A REVIEW ON FAULT DIAGNOSIS IN WIND ENEGY CONVERSION SYSTEM

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ABSTRACT

Electrical energy production based on wind power has become the most popular renewable resources in the recent years because it gets reliable clean energy with minimum cost.The major challenge for wind turbines is the electrical and the mechanical failures which can occur at any time causing prospective breakdowns and damages and therefore it leads to machine downtimes and to energy production loss. Hence, there is an increasedneed to establish a proactive maintenance for wind turbine machines basedon remote control and monitoring. In this paper the thefaults in wind turbine and monitoring of DIFG and turbine blade is viewed.Wind turbine blades can be diagnosed by measuring the power spectrum density at the generator terminals.

Keyword; Fault, turbine, blade, generator, spectrum.

1. INTRODUCTION

The increasing demand in energy over the world, as well as the growth in the prices of the energy fossil fuels resources and it exhaustion reserves in the long run, furthermore the commitment of the governments to reduce greenhouse gases emissions have favoured the research of others energy sources. In this context, the recourse to renewable energy becomes a societal choice.[1] In recent years, wind energy has had great development due to the ongoing need for renewable energy. At the same time, the failure rate of key components in wind turbines has greatly increased because of severe operational environments. The wind turbine gearbox is one of the most fragile components in the turbine because of extreme differences in temperature and complicated alternating loads from wind turbulence. In many wind farms throughout the world, gearboxes fail only several thousand hours after wind turbine is put into operation, and its service life is much less than designed.Therefore, a predictive monitoring scheme of wind turbines, allowing an early detection of electromechanical faults, becomes essential to reduce maintenance costs and ensure continuity of production.Barszcz and Randall [2] detected a tooth crack in the planetary gear of a wind turbine using spectral kurtosis. Yang et al. [3] usedContinuous wavelet transforms to diagnose gearboxes in wind turbine test ring.

2. FAILURE MODE ANALYSIS

Real wind turbine failure data quantitative analyses have shown important features of failure rate values and trends. For illustration, Fig. 2.1 shows the main wind turbine components that are concerned by the above failure analyses.

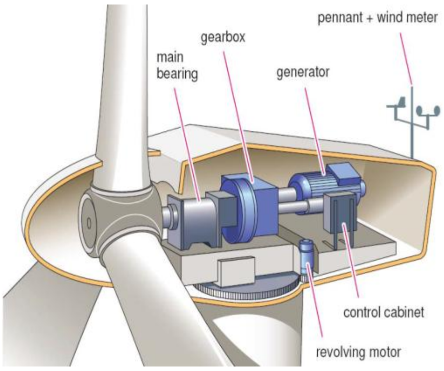

Fig2.1. Wind turbine nacelle cross-section.

In the first study concerning Swedish wind power plants ; it has been shown that most failures were linked to the electric system followed by sensors, and blades/pitch components. This is clearly illustrated by Fig.2.2 that shows failures number distribution for Swedish wind power plants that occurred between 2000 and 2004.[4

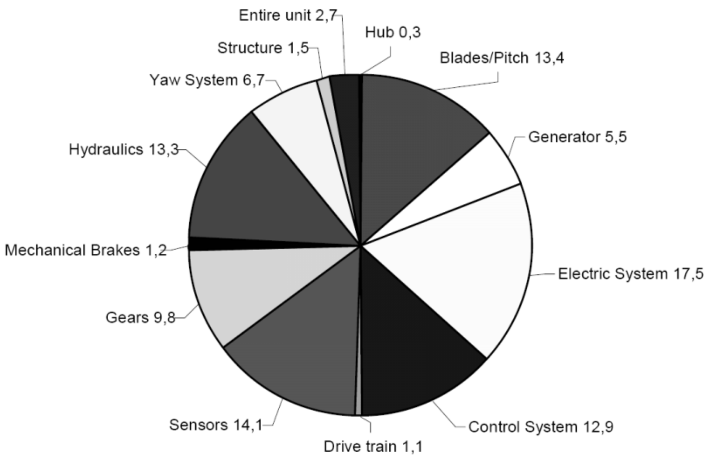

Fig.2.2. Failures number distribution [%] for Swedish wind power plants.

3. PROBLEM FORMULATION

It has several limitations both in terms of performance and installation cost. This is the result of various reasons:

(1) Cable structure monitoring with its problems (cuts, noise, and configuration), mainly through fiber optic, is not effective and not appropriate since wind parks are often deployed over a large geographic area having environmental obstacles such as offshore, desert, mountains, rivers, forests and plains that are located far away from the control center.

(2) Wind turbines monitoring need to implement a proactive maintenance system based on an early, fast and real time fault detection and diagnosis, allowing a secure and reliable communication for better maintenance management. This strategy avoids failures leading to serious damages, expensive repair and production loss.

(3) The storage of the monitored parameters in the control center database is a need, because it is an essential operation which helps to monitor accurately the lifetime of the wind turbine components. Therefore, it allows exploiting collected data for studying statistically the most occurring faults and their timing.

To overcome these imposed application constraints, an interactive embedded system has been designed to provide an efficient, reliable and economical link between various wind turbine sensors for an accurate remote controlling and monitoring scheme.[5]

4. VIBRATION SIGNAL OF GEARBOX ANALYSIS

During gear mesh in the gearbox, the excitation due to variable stiffness generates vibration signal consisting of typical multi-harmonic components. The signal above mentioned can be described as [6]:

$$x(t) = \sum_{m=1}^{M} x_m \cos(2\pi f_z mt + \varphi_m), \qquad (1)$$

where $x(t)$ denotes the vibration time signal of gearbox, $x_m$denotes the amplitude of the m order harmonic, $\varphi_m$denotes the phase of the m order harmonic, and $f_z$denotes the gear mesh frequency, which is also a carrier frequency.

When a defect happens in a gear system, there will be a multi-component amplitude modulation phenomenon in the gearbox vibration signal. The modulation function can be shown as:

$$a_m(t) = \sum_{n=1}^{N} A_{m,n} \cos(2\pi f_n nt + \alpha_{m,n}), \qquad (2)$$

Where $a_m(t)$ denotes a amplitude modulation function, $A_{m,n}$ denotes the amplitude of the n order harmonic of the modulation function, $\alpha_{m,n}$denotes the phase of the n order harmonic of the modulation function, and f_n denotes the rotational frequency of the shaft fixed with defective gear, which is also a modulation frequency. From Eqs. (1) and (2), the model of gearbox vibration signal with fault modulation can be shown as:

$$x(t) = \sum_{m=1}^{M} x_m \left[1 + a_m(t)\right] \cos\left(2\pi f_z mt + \varphi_m\right). \qquad (3)$$

5. FAULTS IN WIND TURBINE GENERATOR

The wind generator is subjected to various electro-mechanical failures that affect mainly five components: the stator, the rotor, the bearings, gearbox and/or air gap (eccentricity) [5]. These faults require a predictive detection to avoid any side effect causing a breakdown or a fatal damage. However, these defaults require periodic monitoring to avoid any unforeseen deterioration. Recent researches have been directed toward stator current supervision. Particularly, the current spectrum is analyzed to extract the frequency components introduced by the fault. A summary of wind turbines faults and theirs related frequencies are presented in

table 1. wind turbines faults signatures

Failure	**Harmonic frequencies**	**Parameter**
Broken rotor bars	$f_{brb} = f_0 [k(1-s / p) \pm s]$	K = 1, 3, 5,...
Bearing damage	$f_{bng} = / f_0 \pm k f_{i,o} /$	K = 1, 3, 5,.... $f_{i,o} = 0.4$ $n_b fr$ **TO** 0.6 4 nbfr
misalignment	$f_{mis} = / f_0 \pm k f_r /$	K = 1, 3, 5, ...
Air gap eccentricity	$f_{ecc} = f_0 [1 \pm m(1-s / p)]$	m = 1, 2, 3, ...

Where $f_0$is the electrical supply frequency, s is the per-unit slip, $p$is the number of poles, f_r is the rotor frequency, n_b is the bearing balls number, $f_{i,o}$ is the inner and the outer frequencies depending on the bearing characteristics, and $m, k \in \mathbb{N}$.[7]

6.CONDITION MONITORING AND DIAGNOSIS

In the case of wind turbine condition monitoring, a number of published work are based on the following hypothesis: It is possible to detect wind turbine drive train faults through the terminals of the associated generator.The basic configuration that is used for WECS condition monitoring and diagnosis is shown by Fig. 6.1.

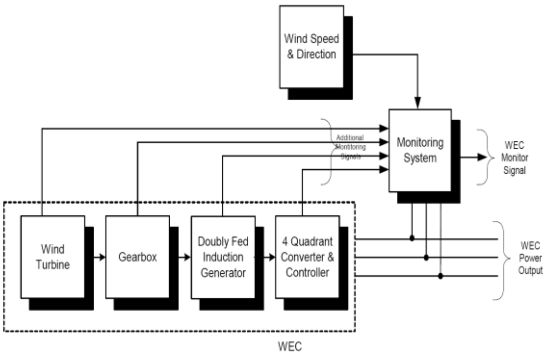

Fig.6.1. Basic architecture of WECS condition monitoring and diagnosis

6.1 Electrical System (DFIG) Condition Monitoring

This technology used for monitoring includes sensors, which may measure speed, output torque, vibrations, temperature, flux densities, etc. The most popular methods of induction machine condition monitoring utilize the steady-state spectral components of the stator quantities. These stator spectral components can include voltage, current, and power and are used to detect turn faults, broken rotor bars, bearing failures, air gap eccentricities.

The above techniques that are based on steady-state analysis are being applied to induction generators. It has been found that fault detection and diagnosis techniques are mainly arranged for inter-turn stator faults and stator or rotor asymmetries [8]. The authors are using the rotor modulating signals spectra as a diagnosis index for the stator and rotor faults characterization.

The authors have raised a key feature of wind turbine generator operations. Indeed, they are predominantly transient, therefore prompting the use of nonstationary techniques for fault detection [9]. In this case, wavelet analysis has been used to the detection of stator turn faults in a DFIG. The detection algorithm is a combination of the Extended Park Vector, wavelet analysis, and statistics. This technique was not affected by changes in DFIG speed, which is crucial in WECS applications. One of the preferred options at present, for large turbines in excess of 2-MW rating, is the variable speed DFIG with the rotor converter connected to the rotor via slip rings [10]. However, in contrast to squirrel cage generators there are additional wear parts, e.g. the slip ring system (Fig. 6.2). Therefore, the authors are suggesting a patented diagnostic technique for the monitoring of the transmission properties and sparking of DFIG with slip rings. In this case, modifications in the transmission properties are diagnosed using the monitored rotor currents through FFT analysis.

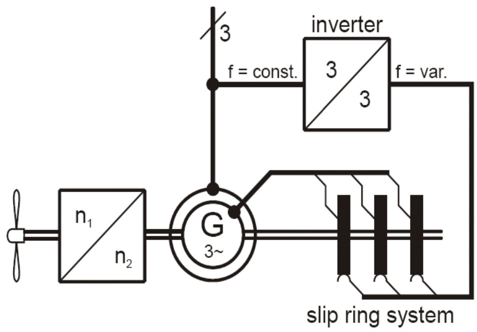

Fig.6.2.Slip ring generator system principle.

6.2 DAMAGE DETECTION OF WECS BLADES

Wind turbine blades are a vital component. Due toexternal conditions and internal stress as well as fatigue, thecrack and damage may gradually take place as time goes by,thus leading to the performance deterioration of windgeneration. In other words, it is crucial to monitor the turbineblades such that the operation performance can be betterensured. The authors used the above mentionedhypothesis to detect the presence of unbalance and defects inthe blades of a small wind turbine by measuring the powerspectrum density at the generator terminals.This is a veryuseful technique as it requires no additional sensors,particularly on the blades, which is the case in [11], where acontinuous wavelet transform-based approach is used todetect blades damage. To prevent damage, bladesare equipped with a lightning protection system, as mostmodern WECS [12] (Fig. 6.3). However, as lightning is randomin nature, a complete protection against its damages is notachievable. Therefore, in is presented a method forlightning impact localization and classification using a fiberoptic current sensor network that helps to detect damagescaused by lightning and to monitor the blades. The system isconnected to the wind turbine control and monitoring.

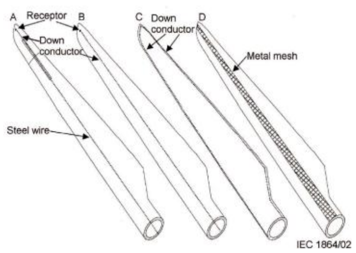

Fig.6.3. Lightning protection for large modern wind turbine blades

CONCLUSION

This paper has review the state of art of wind energy conversion systems condition monitoring and diagnosis. The emphasis has been put on faults that could be monitored using the wind turbine generator (DFIG) terminals in an attempt to use well-established techniques developed for induction motors. An empirical mode decomposition can decompose the vibration signal of field gearbox andextract the fault feature frequency from an intrinsicmode function adaptively it has been found that unbalance and defects in small wind turbine blades can be diagnosed by measuring the power spectrum density at the generator terminals. This was also the case of WECS gearbox. However,the future work will be focused on the test and application of the whole monitoring system in the practice.

REFERENCE

[1]SaadChakkor University of AbdelmalekEssaâdi, Faculty of Sciences, Department of Physics, communication and detection systems laboratory, tetouan, morocco, wind turbine fault detection system in real time remote monitoring.

[2] Wei Teng, North China Electric Power University, School of Energy Power and Mechanical Engineering, China, pitting fault detection of a wind turbine gearbox using empirical mode decomposition.

[3]YassineAmirat, Mohamed Benbouzid, BachirBensaker, Rene Wamkeue, condition monitoring and fault diagnosis in wind energy conversion systems: a review

[4] BaghouriMostafa , Department of Physics, Team: Communication and Detection Systems, University of AbdelmalekEssaâdi, Faculty of Sciences, Tetouan, Morocco.

[5]Barszcz, T., Randall, R.B. (2009).Application of spectral kurtosis for detection of a tooth crack in the planetary gear of a wind turbine. Mechanical systemsand signal processing, vol. 23, no. 4, p. 1352-1365.