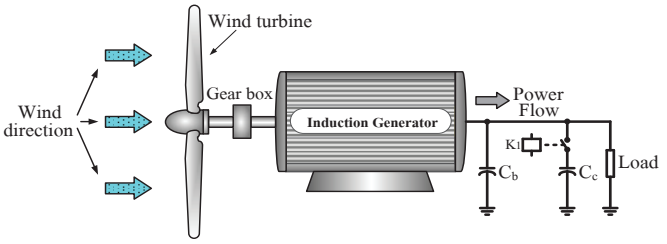
Selection and peer-review under responsibility of COE of Sustainalble Energy System, Rajamangala University of Technology Thanyaburi (RMUTT)
doi:10.1016/j.egypro.2013.06.731

1. Introduction

Wind energy is one of the most important sustainable energy resources since it is clean and available in some areas like coasts, mountains, etc. Due to lower maintenance demands and simplified controls, an induction generator seems to be a good solution for small hydro and wind power plants. A small self-excited stand-alone induction generator is likely found in remote areas where extension of grid is not economically viable. A grid connected induction generator is also one of the most attractive machine where wind energy is used to convert into electricity feeding back to the utility. It offers various advantages over other machines such as reduced unit cost, brushless rotor (squirrel cage construction), absence of DC excitation and ease of maintenance. This paper describes characteristic requirements of a squirrel cage induction generator to obtain good performance in effective electricity generation from wind energy under both grid connected and standalone operation. The characteristic requirements include voltage buildup capability, efficiency, power quality, machine structure, build-up voltage capacitor and compensating capacitor, etc. These characteristics are obtained from both modelling and testing results. Power quality of generated electricity from the induction generator is demonstrated. The capability of voltage buildup for each type of the induction generator during speed climb up and down is also given. As a consequence the suitable induction generators for a low speed wind energy application can be recommended.



(a)



(b)

Fig.1. (a) Grid – connected induction generator, (b) Self-excited induction generator

Operating behavior of a grid connected induction machine as shown in Fig.1(a) can be determined under two conditions namely, motoring mode and generating mode. Such important conditions can be considered from a slip value given in (1)-(2). When induction machines are applied to convert mechanical power into electrical power, the induction machine is called as an induction generator. The induction generator is, in fact, an induction motor which is driven above its synchronous speed to produce electrical energy. The same machine, operating as a motor, consumes electrical energy to drive a