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Plant Efficiency Improvement by Effective Maintenance Procedures: a Case Study of Wind Farms Limited, Dewas, Madhya Pradesh (M.P.), India

Md Wasif Rizvi[1], Anurag S. D. Rai[2], Reeta Pawar[3], Anjana Tripathi[4]

[1234]Department of Electrical Engineering, AISECT University, Madhya Pradesh, India

ABSTRACT

The Madhya Pradesh (M.P.) Wind Farms Limited Dewas, India is a leading power generating industry in wind power and it is having 58 conventional wind electric generators along with 58-unit sub stations and three main sub stations. At present this machine, which is an integral part of case company, is not running smoothly, it is observed that there are too many breakdowns and due to this it is causing too many difficulties to the maintenance department. Initially as such no scheduled maintenance program was given by the supplier, which leads to number of problems like production loss, lack of quality power and too much time consuming, so it is intended to reform this expensive conventional system and bring about a lot of improvement in the way of handling this machine. Preventive maintenance can provide the effective solution to this. This companion part of the paper presents the overall analysis of operating status of the machines of Wind Farms Limited, Dewas, Madhya Pradesh (M.P.), India, which is a leading power generating company in wind power sector as per the analytical data collected for continuous five years. According to the data the need of preventive maintenance can be executed.

Keywords : Preventive Maintenance, M.P. Wind Farms Limited, Wind Electric Generator (WEG)

I. INTRODUCTION

M.P. Wind Farms Ltd., Dewas, M.P. is India's first joint sector company, in this company three different body's are involved.

i. M.P. UrjaVikas Nigam Nodal agency of state government having 24% share
ii. Indian Renewable energy development agency nodal agency of central government having 25% share
iii. Consolidated Energy Consultants Ltd. Bhopal CECL is a consultant company provides technical support and having 51% share in this company.

The technical details of machine are as given below,

Capacity of project - 15 MW
No. of machine running - 58 Nos.
Capacity of one machine - 225/40KW
Area covered - 5 acre
Expected annual generation m/c. - 3, 00,000 units
Minimum wind speed required- 2 m/s.
First WEG inaugurated on - 26th July 1995

Estimated wind power potential India state wise given below [1, 2].

Table 1State Wise Wind Power Potential In India

SN	State and installed capacity	Gross potential (MW)
1.	Tamil Nadu (4301.63 MW)	4500
2.	Maharashtra (1942.25 MW)	3650

3.	Gujarat (1565.61 MW)	9675
4.	Karnataka (1340.23 MW)	6620
5.	Rajasthan (738.5 MW)	5400
6.	Madhya Pradesh (212.8 MW)	5500
7.	Andhra Pradesh (122.45 MW)	8275
8.	Kerala (26.5 MW)	875
9.	West Bengal (1.1 MW)	450
10.	other states (3.20 MW)	1700
Total		46645

Table 2 presents the wind electric generators operational hours and stopped hours of consecutive three years of case company.

Table 2 Wind electric generator's operational hours and stopped hours, of previous year of case company

Month	Operational and stopped hours									
	Total hours	2012			2013			2014		
		Op. hr.	Stop hr.	Grid fail	Op. hr	Stop hr.	Grid fail	Op. hr	Stop hr.	Grid fail
Jan	744	610	120	14	587	142	15	624	102	18
Feb	672	568	94	10	595	60	17	618	42	12
Mar	744	630	94	20	664	68	12	669	62	13
Apr	720	626	82	12	616	92	12	645	64	11
May	744	656	58	30	647	82	15	688	40	16
Jun	720	637	64	19	607	106	7	646	66	08
July	744	660	65	19	694	50	11	630	105	09
August	744	640	93	11	698	32	14	665	64	15
Sep	720	610	92	18	580	134	06	645	59	16
Oct	744	626	93	25	590	135	19	689	49	06
Nov	720	610	94	16	586	122	12	648	63	09
Dec	744	620	101	23	620	108	16	649	85	10

In the Table 2 the average operational hours are given for 58 units of wind electric generators. If we calculate the Total stopped hours in a year that is only in year 2012 stopped hours of WEG are 1050 hour, in year 2013, 1131 hours and in year 2014, 801 hours, at this time machines is not in operation. The only two reasons are behind it, first is wind speed is not sufficient i.e. less than 2 m/s. and the second is machines are not working properly.

This will show that if we are taking an average of 48 hours, for one maintenance schedule there will be only 144 hours which may be required for the maintenance purpose in a year that means we are stopping wind electric generators for only 144 hours per year which will be very less because after applying this maintenance schedule the stopped hours due to improper working of wind electric generator will surly decreases.

From data given in Table 2 the percentage machine availability can be evaluated as given in Table 3

Table 3 Percentage Machine Availability

Month	**2012**	**2013**	**2014**
January	82	78.9	83.9
February	84.5	88.7	92
March	84.6	89.2	89.9
April	86.9	85.5	89.5
May	88.1	86.9	92.4
June	88.4	84.3	89.5
July	88.7	93.2	84.6
August	86.0	93.8	89.3
September	84.7	80.5	89.5
October	84.1	79.3	92.6
November	84.7	81.3	90
December	83.3	83.3	87.2

Figure 1 presents the comparative analysis of percentage of machine availability of year 2012, 2013 and 2014. It indicates that there is sufficient possibility for improvement in maintenance availability.

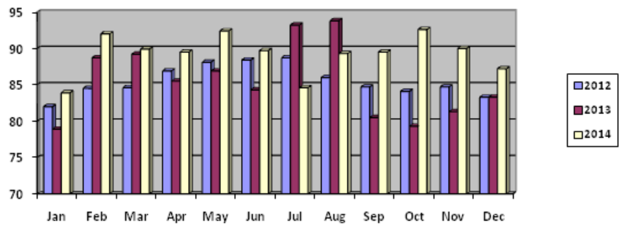

Figure 1 Percentage machine availability for year 2012, 2013 and 2014

II. PARTICULARS OF ELEMENTS CONSIDERED FOR APPLYING PREVENTIVE MAINTENANCE SCHEDULE

This section covers the detailed list of components of wind electric generator (WEG). Here each components of WEG are listed and maintenance requirement of components is given [3, 4, 5, 6].

Each component and its parts are used for scheduling maintenance procedure. In this paper the assortment of WEG's components failure history of previous five year is given. This analytical data is used to set the priority i.e. low, medium and high by which each component may be placed in different maintenance schedules. The components which require more emphasis in maintenance were set at the high priority. It was found that those components were failed too many times in previous years. The components set at medium and low priority are the components which require less maintenance were found to be comparatively failed less time in previous years. It is recommended that the maintenance schedule should be applied before season of peak performance i.e. in the approximate ending of March and it ends with August for the case plant as in this period the speed of wind is good for the high generation of electric power. Thus the WEGs should be in perfect status at this time period with minimum breakdowns and maximum machine availability. So the Quarterly maintenance schedule is suggested to be applied before the peak season comes and after the end of the season (i.e. in September month) half yearly maintenance schedule can be scheduled and in December month yearly maintenance schedule can be scheduled.

Schematic diagram of components of WEG s is shown below:

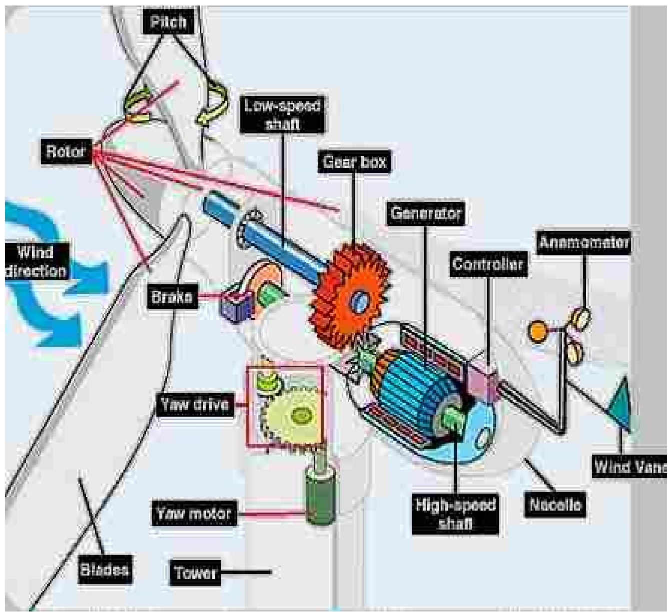

Figure 2 Components of wind electric generator

Schematic diagram of Wind Electric Generator's main components mounted over the tower is shown in Figure 2 and cross view of the same is shown is Figure 3

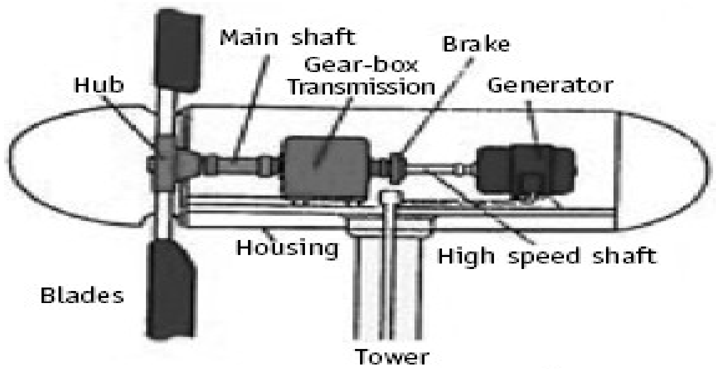

Figure 3 Wind Electric Generator's main components mounted over the tower

Specification of elements are discussed below which can be undertaken for preparing of preventive maintenance schedule.

2.1 TOWER

Tower is the base of WEG which consist of control panel, switch board and capacitor bank which are discussed in the category "Electrical installation".

The specification of tower is:

Material	-	Galvanized steel
Type	-	Shell type bolted tower
Height	-	30 miters.
Weight	-	8 tons
Thickness of sheet	-	10 m
Internal diameter	-	2.5 meter at bottom & 1.5 meter at top.
Make	-	NEPC

Sub parts of tower (maintenance requirement of components of tower)

- Tower bolts
- Door
- Blade inspection door
- Top flange
- Top Platform
- Ladder
- Safety devices and rope

All these components require less maintenance because they are rigid in nature and stable (not movable).

2.2 ROTOR

It consist of Blades, blade hydraulic unit and nose-cone

The specification of Rotor are

Make	-	L.M. Glass fiber
Material	-	Glass fiber
Length	-	13.4 meter.
Weight	-	850 kg / blade
Type	-	movable tip spoiler
Length of tip	-	2.2 meter

Sub parts of Rotor (maintenance requirement of components of rotor).

- Blades
- Blade tip and hydraulic System or blade hydraulic unit
- Blade hub

The rotor is a moving part so it requires a frequent maintenance.

2.3 Transmission

Transmission of WEG is consisting of main shaft which connect the rotor to the gear box, by main shaft.

The specification of Transmission is:

Weight of main shaft	-	1 tons
Diameter of main shaft	-	600mm
Material of main shaft	-	M.S.
ID of main bearing	-	600 mm
Make of main bearing	-	SKF

Sub parts of Transmission (maintenance requirement of components of Transmission)

- Bolt connection blade hub/ main shaft
- Main bearing housing
- Sealing
- Bolt connection bearing housing
- Shrink disk
- Main shaft

2.4 Gear Box

Gear box is used for converting the low speed rotation of rotor to high speed rotation for generator. The gear box used in WEG is normally having ratio 1:40 i.e. for one rotation of low speed rotor the high speed rotor rotates 40 times. Low speed rotor of gear box is connected to the main shaft and high speed rotor is coupled to the generator. This means for one rotation of WEG blades the generator rotates 40 times. Gear box is filled with oil for lubrication.

The specifications of Gear box are:

Make	-	flender / hansan
Ratio	-	1/40
Weight	-	2 tons
Oil use	-	castrol 460
Quantity of oil	-	7 liters

Sub parts of Gear box (maintenance requirement of components of Gear box).

- Shrink disk on low speed shoes
- Sealing
- Oil level indicator
- Breather
- Gear teeth
- Oil cooler

Gear box of WEG is the most important component. Hence it requires more emphasis in maintenance point of view.

2.5 Brake Disc

Brake disc is coupled with the high speed shaft for providing Brake operation in WEG.

The specification of Brake disc is:

Make	-	NEPC
Thickness	-	30 mm
Diameter	-	900 mm
Weight	-	110 kg
Material	-	MS

Subparts of Break disc (maintenance requirement of components of Brake disc). Bolt connection hub / Brake disk

2.6 Hydraulic Brake

On Brake disc hydraulic Braking system operates. In WEG the Braking phenomenon is applied for stopping the rotor of WEG in case if the wind speed is below or above the rated speed, at the time of maintenance, failure of WEG etc.

The main components of the hydraulic Brake system are accumulator in which high pressure oil is filled by the motor pump set. An electrically operated Solenoid valve is used when braking operation is required, the solenoid valve releases the high pressure oil which forces the Brake pads for applying brakes.

The specifications of Hydraulic brake are:

Make	-	SIME
Type	-	Horizontal
Oil Quantity	-	2.2 Liter
Oil type	-	SERVO – 32

Subparts of Hydraulic brake (maintenance requirement of components of Hydraulic brake)

- Bolt connection brake / console
- Bolt connection console /gear box
- Hydraulic oil
- Accumulator
- Motor pump set
- Hose pipe
- Low / High level limit switches
- Solenoid valve

Hydraulic breaking plays important role in WEG operation hence it requires maintenance with more emphasis.

2.7 Flexible Coupling

It is the coupling between gear box high speed shaft and generator shaft.

The specifications of Flexible coupling are:

Make - Magi flex / central flex
Material - (molding) Rubber element with hollow MS shaft.

Weight	-	40 Kg
Diameter	-	500 mm
No. bolt	-	4 Nos.
Type of bolt LN key	-	LN key

Subparts of Flexible coupling (maintenance requirement of components of Flexible coupling)

- Rubber elements
- Bolt connection Rubber element / center shaft
- Bolt connection rubber elements Brake disc
- Alignment

The distance between brake disc and generator hub must correspond with the length of the coupling +/- 1mm.

Flexible coupling needs emphasis on maintenance in its moving part.

2.8 Generator

To generate electrical power from the mechanical power of rotor induction generator is used which works on two modes of operation. First is of 225 kW rating which has 4 pole winding and rated speed is 1500 RPM and the second one is 40 kW rating which has 6 pole winding and rated speed is 1000 RPM.

The specifications of Generator are:

Make	:	Jyoti/ Comptor/ Siemens.
Capacity	:	225/40 KW
Voltage	:	415 V
Power frequency	:	50 Hz A.C.
Weight	:	1.2 tones
No. of poles	:	4/6 poles
RPM	:	1500/1000 RPM

Subparts of Generator (maintenance requirement of components of Generator)

- Bolt connection Generator / Frame
- Lubrication Arrangement
- Seals
- Generator Terminal box
- Cover for Generator

2.9 Electrical Installation

Electrical installation mainly covers the electrical panels, conductors, lightning arrestors, control equipments etc. which requires negligible maintenance hence in electrical installation we cover only specifications. From maintenance point of view checking of loose connection in the terminal blocks, retightening the connector screw, check connection to the earth, sign of overheating etc. are required. Inspection against proper working of the electrical component is very important because failure of electric component directly affect the working of the WEG.

2.10 Electrical Panels

2.10.1 Main MCCB with trip unit

Make	-	ABB / GEC Alsthom
Voltage	-	600 V
Amperes	-	630 Amperes
Frequency	-	50 Hz AC.
No. of poles	-	three
Trip coil voltage	-	24 V DC/220 V A.C.

2.10.2 Power Contactor for G 1 Gen. & by Pass

Make	-	ABB/BCH Allen Bradley
Voltage	-	415 V A.C. 50 HZ
Amperes	-	550 Amperes
No. of poles	-	three
Coil voltage	-	24 V A.C.

2.10.3 Power contactor for G2 Generator

Make	-	ABB / BCH / Allen Bradley
Voltage	-	415 V
Amperes	-	110 Amperes
Coil voltage	-	415 V A.C. 50 HZ
No. of poles	-	three

2.10.4 Auxiliary Contactor

Make	-	ABB /BCH / Allen Bradley with 3No. & 3NC
Rating	-	9.1 Amps
Coil Voltage	-	24 V A.C.

2.10.5 Over Load for yaw / Hyd. Motor

Make	-	ABB / BCH with 1 No and 1 NC
Range	-	9.1 to 2.4

2.10.6 Current transformer

Make	-	ABB
Ratio	-	500/1 Amps
Loading	-	15 VA

2.10.7 Lighting Arrestor

Make	-	Uberspannungs
Type	-	OBO
Amperes	-	15 kA
Voltage	-	1.8 kV

2.10.8 Thyristor with heat sink

Make	-	Herict
Rating	-	550 Amps
Voltage	-	600 V 50 Hz A.C.
Control voltage	-	1 to 10 V D.C.

2.10.9 WP- 2060 wind controller

Make	-	Mita Teknikas

2.10.10 Control MCBs

Make	-	Siemens
Amps .	-	10 Amps.
Voltage	-	415 V 50 Hz A.C.
No. of Poles	-	4/3

2.10.11 Wind Power – 2000 :-

Make	-	Mita Taknikas
Type	-	Microprocessor based
Supply	-	24 V A. C. & D.C.

2.10.12 Control transformer:-

Make	-	Made in Den mark
Input	-	415 V + 13 % Hz
Rating	-	24 V - 6.5 Amps
Outputs	-	19 V - 2.63 Amps

2.10.13 Diode

Make	-	Bridge rectifier type
Voltage	-	19 V A.C. input
Filter capacitor	-	4700 micro farad, 6.3 V

2.10.14 MCCB for capacitors

Make	-	ABB
Rating	-	250 Amps.
Setting	-	110 to 250 Amps.
No. of poles	-	three
Voltage	-	415 V 50 Hz A.C.

2.10.15 Capacitors :-

Make	-	Rodrastrain/ Vishwa
made in Germany		
Roting	-	12.5 KVAR.
Voltage	-	415 V A.C. 50 Hz
Discharge resistance	-	30

III. CONCLUSION

The focus of these companion papers is to provide an efficient tool to evaluate the status of any plant and to understand the need of proper maintenance schedule to improve the operating efficiency of the plant by attaining the maximum machine availability and minimum down time. Part I discusses the detailed analysis of the most commonly used maintenance procedures which leads to the conclusion that the most promising technique is preventive maintenance which may provide the fruitful solution. Thus to execute the efficacy of the outcome method the case study of Wind Farms Limited, Dewas, Madhya Pradesh (M.P.), India has been presented in Part II. The detailed analytical analysis presented in this part of companion papers may help the plant operators to evaluate the exact space of need to apply the necessary actions.

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