Study and Analysis of Power Generation from Wind Turbine using Multi Physics of Homer

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Abstract— This report starts discussing a number of possible risk analysis methods related to different challenges identified by INOX wind energy industry, and it ends up with case studies on all those different challenges by testing method and proposing risk reducing measures with complete layouts and checklist. I answer to all the questions, which are defined in the thesis assignment. I consider different risk analysis techniques and suggest a few of them for each individual challenges in a tabular fashion. I describe the proposed risk analysis techniques with their strengths and limitation and discuss, to a considerable extent, how they can be related to the challenges. The risk analysis technique HOMER which was suggested includes both technical and human error related methods. The technical related methods are based on some available risk analysis methods which are broadly acceptable in different applications. The human error analysis techniques, which have been practiced in nuclear industry, are the main focus in this report as it is believed that the techniques are applicable in the wind firm industry.

Keywords: Horizontal-Axis Wind Turbine (HAWT), Vertical-Axis Wind Turbine (VAWT), Homer

I. INTRODUCTION

A. *Horizontal-Axis Wind Turbine (HAWT)*

Horizontal-Axis Wind Turbines (HAWT) has the main rotor shaft and electrical generator at the top of a tower, and must be pointed into the wind. Small turbines are pointed by a simple wind vane, while large turbines generally use a wind sensor coupled with a servo motor. Most have a gearbox, which turns the slow rotation of the blades into a quicker rotation that is more suitable to drive an electrical generator.

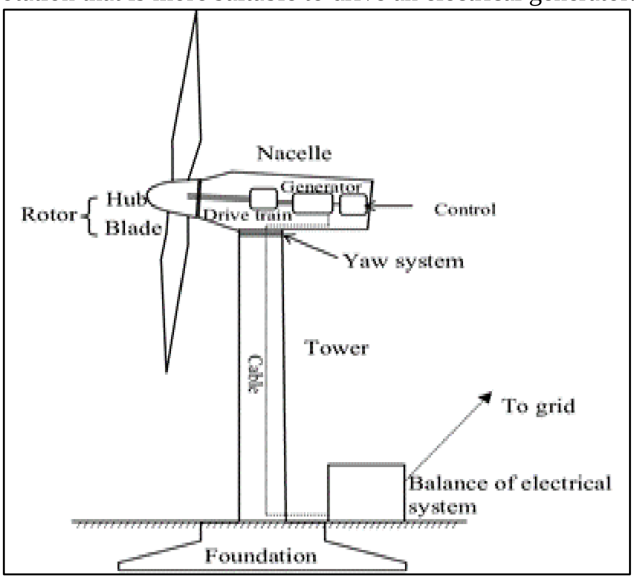

Fig. 1: Horizontal axis wind turbine [1]

B. *Vertical-Axis Wind Turbine (VAWT)*

Vertical axis wind turbines are a type of turbine where the main rotor shaft runs vertically. These turbines can rotate unidirectional even with bi- directional fluid flow. VAWT is mainly due to the advantages of this kind of machine over the horizontal axis type, such as their simple construction, the lack of necessity of over speed control, the acceptance of wind from any direction of the mechanical design limitations due to the control systems.

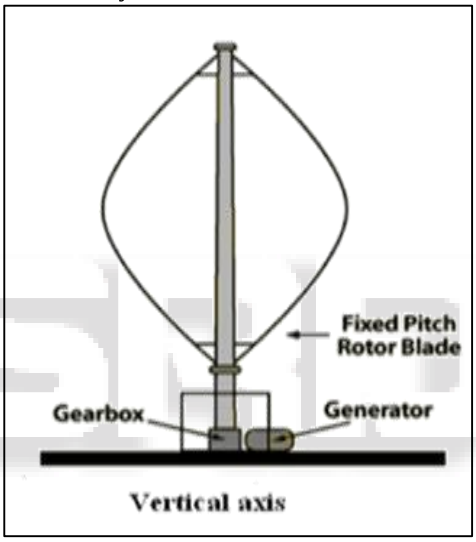

Fig. 2: Vertical axis wind turbine [1]

Ian Prowell et.al [4] various sources of risk exist for all civil structures, one of which is seismic risk. As structures change in scale, the magnitude of seismic risk changes relative to risk from other sources. This paper presents an introduction to seismic hazard as applied to wind turbine structures. The existing design methods and research regarding seismic risk for wind turbines is then summarized. Finally a preliminary assessment is made based on current guidelines to understand how tower moment demand scales as rated power increases. Potential areas of uncertainty in the application of the current guidelines are summarized.

N. Booij et.al [5] a third-generation numerical wave model to computer random, short crested waves in coastal regions with shallow water and ambient currents (Simulating Waves Near shore (SWAN)) has been developed, implemented, and validated. The model is based on an Eulerian formulation of the discrete spectral balance of action density that accounts for refractive propagation over arbitrary bathymetry and current fields. It is driven by boundary conditions and local winds. As in other third-generation wave models, the processes of wind generation, white capping quadruplet wave-wave interactions, and bottom dissipation are represented explicitly. In SWAN, triad wave-wave interactions and depth-induced wave breaking are added. In contrast to other third-generation wave models, the numerical propagations scheme is implicit, which implies that the computations are more economic in shallow water. The model results agree well with analytical solutions, laboratory observations and (generalized) field observations.

Mahmood Shafiee et.al [6] Failure mode and effects analysis (FMEA) has been extensively used by wind turbine assembly manufacturers for analyzing, evaluating and prioritizing potential/known failure modes. However, several limitations are associated with its practical implementation in wind farms. First, the Risk-Priority-Number (RPN) of a wind turbine system is not informative enough for wind farm managers from the perspective of criticality; second, there are variety of wind turbines with different structures and hence, it is not correct to compare the RPN values of different wind turbines with each other for prioritization purposes; and lastly, some important economical aspects such as power production losses, and the costs of logistics and transportation are not taken into account in the RPN value. In order to overcome these drawbacks, we develop a mathematical tool for risk and failure mode analysis of wind turbine systems (both onshore and offshore) by integrating the aspects of traditional FMEA and some economic considerations. Then, a quantitative comparative study is carried out using the traditional and the proposed FMEA methodologies on two same types of onshore and offshore wind turbine systems. The results show that the both systems face many of the same risks; however there are some main differences worth considering.

Josua Kirsch et.al [8] this project envisages the design and implementation of a small wind turbine for electric power generation: 1-5 kW. The project encompasses the mechanical design of the wind blades, tower, gearbox, and choice of the proper electricity generator. The ability to provide a feasible and reliable electrical supply shall be emphasized. Connection to electricity networks with the associated proper frequency and voltage requirements and the involved technical modifications is described and discussed. The wind turbine shall be tested under local conditions in Toowoomba and Ipswich.

M. Ragheb et.al [9] The reliable, safe and beneficial operation of wind turbines requires the use of a number of Engineered Safety Features (ESFs), much like any other engineered device. Identification of the possible failure modes under severe wind conditions, risks and hazards will lead to future even more reliable and safer wind turbine designs. The design lifetime of wind turbines is about 20 years, over which they have to be operated reliably and safely even under hazardous stormy conditions. This presents a design challenge for present and future turbine designers. In comparison, automobile engines are designed to operate for about 5,000 hours, whereas wind turbines are expected to operate with a capacity or intermittence factor of 0.40 for:

$$20 \text{ Years } \times 365.12 \frac{\text{Days}}{\text{Years}} \times 24 \frac{\text{Hours}}{\text{Days}} \times 0.40$$
$$= 70{,}103 \text{ Hours}$$

II. OBJECTIVES

Based on the literature review presented below the objectives of the present study is identified as follows:

1) To study various factors of hazards and risk in wind energy generating industry.
2) To study various PPE’s related to the industry which is responsible for the safety of worker as well as environment.
3) The study also provides the respective audits and layouts for efficient environment.

III. METHODOLOGY

1) A thorough literature review to understand the seismic evaluation of past work done by researchers was done by me in detail.
2) Select an existing method of calculating risk and hazards and find a best solution to resolve.
3) A modified audit sheets was prepared by me using the methodology of HAZOP.
4) Carry out various audits with respect to the standard PPE’s selected in the theoretical portion by the company.

A. Periodic audit

All Sites shall undertake HSE Audit at periodic intervals. Such audit shall be as per the below schedule

1) Annual Site HSE audit – Such audit shall be organized by the Corporate HR function to reviews all the aspect of HSE Management and compliance to all HSE Guideline.
2) Quarterly safety audit will be done by external agency.
3) Half yearly cross audit –interstate internal safety audit by site safety personals.
4) Periodic Specific Audit – Such audit shall include the following and shall be conducted by external agencies
5) Ambient air testing once in 6 months
6) Noise Test once in 6 months
7) Fauna audit once in 6 months

Date/Time	21/12/2016	Location	Sajapur		WTG’s condition On/Off
Site	Sajapur	Cluster/Section	Reference PTW no:		
Frequency			Submitted to		
	USS				
Sr no	Check points		Yes	No	Remarks
1	Are the USS yard Gate is locked?		Y		
2	Ensure USS yard 9 Earth pits champers is available in Good condition.		Y		
3	Check yard fencing free from damage & corrosion.		Y		
4	Check availability of 3 no’s Fire buckets with Sand inside the yard.			N	Available Update

5	Yard cleaning- Free from grass, Bushes and unwanted material		N	Working
6	Check Yard light is glowing & their MCB boxes are in Good condition	Y		
7	VCB/ C&R control panels door closed and secured:		N	In Progress
8	Check Transformer oil leakage/spillages over yard & level indicator is OK	Y		
9	Check WTG's 3 Earth pit pipe, wall and cover is OK free from damage?	Y		
10	Other If Any		N	
	WTG			
1	Are the Turbine main entrance door is locked?	Y		
2	Please specify if any abnormal sound Coming from HUB/Nacelle.		N	Checking
3	Is the site approach road condition is Good and free of muddy water.	Y		
4	Is the turbine kept clean and tidy? (Ex: Good Housekeeping, Grass cutting)	Y		
5	Check WTG's surrounding land cultivated by local or any observation?	Y		
6	Check Tower walls are any Paint peel off/ Scribble by unknowns?	Y		
7	Fire Extinguisher available inside	Y		
8	Rubber mats available in front off panel	Y		
9	Relevant Safety Singes / Safety Stickers/Emergency Contact No/	Y		Available
10	Ladder Condition is ok or not	Y		OK
11	Panel door properly closed or not	Y		
12	First aid kit available at & near work site	Y		
13	Electrical equipment (viz. Electrical connections, Power distribution board etc.)& accessories checked for good working condition	Y		
14	Other If Any		N	
	Security			
1	Check Employees/Contractors are using PPE's work at site.	Y		
2	Check and confirm presence of security Personnel during site rounds?	Y		
3	If any nuisances or ROW issues?		N	
4	Other If Any		N	
	Environmental Assessment			
1	Any feathers/scavenged body parts of birds found around/inside WTG's/USS?		N	
2	Any Complaint about Noise/Other Grievance received from Indigenous peoples?		N	
3	Each & every (Waste) material which can harm environment has collected from site. If no please specify in detail & Intimate to Concern person immediately.	Y		

Table 1: Site Inspection Checklist

Sr. No.	DESCRIPTION	GROUP	PERIOD	CONDUCTED BY
1.	HSE induction briefing	All	While joining	HSE team
2.	HSE management programmed	Project in-charge, O & M in-charge(state head) section heads, Engineers	Quarterly	HSE Manager
3.	Trade and skill training	Site engineer/ Supervisor	Every 2 months from start of work	In-house or institutional
4.	Safety motivation programmed (Audio visual)	Workers/Supervisors/Engineers	Quarterly	HSE Manager in coordination with Project/ O & M , in-charge(state head)

5	Other Safety Training e.g.(Fire protection, Rescue system, statutory requirements, Health emergencies, Environmental programmed, and other wind farm activities related safety training etc.	Workers/ Supervisors/ Technicians/ Engineers/ Specific team members	Quarterly	HSE Manager in coordination with Project/ O & M , in-charge(state head)

Table 2: HSE Training Chart

IV. Conclusion

A. Job Safety Analysis (JSA)

All JSA shall be done in the approved format as given in Annexure - I Compulsorily a JSA shall be required for the following tasks:

1) Anynewornon-routine task that has not been performed before on site that may be hazardous.
2) All permit work, confined space entry, hot work, lockout-tag out, electrical, etc.
3) Work including high levels of pressure, electrical voltage, chemical concentration, heights, noise, etc.
4) Deep excavations, pile driving, excavations near existing /glinesor cables.
5) Use of arcane supported work platform.
6) Pneumatic orhydro testing of pipelines equipment
7) Critical lifts, major lifts, heavy lifts, high lift so lifts over equipment.
8) Erection of tall structures, elevators, tower cranes, ringer cranes, etc.
9) Elevated work where no engineering fall protection is provided.
10) Work over or near water.
11) Work over or near high voltage power lines
12) Work involving specialized equipment: drilling pile.
13) Use of toxic or hazardous substances: chemical cleaning.
14) Use of explosives or radiation sources.
15) Commissioning activities
16) WTG Maintenance work
17) GSS maintenance work
18) USS maintenance Work
19) Replacement of Heavy equipment’s
20) Any new technology or tasks identified at weekly safety meeting.

Position	Safety equipment	Number	Function
27	Blocking bolt	1	Fixes the crane
28	Emergency stop button at the operating unit of the crane	1	Stops the crane immediately and switches current off
29	Emergency stop switch	4	Stops the WEC and switches current off
30	Protective cover	1	Prevents access to the gear rim of the yaw system
31	Protective cover	1	Prevents access to the brake-coupling unit
32	Rotor Lock	1-2	Locks the rotor in position for entering the hub
33	with separating skirting and hatches	2-3	Protects personnel standing at the bottom from falling objects
34	catching device	2	Protects climbing personnel from falling
No Figure	Emergency descending aid	1	Enables escape from the nacelle in an emergency situation

Table 3: Safety Chain Restating

References

[1] Yamini Sarathi, Khemraj Patel, Arti Tirkey, Prakash Kumar Sen and Ritesh Sharma. Study on wind turbine and its Aerodynamic performance, IJMERR: 2015, Volume 04, Issue 01.

[2] Benjamin McLellan, Qi Zhang, Hooman Farzaneh, N. Agya Utama and Keiichi N. Ishihara. Resilience, Sustainability and Risk Management: A Focus on Energy, Challenges: 2012, ISSN 2078-1547

[3] Chunhui Zhou, Xin Liu, Langxiong Gan. Assessment and Countermeasures for Offshore Wind Farm Risks Based on a Dynamic Bayesian Network, Journal of Environmental Protection: 2018, Issue 09

[4] Ian Prowell and Paul Veers. Assessment of Wind Turbine Seismic Risk: Existing Literature and Simple Study of Tower Moment Demand, SAND: 2009-1100

[5] N. Booij, R. C. Ris, and L. H. Holthuijsen. A third-generation wave model for coastal regions, Journal of geophysical research: 1999, Volume 104, Issue C4.

[6] Mahmood Shafiee, and Fateme Dinmohammadi. An FMEA-Based Risk Assessment Approach for Wind Turbine Systems: A Comparative Study of Onshore and Offshore, Energies: 2014, ISSN 1996-1073

[7] Maria A. Kougioumtzoglou, Iraklis Lazakis. Developing a Risk Analysis and Decision Making Strategy for an Offshore Wind Farm, Cyprus Sea Lines Co Ltd., Greece: 2017

[8] Josua Kirsch. Design of a small wind turbine for electric power generation (1-5kw), University of Southern Queensland: 2009

[9] Cun-Zheng Ning, Semiconductor nano lasers and the size-energy-efficiency challenge: a review, Spie digital library: 2019

[10] The solar cell under illumination, Alternate lectures: The PV Cells Principal. PV Lecture House: 2016

[11] M. Sojoudi and R. Madatov. Simultaneously Improvement of Heterojunction Solar Cells Efficiency by Electron Irradiation and Varying Series and Parallel

Resistances. Research Journal of Applied Sciences, Engineering and Technology: 2012, ISSN: 2040-7467
[12] I-V and P-V curves of a solar cell, Short-Circuit Current, PV Educationas: 2015
[13] Yu Xie, Manajit Sengupta, A Fast All-sky Radiation Model for Solar applications with Narrowband Irradiances on Tilted surfaces (FARMS-NIT): Part I. The clear-sky model, Solar Energy: 2018, 691-702
[14] E-Facts, Hazard identification checklist: occupational safety and health (OSH) risks in the wind energy sector: 2014
[15] Rambool, Mitigating the risk in wind power, Risk analysis in wind power: 2016
[16] Siraj Ahmed, Wind Energy: Theory and Practice: 2011
[17] Phillip Bratby, Wind Turbine Risk, HSE Risk theory: 1999
[18] D. Katsaprakakis, D.Christakis, Wind Energy, Comprehension in wind energy: 2012
[19] Sustainable alternate jet fuel, the national academic press: 2019
[20] Electric and Fuel, Hybrid Wind and Solar Electric Systems: 2017
[21] Solar Online, Components of solar hybrid system: 2019