Optimized Blade Replacement Solution in Wind Turbine using Craneless Technology

Mr. S. Anthonyraj PremKumar[1]

[1]*CEO cum Founder, Windcare India Pvt Ltd, 3/241 A, Four Road, Gudimangalam, Pollachi Road, Udumalpet, Tirupur, Tamilnadu, India-642201*

---***---

Abstract - We proposed a cost-cutting and simplified mechanism system for de-erection and re-erection of a blade of a wind turbine, the proposed system comprising at least one first pulley in bottom of wind turbine hooked up to the jig as fixed, at least one secondary pulley in adjacent blade and at least one third pulley using gun tackle arrangement principle, a receptacle disposed over a substantial length of the blade for holding purpose, a lifting line passing over the at least one first pulley then to the at least one second pulley and last to the at least one third pulley ,lifting line attached back to the at least one second pulley, at least one load bearing mechanism is configured for pulling ,releasing of the lifting line for enable vertical motion of the receptacle disposed over the blade, where a load supporting mechanism connected to an operative bottom portion of the blade which is configured to support the blade during de-erection and re-erection thereof and at least one holding mechanism attached to the at least one third pulley, the at least one holding mechanism is customized to carry the receptacle.

***Key Words*: Angles of attack (AoAs), Blade element momentum theory (BEM), Annual energy production (AEP), Computational fluid dynamics (CFD), Megawatt (MW), Kilowatt hour (KWH), Working days (WD)**

1. INTRODUCTION

Since wind turbines operate within the lower atmosphere, they're exposed to the native weather. Rain, hail or maybe insects result in the erosion of rotor blades. Even we got damage due to lightening and hitting of birds during flying, Due to the higher rotational speed, this erosion mostly appears at the leading edges in the outer part of the blades. Although measurements of the mechanics result of abrasion on real operative wind turbines area unit rare, it's illustrious that erosion results in higher drag and lower elevate, particularly at angles of attack (AoAs) near the stall.

Dalili et al. [1] reviewed the consequences of surface roughness because of insects or ice on turbine performance, however not abundant is alleged concerning the result of vanguard erosion due to rain or hail. Corten and Veldkamp [2] showed within field experiments that increased roughness by insect contamination can lead to power losses of more than 25%. It is expected that robust erosion and ensuing delamination result in even higher power losses. Experiments with vanguard roughness on airfoils by Janiszewska et al. [3] showed a decrease in most elevate of twenty fifth, whereas the minimum drag was accumulated by hour. The stall angle was shifted slightly to smaller AoA.

Sareen et al. [4] investigated the result of abrasion on airfoils through an experiment with varied degrees of abrasion, wherever the measurements were conducted at painter numbers between Re = one □106 and Re = 1.85 □ 106 in a low-turbulence subsonic wind tunnel. In the case of serious erosion, the most elevate was remittent by terrorist organization compared to the elevate of the clean control surface, and the drag was increased up to 500%, although it should be noted that this increase did not refer to the minimum drag in the laminar drag bucket. The ensuing polars of the experiments were utilized in numerical simulations of a pair of.5 MW turbine based on blade element momentum theory (BEM), and they concluded that heavy erosion could lead to a loss in annual energy production (AEP) of roughly twenty fifth. Note that the simulations were done victimization constant level of abrasion on the complete blades, that is perhaps not the case for real turbines because of varied motion speeds.

In order to avoid or prevent erosion, it is possible to use special leading-edge protections. Weigel [5] investigated a protection system for eggbeater blades, that area unit scoured by rain or sand. He showed that the protection used may cut back the result of abrasion. Still, eggbeater blades area unit totally different completely different from wind turbines because of different flow behavior and rotor speeds. Additionally, the materials of helicopter blades and possible coatings are different from those of wind turbines.

In distinction, Giguere and Selig [6] experimentally investigated the effect of tapes on wind turbine airfoils. The construction measurements were conducted at low painter numbers from Re = a hundred and fifty,000 to Re = five hundred,000 and airfoils which are not used on bigger turbines. The power losses due to the used tapes were less than 2%, which is small compared to the losses with eroded airfoils. Still, it's not illustrious what quantity a number one edge protection changes the turbine performance for contemporary multi-MW turbines compared to scoured control surface shapes. This is the focus of this work, and in order to be able to reach the high Reynolds numbers of modern wind turbines, the investigation is done purely numerically.

Fernandez-Gamiz et al. [7] investigated the result of microtabs and will show that turbine power is accumulated by victimization these add-ons. They computed control surface polars by suggests that of machine Fluid Dynamics (CFD) and used these polars in BEM computations to estimate the facility output of a five MW rotary engine. A similar approach is followed in this work.

Corsini et al. [8] report a numerical study of rain erosion on a half-dozen MW rotary engine and compared normal and aerodynamically optimized blades with one another. They simulated erosion by a steady-state Euler-Lagrangian approach with droplet tracking using CFD, but they do not report any difference in total power or AEP between eroded and clean blades.

Thus, the subsequent work shall provide a numerical estimation of the expected losses because of erosion, and shall compare the wind turbine performance to coated blades equipped with leading edge protection. The selected rotary engine is that the NREL five MW analysis rotary engine [9], which is often used in comparative research studies [10,11]. It is a three-bladed horizontal axis upwind turbine with a rated power of 5 MW at a wind speed of 11.4 m/s and a rotational speed of 12.1 rpm. The control surface within the outer region of the rotary engine could be a slightly changed version of the NACA 64-618, called "NACA64_A17" in the NREL reports. Since the coordinates of this modified airfoil are not available for the authors, the NACA 64-618 was used instead.

After a validation of the numerical methodology, aerodynamic polars of clean, eroded, and coated airfoils were generated by means of CFD. Then, these polars were utilized in BEM calculations so as to estimate power Associate in Nursing hundreds further because the AEP for an exemplary web site.

1.1 Existing methodology

A wind turbine is a device used to convert the wind energy into electricity by the motion of its blades. one amongst the key challenges to the construction and operation of the wind turbine is the de-erection and re-erection of its blades. Throughout regular use, the rotary engine blades are subjected to failure and other form of damages caused by natural reasons like lightning and birds and mass particles hit the blade. The traditional strategies of de-erecting and re-erecting the turbine blades make extensive use of the crane. Some of the disadvantages related to this conventional method include the requirement of large capacity cranes and requirement to mobilize them, the need of huge quantity of fuel to operate the crane, large trucks to mobilize the crane components and inaccessibility for the cranes when wind turbines are located on uneven terrains. variety of previous arts of techniques have been tried to resolve the on top of mentioned issues.

For example, (12) discloses a technique and a system to hoist or lower the wind turbine blades Hoisting instrumentality is organized among a wind turbine hub with the assistance of a wind turbine service crane, typically settled in a nacelle. The hoisting instrumentality includes a carrier member with a root winch and a tip winch mounted on a bearing plate. The root winch and the tip winch facilitate the mounting of a root wire and a tip wire severally. A sling is connected to the tip of the blade with the assistance of a tip wire. By comparatively moving the tip wire and also the root wire, the blade is down to the bottom. Whereas the aforementioned patent document provides a crane less solution for hoisting or lowering of the blades, the system still lacks in effective harness to carry the blade.

(13) discloses a technique for crane less wind turbine blade handling via a turbine hub. The blade to be dismounted is positioned during a vertical position pointing towards the bottom. A lifting yoke is employed for lowering the blade for maintenance or repair. A wire, chain or the other famous suggests that, applies the force needed for lowering the blade. A wire is connected to the lifting yoke that is introduced into the hub by a minimum of one pulley. The wire is introduced into the hub via a receiving portion settled on the concave part of the hub. A nacelle winch or a ground-based winch operates the wire. The blades are moved to or from the intermediate position by actuators operated pneumatically, hydraulically, or electrically. whereas the aforementioned patent document discloses the use of lifting straps for covering the blade, it fails to provide any details on its design. Faulty design of the straps leads to the blade slippery and falling to the bottom, thereby inflicting damages.

Hence there is a desire for a system and a method that alleviates the drawbacks related to standard strategies and systems for de-erecting and re-erecting of a blade of a wind turbine.

2 Proposed methodology

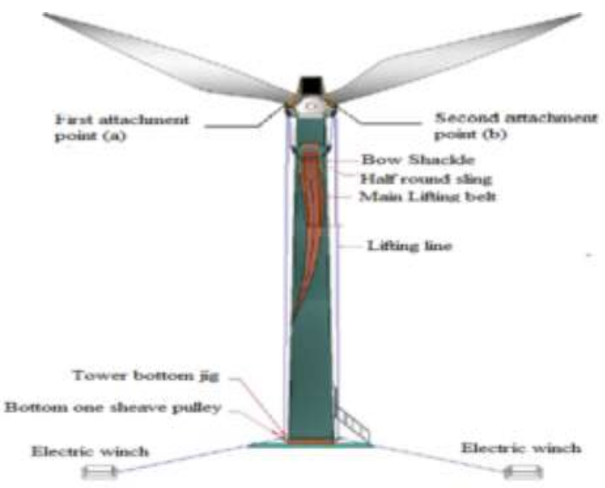

Fig-1:

Method for de-erecting the blade from a wind turbine with three blades installed on the top of wind turbine tower is explained below in steps, where each part is plotted in fig-1.

Step 1: Positioning the blade to be de-erected, in 6 O' clock position.

Step 2: Assembling the rotor lock.

Step 3: Attaching the jig at the bottom of the tower of the wind turbine

Step4: Attaching the 1st pulley set with the tower bottom jig

Step 5: Assembling the blade holding mechanism at the ground level;

Step 6: Configuring the sky-lift, lifting and positioning the blade holding mechanism over the blade to be removed and tightening straps of the blade holding mechanism.

Step 7: Lifting the 2nd and 3rd pulley assembly with the sky lift to the required height

Step8: Attaching the 1st two sheave pulleys to the attachment point at the adjacent blade-1 and attaching a 2ndtwo sheave pulley to the attachment point at a second adjacent blade-2.

Step 9: Attaching the 3rd pulley with the blade holding mechanism

Step 10: Attaching a load supporting mechanism to the bottom portion of the blade as shown Fig-2.

Fig-2:

Step 11: Lowering the blade by operating the ground winch

Step 12: Attaching a tail end support line between the blade supporting mechanism and a tail pick crane after the de-erected blade reaching the required level as shown in Fig-3.

Fig-3:

Step 14: Positioning the blade in storage stand using the winches and tail pickup crane. As in fig 4.

Fig-4:

2.1 Working Conditions of proposed methodology:

1. Temperature range: -10 to +50;
2. Max. allowed wind speed: 10 m/s (i.e. 36 km/h)

2.2 Benefits of Proposed Methodology:

We now present the impact of our innovation with respect to the conventional method in terms of time, fuel consumption, Pollution control and Cost reduction.

2.2.1. Project Time Reduction

By using Craneless proposed technology, we can complete the whole operation within 6 days of its commencement. With the old technology, mobilization of the crane to the site, De-erection, Repair and Re-erection of the blade will take a minimum of 20 days.

Table -1: Execution time data

ACTIVITIES	TIME TAKEN IN HOURS /WITH CRANE	TIME TAKEN IN HOURS /WITHOUT CRANE
Mobilization	192	24
Work	96	96
De Mobilization	192	24

Note: Total day hours (24 hours) are considered and the days is calculated by the working man hours (8 hours)

While using conventional crane method of work, 18 Man power required for 20 days (i.e.) 360-man days = 2880-man hours whereas with our technology 12 Man power required only for 6 days (i.e.) 72-man days (i.e.) 576 man-hours. Thus, we are able to save around 80% in man hours.

2.2.2 Reduction of transport fuel consumption

Table-2: Fuel Utilization in Liters

ACTIVITY	WITHOUT CRANE	WITH CRANE
Mobilization	550 Liter	18700 Liter
DG	80 Liter	0
Crane	0	100 Liter
Fuel for 100 KM	25 Liter	850 Liter

Transporting the crane from one place to another place requires at least 17 trailers which consume 850lts of fuel/100km. Our Craneless technology requires only one 20ft container trailer which consumes 25ltrs/100kms. This also reduces the pollution by 97%.

2.2.3 Reduction of transport fuel consumption

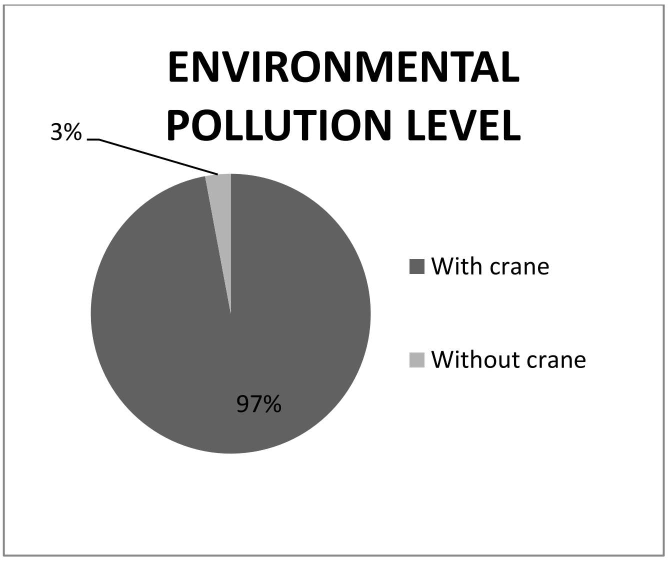

Chart -1: Comparison of Environment Pollution level of a crane and without crane

With this innovation, we are reducing 97% pollution which will save the society from its ill effects (see the table.10). Also, the low cost in maintenance may bring down the total cost of wind power production thus reducing the cost of the clean energy.

2.2.4 Result of generation improvement compression with existing methodology while apply proposed methodology:

Table-2: Comparison of Generation Loss

SL. NO	GENERATION LOSS CALCULATION DURING HIGH WIND SEASON	GENERATION LOSS CALCULATION DURING LOW WIND SEASON
1	Example of 2MW WTG (Blade Work) Total KWH from 20Th May to 12th Oct = 3969291 unit Average KWH = Total KWH/No of Days = 396921/146 **= 27186.9Kwh**	Example of 2MW WTG (Blade Work) Total KWH from 13Th Oct to 19th May = 485829.6 unit Average KWH = Total KWH/No of Days = 485829.6/220 **= 2208.3Kwh**
2	Generation Loss (With Crane technology) = Ave KWH x No of Days WD = 27186.9 x 20 **= 407803.5 kwh**	Generation Loss (With Crane technology) = Ave KWH x No of Days WD = 2208.3 x 20 **= 44166 kwh**

3	Generation Loss (Craneless technology) = Ave KWH x No of Days WD = 27186.9 x 6 **= 163121.4 kwh**	Generation Loss (Craneless technology) = Ave KWH x No of Days WD = 2208.3 x 6 **= 13249.8 kwh**
4	**Effectiveness of the Craneless technology** $= \frac{407803.5 - 163121.4}{407803.5} \times 100$ Machine availability time improved by **60%**	**Effectiveness of the Craneless technology** $= \frac{44166 - 13249.8}{44166} \times 100$ Machine availability time improved by **70%**

Above statistics is self-explanatory in Rasipalayam region located in Dharapuram, Tirupur, Tamil Nadu. -i.e. due to the reduced down time when the customers are executing the maintenance activities with our Craneless technology, resulting more power generation 60% during high wind season and more power generation 70% during low wind season.

3. CONCLUSIONS

Our proposed method is for the de-erection and re-erection of the BLADE of wind turbine, is a "***GREEN TECHNOLOGY FOR CLEAN ENERGY"*** provides safe and easy-to-use that suits the customer needs. Our design is simple & portable, cost effective, can perform the operation at different hub heights, can be realized for KW to MW class wind turbines, can be realized on different terrains, time effective, completely no need to deploy heavy and costly cranes; resulting the following benefits to the customer and society;

a) Customers are enjoying the benefits of more power generation due to the less down-time for the repair and maintenance activities and thus improved revenue generation.

b) Dozens of trucks need to be engaged for the movement of conventional crane components – leads to road traffic disturbances, but our system required only 1 truck.

c) 97 % of fossil fuel reduction, resulting environmental impacts, resulting reduction in carbon foot print and contribution towards minimizing the global warming impacts.

d) Less down-time for the repair and maintenance activities resulting more power generation and hence the benefits passed-on to the society, agriculture and industry.

ACKNOWLEDGEMENT

This work was first space to prove our execution in their First of all, I would like to express my gratitude to almighty God to enabling me to complete this project work as our company mission "with all things are possible with god grace ", I would like to express my special thanks of my clients turbines such as Vestas India Pvt Ltd, Suzlon energy Pvt ltd, Siemens Gamesa renewables Pvt Ltd, inox wind ,Regen GE. to provide space to prove our self,

The author gratefully acknowledges extremely valuable colleagues which are members of Windcare India Pvt Ltd family.

REFERENCES

1. Dalili, N.; Edrisy, A.; Carriveau, R. A review of surface engineering issues critical to wind turbine performance. Renew. Sustain. Energy Rev. 2009, 13, 428–438.

2. Corten, G.P.; Veldkamp, H.F. Aerodynamics: Insects can halve wind-turbine power. Nat. Brief Commun. 2001, 412, 41–42.

3. Janiszewska, J.M.; Reuss Ramsay, R.; Hoffmann, M.J.; Gregorek, G.M. Effects of Grit Roughness and Pitch Oscillations on the S814 Airfoil; Technical Report; NREL/TP-442-8161; National Renewable Energy Laboratory: Golden, CO, USA, 1996.

4. Sareen, A.; Sapre, C.A.; Selig, M.S. Effects of leading-edge erosion on wind turbine blade performance. Wind Energy 2014, 17, 1531–1542.

5. Weigel, W.D. Advanced Rotor Blade Erosion Protection System; Kaman Aerospace Corporation, USAATCOMTR95-D-8; Defense Technical Information Center: Bloomfield, CT, USA, 1996.

6. Giguere, P.; Selig, M.S. Aerodynamic Effects of Leading-edge Tape on Aerofoils at Low Reynolds Numbers. Wind Energy 1999, 2, 125–136.

7. Fernandez-Gamiz, U.; Zulueta, E.; Boyano, A.; Ramos-Hernanz, J.A.; Lopez-Guede, J.M. Microtab Design and Implementation on a 5 MW Wind Turbine. Appl. Sci. 2017, 7, 536.

8. Corsini, A.; Castorrini, A.; Morei, E.; Rispoli, F.; Sciulli, F.; Venturini, P. Modeling of Rain Drop Erosion in a Multi-MW Wind Turbine. In Proceedings of the ASME Turbo Expo 2015: Turbine Technical Conference and Exposition (GT2015), Montreal, Quebec, Canada, 15–19 June 2015.

9. Jonkman, J.; Butterfield, S.; Musial, W.; Scott, G. Definition of a 5-MW Reference Wind Turbine for Offshore System Development; Technical Report; National Laboratory of the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy; NREL: Wasington, DC, USA, 2009.

10. Fernandez-Gamiz, U.; Zulueta, E.; Boyano, A.; Ansoategui, I.; Uriarte, I. Five-Megawatt Wind Turbine Power Output Improvements by Passive Flow Control Devices. Energies 2017, 10, 742

11. Jha, P.K.; Duque, E.P.N.; Bashioum, J.L.; Schmitz, S. Unraveling the Mysteries of Turbulence Transport in a Wind Farm. Energies 2015, 8, 6468–6496.

12. UFUK, Okutan; DK, A method for lifting and lowering of a wind turbine blade, Pub. No.: WO/2011/095167

13. HVID NIELSEN, Kennet; DK, Method for craneless wind turbine blade handling via a turbine hub, Pub. No.:WO/2012/065613

BIOGRAPHIES

Mr. S. Antony Raj Prem Kumar, CEO and founder of Windcare India Pvt Ltd. He did diploma in Mechanical, started out with big dreams from a small village Sayarpuram in Tuticorin joined the wind Industry 1996. In 2001, Mr. Antony Invented special system for erection and de-erection of wind turbines major components without the use of heavy-duty cranes. By his extensive research and innovation, he brought about a revolution in the wind industry - service sector by pushing down the maintenance cost of turbines by about 50%, a boon for wind farm owners. Mr. Antony began to execute his dreams with a small 5-member team and faith in God who makes impossible things possible. Today, he heads an 800-member strong team which works with the same passion to bring quality in the field and catering to nearly 40 % of the industrial needs.