Power Management of Wind-Diesel Hybrid System

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Abstract— Modeling of a wind diesel hybrid system (WDHS) is done to perform under varying wind and load conditions on MATLAB Simulink platform. The hybrid system is design in such a way that under low wind conditions, a diesel generator feeds required power to the load. A load flow controller is designed for WDIS to control the load flow depending on the load condition. The power controller reduces the fuel consumption and running costs of generating of hybrid system. The frequency of the system is also monitored. The models of the generation units, the power system and frequency-power control are developed and simulation studies have been performed under various conditions using Mat lab/Simulink. It has been demonstrated that this system can provide reliable and good quality power to the customers in WDIS systems.

Key words: WDIS, Load Flow Control, Performance Analysis, Dump Load

I. INTRODUCTION

In this paper, these two systems models are integrated to form a model of the hybrid generation system as explained in the following paragraphs. The hybrid system presented in this paper comprises of a wind turbine generation system acting as the renewable source of energy and a Diesel generation system serving as the conventional source of energy. In this paper, the frequency is controlled and generator is start/stop automatically when needed. This methodology can reduces a fuel cost and power consumption of the hybrid system.

The dynamic consumers in the remote area who are not connected to the grid system or by the main electrical network, hybrid system such as wind/diesel generator have been considered as the most reliable, preferred and attractive alternative source of power supply. Reference [2] presents the modeling and performance analysis of wind/diesel hybrid generating system by regulating the frequency and voltage output of the wind turbine generator.

In order to find transient performance problems and penetration limits associated with the connection of wind turbines in isolated diesel supplied power systems, a computer program has been developed in [3]. The modeling of the main components of the system, and the method used for the identification of the parameters of the diesel-generator units, are described. Frequency and voltage variations obtained by the diesel units model, are compared experimentally obtained results. This paper introduces the hybrid system of two generating system i.e. Diesel generating system and wind turbine generation system in section 3.

Section 4 describes the component Wind Diesel generation System. Section 5 shows the control strategies of the isolated hybrid system for Diesel generator by power controller with Fuzzy logic application to reduce the fuel cost and power consumption when needed. Section 6 shows the performance and simulation results of the WDHS with power controller and without and without power controller. Conclusions have been made in section 6.

II. TYPES OF WIND ENERGY SYSTEMS

Wind turbines are generally classified on two basis i.e. one on the basis of axis and one on the basis of machine used for generation. Horizontal-axis wind turbines (HAWT) have the main rotor shaft and electrical generator at the top of a tower, and must be pointed towards direction of the wind. Turbines used in wind farms for commercial production of electric power are usually three-bladed and pointed into the wind by computer-controlled motors. They have high tip speeds of over 320 km/h (200 mph), high efficiency, and low torque ripple, which contribute to good reliability. The blades are usually colored white for daytime visibility by aircraft and range in length from 20 to 40 meters or more. The tubular steel towers range from 60 to 90 meters (200 to 300 ft) tall. The blades rotate at 10 to 22 revolutions per minute. At 22 rotations per minute the tip speed exceeds 90 meters per second (300 ft/s). Vertical-axis wind turbines (VAWTs) are a type of wind turbine where the main rotor shaft is set vertically and the main components are located at the base of the turbine. Among the advantages of this arrangement are that generators and gearboxes can be placed close to the ground, which makes these components easier to service and repair, and that VAWTs do not need to be pointed into the wind. On the basis of generator used, wind turbine are majorly classified as squirrel case induction generator and doubly fed induction generator (Wound Type). Squirrel cage generators have slip, and hence the rotor speed of a squirrel cage induction generator varies continuously with the amount of power generated.

III. WIND DIESEL GENERATION SYSTEM

A hybrid generation system consisting of a WTGS and a DGS along with the power electronic interfacing is presented in this section. Fig. 2.1 shows the block diagram of the proposed system. The WDIS uses a 480 V, one 300 kVA synchronous machine, a wind turbine driving a 480 V, 275 kVA induction generator, a 200 kW and 150 kW customer load, at wind speed of 6m/s and 14m/s respectively with a variable secondary load 0 to 446.25 kW.

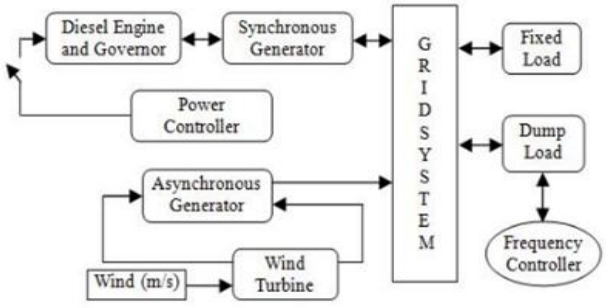

Fig. 3.1: Hybrid Wind Diesel Grid System Block Diagram

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Turbine for generating mode. In this paper we are taking wind speed is 6m/s for low wind power generation and wind speed is 14m/s for high wind power generation connected to the grid system. The wind speed produces negative electromagnetic torque to SCIG through wind provides electricity to fixed and variable load directly. (SCIG) is connected to grid system and this generator

IV. COMPONENTS OF WDIS

A. Wind Generation System:

The wind turbine model as shown in figure 4.1 is based on the steady-state power characteristics of the turbine. The stiffness of the drive train is infinite and the friction factor and the inertia of the turbine must be combined with those of the generator coupled to the turbine. The output power of the turbine is given by the following equation.

It was demonstrated that for fixed speed WTGS the power modeling from curve at stationary wind speed assumption is sufficient for power system studies. This figure is obtained with the default parameters (base wind speed = 12 m/s, maximum lower at base wind speed = 0.73 p.u. (= 0.73) and base rotational speed = 1.2 p.u.)

B. Diesel Generator System:

The basic components of a diesel generation system are: engine, governor, excitation and synchronous generator. A governor can be defined as a mechanical or electromechanical device for automatically controlling the speed of an engine by relating the intake of fuel. Several types of governors exist as mechanical-hydraulic, direct mechanical type, electro hydraulic, electronic and microprocessor based governors.

V. POWER CONTROLLER

This strategy is mainly used for reducing the fuel consumption and running cost of the diesel generator. The power controlled is designed with fuzzy logic. The power controller is connected to diesel engine and governor through a switch. This controller compares the load power and wind power and produces an error. The error is negative value or positive/zero value. This error can start or stop the Diesel generator. If the error has negative value it means load power consumption is less than wind power generation. It means extra generation will not need. In this condition, switch will be OFF and reference speed is zero, mechanical power is also zero. So Synchronous generator will not generate any power. Fixed speed wind turbine generation is enough to supply the load power demanend means extra generation will not need. In this condition, switch will be OFF and reference speed is zero, mechanical power is also zero. So Synchronous generator will not generate any power. Fixed speed wind turbine generation is enough to supply the load power demand

VI. PERFORMANCE AND SIMULATION RESULTS

In this study, the performance of WDIS with power controller at different wind speed and load is shown by using MATLAB/SIMULINK. Here diesel generator component would control the voltage and frequency by means of the exciter and governor. The diesel generator automatically start or stop when wind turbine generator have enough power supplied to load demand . The performance of WDIS is performed with frequency and power controller, without frequency controller, and without power controller. In with frequency and power controller, a controller is designed for the dump load to consume excess power output from the wind turbine when the diesel powered generation is at minimum.

A. When the Wind power is less than load

In this case a wind speed is 6 m/s is applied to the wind turbine and fixed load of 200kW is connected to the system including consumer load of 25kW. At this wind speed, wind turbine produces the negative electromagnetic torque to induction generator which generates the wind power of 22.79kW. The power consumption by load is 198.8 kW which is greater than wind power generation thus no need to generate the extra power. The automatic power controller stops the diesel generator. Now the diesel generator system consume the power (-1.52 kW) and power consumption by secondary load is 94.66kW. The frequency is controlled to 60.01 Hz by frequency regulator. The variation of frequency, wind power, and diesel power, are sho

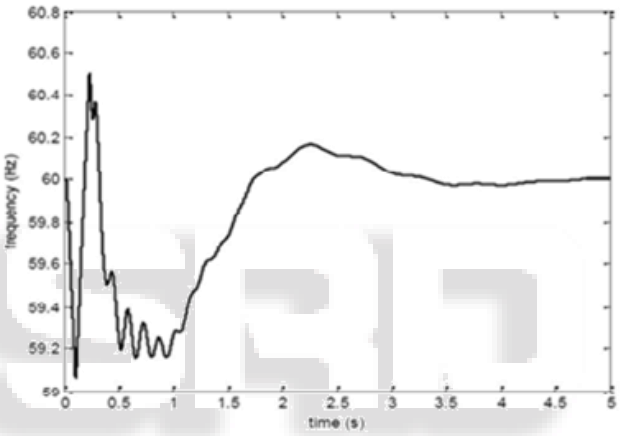

Fig. 6.1: Frequency Response of System

B. When the Wind power is more than load

When the wind power is greater than load power: In these cases winds speed = 14 m/s is applied to the wind turbine and fixed load of 150kW is connected to the system including consumer load of 25 kW. At this wind speed, wind turbine produces the negative electromagnetic torque to induction generator which generates the wind power of 246.4 kW. The power consumption by load is 150.2 kW which is less than wind power generation, thus no need to generate the extra power and respectively. The automatic power controller stops the diesel generator. Now the diesel generator system consume the power (-1.52 kW) and power consumption by secondary load is 94.66kW. The frequency is controlled to 60.01 Hz by frequency regulator.

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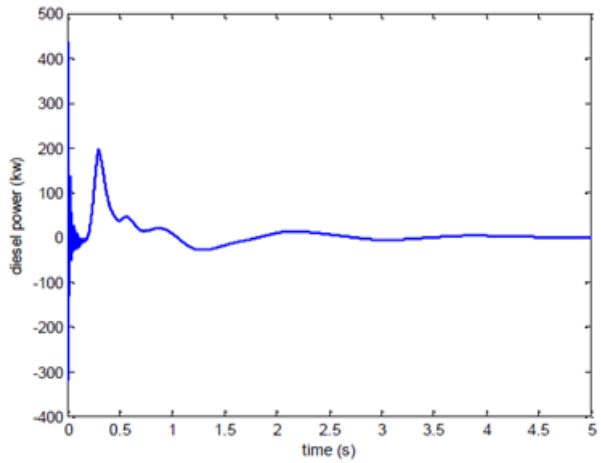

Fig. 6.2: Diesel Generator Power

The variation of frequency, wind power, and diesel power as shown in figure

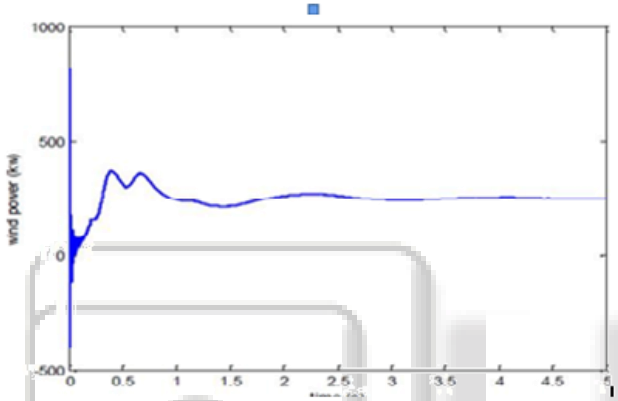

Fig. 6.3: Wind Generator Power

VII. CONCLUSION

The isolated diesel wind turbine generation system is developed and implemented by using MATLAB / SIMULINK. The system is simulated for different cases involving variation in wind speed and connected to the system. The system is simulated for different cases involving variation in wind speed and connected to the system. As the wind turbine output depends on wind speed which varies time to time, a diesel generator with automatic power controller is coupled to the system to make the power output of the hybrid system more reliable.

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