Indian Wind Power

Volume: 4 Issue: 3 August - September 2018 ₹ 10/-
Bimonthly, Chennai

Preventive Maintenance

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INDIAN WIND TURBINE MANUFACTURERS ASSOCIATION

Indian Wind Power

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Volume: 4 Issue: 3 August - September 2018

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Indian Wind Turbine Manufacturers Association
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From the Desk of the Chairman - IWTMA

Dear Readers,

Greetings from IWTMA!

The three-day national event on RE-Invest which is attended by some of the biggest national and international industry players will be held from 3-5 October 2018. This event will serve a great opportunity to reaffirm our targets for onshore wind, strides in solar and announcement from the Indian Ocean Rim Association (IORA) for offshore projects.

Wind industry can pride on being a champion for the cause with over 75% localization and playing a lead role in the "Make in India" initiative while establishing 45 manufacturing units with an investment of over INR 25,000 Crore throughout India. There are 23 manufacturers with over 60 models and furthermore, the country has established around 16 R&D centres that maintain an international level of excellence. It is worthy to note that this industry supports over 4000 vendors starting from the MSME industry and supports job creation of around 2 millions.

The Indian Government has increased the country's renewable energy target to 227 GW from the earlier target of 175 GW by 2022. This will demonstrate volumes of business, creation of jobs, promotion of "Make in India", export business and finally affordable energy to all.

Operation and Maintenance of wind turbines that are based in distant and complex terrains have always been a challenge. As the adage goes prevention is better than cure, the current issue is on "Preventive Maintenance" with seven articles devoted to the subject.

We regret to inform that due to unavoidable circumstances the "Windergy India 2019" event scheduled from 13-15 February 2019 has been postponed. We will inform you of the next dates of the event shortly.

Enjoy reading and we look forward to your response and patronage to the wind sector.

Tulsi Tanti
Chairman

Shaping of the Future Energy System

Steve Sawyer, Senior Policy Advisor
Global Wind Energy Council (GWEC), Brussels, Belgium

2018 has so far been a year of strange weather: extreme heat coupled with drought in northern Europe, unusual storms and floods throughout most of the rest of the northern temperate zone, and new extremes for heat, cold and precipitation in many if not most parts of the globe – along with the fact that 2018 will likely be the 4th warmest year on record since the middle of the 19th century.

All of this has refocussed political discourse, when not distracted by the bizarre antics of the US president, on the subject of climate change. A recent feature piece in the New York Times bemoaned the fact that we had the opportunity to address the problem during the 80s but didn't, and paints a very pessimistic picture of future prospects of adequately tackling the issue. This of course provoked a dramatic pushback from those actively engaged in the reality of the climate change fight today, where hope and despair abound in equal measure. The main difference between the debate now and that of 30 years ago is that now we have the technology to solve the problem – back then we didn't – and a big part of that is wind energy.

With cratering prices and dramatic technological improvements over the past decade wind (and solar) energy are hailed in all major scenarios as the dominant power generation technologies of the future – which is important, as power generation contributes about 40% of energy-related CO_2 emissions, equivalent to about 25% of all greenhouse gas emissions, and is the single largest source.

The critical questions that remain are two: first, how quickly can we transition to zero emissions power sector dominated by wind and solar and second, how much of the rest of the economy can we electrify, and how quickly?

'Electrification' of just about everything that can be electrified seems to be the order of the day, with the dramatic rise of electric road transport as well as a host of appliances and tools which formerly relied on liquid fossil fuels. Increasing use of electricity for low temperature heating for industry, buildings and the residential sector is on the rise, along with heat pumps in various configurations. This is a boon to the climate, but only when based on a lower and ultimately emissions free power sector.

Boiling it down, there are four major problems in the energy sector yet to be solved: steel, cement, ships and airplanes. While there is progress on all fronts to removing the process emissions from both steel and cement manufacture (assuming the heat is provided by electric arc furnaces), it is not fast enough, and needs to be incentivized. Likewise, with both ships and planes…we have short haul planes in the test phase, with some European countries in the vanguard having targets for domestic short haul flights being electrified within a decade or so…and ferries and river barges are being shifted to batteries in both Europe and China. But there is still some way to go for trans-oceanic shipping and air cargo… there are options which need to be rapidly explored, developed and deployed, all of which can be powered by cheap, ubiquitous wind and solar.

A Market in Transformation

What we are seeing across the globe is a transformation of markets for wind power away from the support schemes that gave birth to the industry, with wind taking its place as a purely commercial technology, increasingly operating without subsidies or support mechanisms. Competing, one might add, with incumbents which are heavily subsidized to the tune of hundreds of billions (low estimate) to trillions of dollars per year, depending on what is included. But that is a discussion for another time.

The point is that the phrase 'renewables are too expensive' can now disappear forever. Whatever ideologues might have to say about it, the marketplace has spoken and we are in the process of adjustment to a direct market-driven competition for the future of the energy system. Policy will also play a role, and it should play a stronger role if we are to avoid the worst ravages of climate change; regardless, we are in a time when it makes extraordinary sense to invest in renewables, and it makes little sense to invest in anything else.

This transformation is taking its toll on the annual market size for wind power. 'Policy gaps' between the new and old systems mean that some markets were on something of a bumpy ride in 2016 and 2017 and that will continue for another year or two (longer in a few markets, including the world's largest, in China) until the kinks are worked out of the new systems.

The Future

Alongside the cratering prices for wind and solar power, other aspects of the transformation are proceeding apace. The dramatic uptake in EVs is one of them. Although it is as of yet limited to just a few markets, the rate of increase is beyond the wildest projections of just a couple of years ago. Likewise, the precipitous drop in the price of battery storage is another game-changer. One result of that is what has been talked about for many years, but which is only now appearing in reality: wind/solar hybrid plants with battery storage. We have examples under construction in Australia and India, and we will see much more in the coming years, with the combination enabling power delivery 24/7 for most of the year.

What does all this mean for wind markets in 2018-2022? Well, from where we sit today, it will mean a more or less flat market for 2018, a return to rapid growth in 2019 and 2020, and tapering off a bit after that, following the rush to install prior to the various deadlines coming up in key markets in 2020. Will there be unforeseen surprises? Probably. Will Russia and Saudi Arabia finally begin to reach their potential and provide rapidly growing major new markets for the industry? Perhaps. What about the Vietnam, the Philippines and the rest of the Southeast Asia? The only thing that we can say for certain is that the increase in the rate of change in energy markets will continue to accelerate in the coming years.

Windergy India 2019 Postponed

Windergy India 2019 has been postponed. The new dates will be announced shortly.

Snippets on Wind Power

NITI Aayog Proposes Nodal Energy Ministry to Streamline Governance

The NITI Aayog has proposed a common nodal energy ministry to streamline governance and speed up decision-making and has included it in its second draft of the National Energy Policy. If implemented, the proposal would help sort out governance issues among the Ministries of Petroleum and Natural Gas, Power, Coal, New and Renewable Energy, and the Department of Atomic Energy. As per the draft policy, the period 2017-2040 is expected to witness a quantum leap in the use of renewable energy, drastic reduction in energy intensity, doubling of per capita energy consumption and tripling of per capita electricity consumption.

ET Bureau, July 30, 2018

Maharashtra Removes Different Wind Zone Tariff

Maharashtra has removed the different wind zone tariff and fixed it as single tariff @ Rs 2.87 by an order issued on Aug 18 and is for projects commissioned between August 2018 and March 2019. The tariff is valid for 13 years.

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Unlocking Digitalization for Preventive Operations and Maintenance Services

Duncan Koerbel
Chief Technology Officer, Suzlon Group

With over 34 GW installations, the Indian wind sector is highly mature and is geared to unlock the 300 GW potential. The Government's target of reaching 175 GW has now been revised to 227 GW by 2022. To meet this demand, the wind energy industry must focus on employing cutting-edge technologies for bigger and increasingly reliable turbines, improving supply chain, enabling grid integration and leveraging digital technologies.

Maintaining equipment at a wind farm has some unique challenges, but frequent monitoring of Wind Turbine Generators (WTGs) scheduled maintenance is important. Operations and maintenance of wind farms is very crucial and affects everything from profitability, safety, environmental compliance, asset life and customer confidence. Hence, preventive maintenance of wind farms can be improvised with the help of Digitalization. We were employing the 'Internet of Things' concept long before it became a buzz word. Predictive analytics plays a key role, as it allows to, better predict or forecast the power generation. Predicting turbine operations and energy output with higher certainty 12-48 hours ahead of time will enable greater penetration of wind into the grid as a reliable energy source. Better analytics simultaneously assists in identifying areas for enhancing the wind turbine generation and optimizing the operation and maintenance costs by proactively identifying failures and taking action before the failures occur. In future, the introduction of Augmented and Virtual Reality based solutions will be effectively utilized for training engineers, in various health & safety scenarios, thereby reducing the chance of human and material losses.

Employment of Predictive/Prognostics Analytics based Maintenance; Condition Monitoring System and Inventory optimization will play a significant role.

Digitalization Initiatives Undertaken

Suzlon has developed a best-in-class Supervisory Control and Data Acquisition (SCADA) system. More than 300 sensors in each turbine continuously transmit data 24x7 on secure network to Suzlon's Monitoring Centre (SMC) in Pune, India. At the SMC, round-the-clock monitoring and advanced analytics is carried out to convert this raw data into valuable insights. This enables us to expedite troubleshooting, identify recurring events, predict likely failure of events and prevent unscheduled downtime.

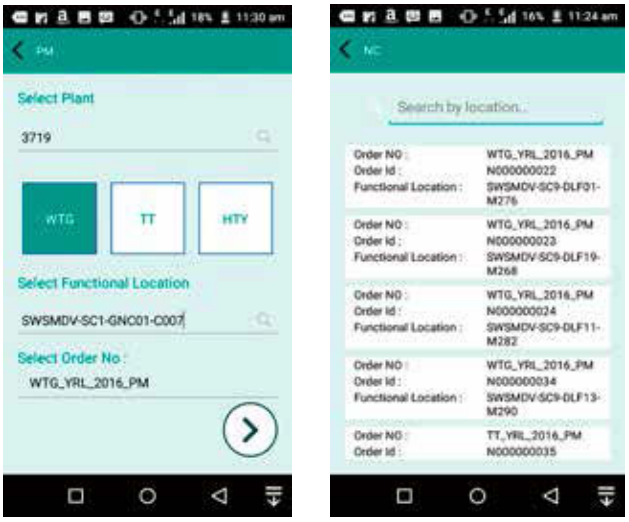
SC-TRINITY, an in-house developed, application based on SCADA system enables real time monitoring, reporting and analysis for the customer. Rich and intuitive interfaces of this application, makes it a real world class product.

SC - TRINITY

Figure 1: Wind Farm View with Real Time Wind Turbine Status

Figure 2: Real Time Monitoring of Wind Turbine Parameters

Figure 3: Graphical Display of Wind Turbine Parameters



Figures 4 and 5: Screen Shots of Mobile App for WTG Preventive Maintenance

Across the board, Operations and Maintenance Services (OMS) processes at site and head office levels have been automated using the SAP based ERP system, which enable end-to-end digital transactions. It was not long ago that every turbine took many sheets of paper in the form of checklists, work instructions, technical documents necessary to maintain the turbines. This transition to automation and digitalization of systems and processes, now form the DNA of Suzlon's OMS operations.

There has been increased thrust on providing mobility solutions to the site teams, in order to enhance the effectiveness of Preventive Maintenance (PM). The mobile app enables technicians to capture all the PM checklist data, while performing tasks in order to have real time input and feedback. It also provides comprehensive overview dashboards to monitor and analyze the progress of Preventive Maintenance (PM) activities of the wind farm. This has greatly improved the quality and timeliness of the PM activities.

PM Mobile App

Predictive analytics based maintenance solutions detect failure patterns to determine wind turbines assemblies that are at the greatest risk of failure. This early identification of issues helps to deploy valuable maintenance resources ahead of time to mitigate potential failures before they happen. This lessens the down time for the turbine and eliminates possible collateral damage due to a failed component. This reduces the demand on the quality and supply chain teams. The predictive models have been developed using machine learning algorithms and big data technologies in order to provide a high degree of accuracy and actionable insights.

Deployment of Condition Monitoring System (CMS) enables integration of vibration sensor data with temperature data and oil sample reports to further enhance accuracy of predicting failures. Advanced data fusion/mining strategies are employed for monitoring and prognosis of major assemblies like; gear box, generators and main bearing, with an aim of reducing turbine downtime and replacement cost. These initiatives directly impacts in enhancing the life of the wind turbine asset.

In order to enable better penetration into the grid, wind power forecast data is shared a day ahead with the state utilities. To improve the forecast accuracy, the revisions are being sent every 1.5 hours, as per CERC guidelines. The forecast models integrate numerical weather prediction data, wind turbine SCADA data & terrain data to accurately predict the wind power.

Our wind turbines are also equipped with sophisticated Low Voltage Ride Through (LVRT)/High Voltage Ride Through (HVRT) systems. These systems enable individual wind turbines to remain connected to the grid during grid voltage fluctuations. Further, our turbines have the provision of a 'park controller' that enables automated control and regulation of wind power at complete wind farm level. This enhances the power supplied to the grid and eases the operations for the utilities at the state level.

Preventive Maintenance aims to maximize turbine efficiency and availability by leveraging the big data technologies. Big data represents the Information assets characterized by such a High Volume, Velocity and Variety. This not only enables increase in energy production at lower lifecycle cost, but also results in greater transparency of performance parameters at all levels. It is a win-win situation for customers and wind farm operators due to enhanced revenue at reduced operations and maintenance cost.

Further, with improved accuracy in scheduling, forecasting and integration in the grid, enabled by the technological advancements, we are continuously reducing the Levelised Cost of Energy (LCoE).

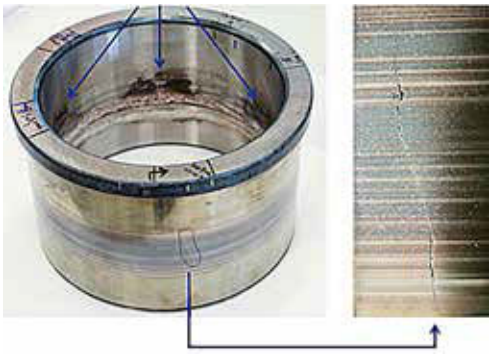
Bearing the Burden - The Leading Causes of Wind Turbine Bearing Failures

Dr. Philipp Schmid
Group Marketing Manager, SKF (Schweiz) AG, Switzerland. philipp.schmid@skf.com

Wind turbine functionality is highly reliant on fully operational bearings. However, these components undergo significant strain and deteriorate. Fully understanding failure modes in turbine bearings can be a challenge. But there are ways to reduce the likelihood of breakdowns.

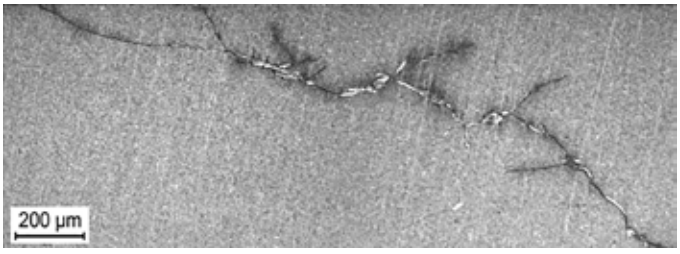
The Mystery of Axial Cracking

Cracking in bearings is a relatively common issue in modern wind turbines and can reduce the component lifespan by up to two years. Despite being a regular occurrence, the cause is not completely understood yet. Research is still ongoing from organizations, such as NREL and Argonne National Laboratory. Although a definitive root cause has not been identified, there are certain theories about contributing factors:



Prematurely Failed Bearing with Axial Crack on the Inner Ring Raceway

1. **Emergency or sudden stops:** There is a relationship between abrupt halts in operation and gearbox service life. It is theorized that this significant strain results in early bearing deterioration.
2. **Friction and traction in bearings:** Significant friction between rollers and raceways subject bearings to greater stress than normal, leading to bearings being unnecessarily strained. Incorrect lubrication can cause this.
3. **Ineffectual condition monitoring systems:** If systems are not accurately reporting on operating conditions, it is likely the problem that will not be identified, meaning operators are unaware where changes must be made.
4. **Rapid changes in torque:** This is similar to sudden stops and may put bearings under strain they were not designed for. Many turbines do not employ a torque limiter that can counteract this.



White Etching Cracks

Accumulative Deterioration Due to Adhesive Wear

The origin of this issue is more clear cut and happens when two surfaces rub against one another and transfer surface material from one component to the other. This creates excess friction as well as unwanted heat leading to degeneration. Over a period of time, this will wear the bearing to a point where it is no longer functional. Specialist products, such as black oxide bearings that provide a protective layer for the component, can help protect against this.

Black Oxidized Separable High Capacity Cylinder Roller Bearing for Wind Turbines

Micropitting May Lead to Bigger Problems

These are incredibly small cracks that gradually increase in size to the point where it interrupts the smooth running of bearings. This degradation is due to lubrication becoming too thin resulting in unwanted contact. By properly lubricating bearings and ensuring that the thickness of grease is always at an optimal level, operators can rest assured that they will not have to deal with what is known as micropitting or surface distress.

Keeping Control of Conditions is Vital to Avoid Moisture Corrosion

Environmental conditions, including moisture can have detrimental consequences for wind turbine bearings. If too much moisture is present within a turbine, rust can occur or lubricants may become ineffective and result in premature failure. Furthermore, bearings may even corrode themselves and electrical equipment is at risk of damage. This can be avoided by correctly sealing the areas where bearings and key machinery is located. Another option is implementing a humidity control system.

A Diverse Issue with Many Causes and Solutions

Bearing failures account for a significant proportion of wind turbine breakdowns. It is not surprising that there are many causes and factors that can lead to premature deterioration. Therefore, there is not a one-size-fits-all solution to keep bearings intact. However, adopting best practices, correctly lubricating, and using durable materials goes a long way to extending lifespans.

Snippets on Wind Power

Tamil Nadu Grants First Licence for Private Power Distribution

TNERC has permitted the India Power Corporation (Tuticorin) Private Limited (IPCTPL), a Kolkata-based company, to provide electricity to units in the multi-product Special Economic Zone (SEZ) at Nanguneri in Tirunelveli district. The term of the licence would be 25 years with retrospective effect from January 19, 2017.

Importance of Torsional Flexibility in Blade Design Process

Amit Kalyani, Senior Specialist, Product & Technology
Senvion India Pvt Ltd, ITPL, Bangalore

The last two decades has seen a significant increase in size of wind turbines. This is primarily driven by requirements for lower Levelized Cost of Energy (LCOE) and research and development efforts enabling design of longer blades. Going by the demand, this trend is envisaged to continue in the next decade.

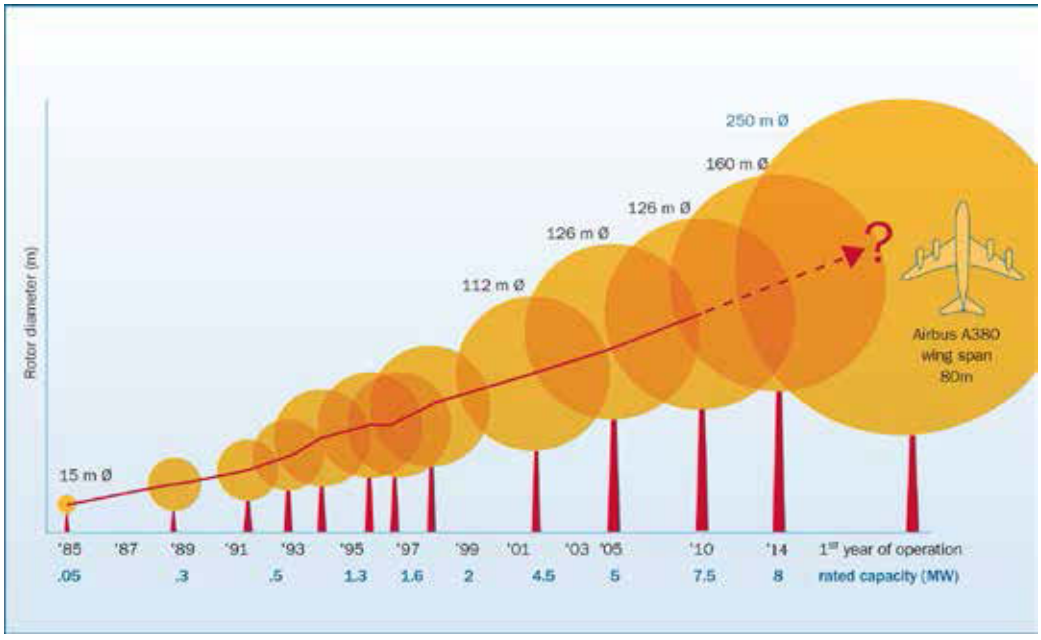


Figure 1: Evolution of Size of Wind Turbine Rotor

(Reference: https://celebrationscakedecorating.com/galleries/wind-turbine-history-timeline.html)

Traditionally a constant blade twist, under load, is assumed while designing the rotor for its optimal performance at the design wind speed. This twist is assumed to be constant in the variable speed region of the power curve. In addition, in most cases the aero-elastic analysis for loads does not include the torsion deflection of blade under loads i.e. the blade is assumed stiff in torsion.

With the increase in rotor size, this assumption does not hold good because with the increase in the blade aspect ratio (ratio of length by max chord), the blade will be flexible in torsion irrespective of its structural design. Capturing this in the design phase is important.

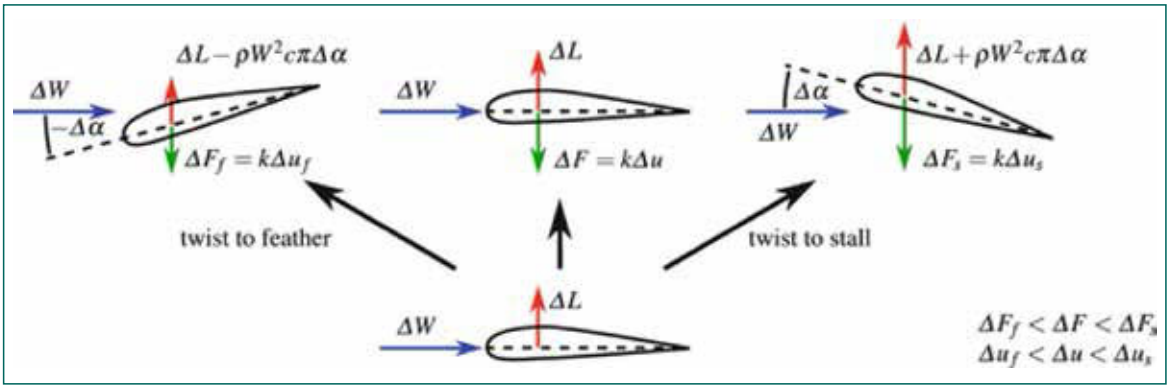


Figure 2: Twist in Blade Section Under Load

(Reference: Analysis and Design of Bend-Twist Coupled Wind Turbine Blades, Alexander R Stablein)


Sustainable development,
supported by Suzlon.
As a leader in the field of renewable energy, Suzlon embodies development for the future.
By reducing carbon footprint, Suzlon's wind and solar energy projects play a significant role in sustainable long-term job creation, and ultimately, a sustainable economy.
We're proud to demonstrate our commitment towards sustainable development across our 15 manufacturing locations across the globe.
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Depending on the design, under load, the blade undergoes bending coupled with torsion deflection. At lower winds (lower load) the blade twists less and at higher winds (higher load) the blade twist more. The direction of twist under load determines the load alleviating capability of the blade. Figure 2 shows two scenarios. Under load if the blade twists to feather, it reduces the angle of attack (AoA) and reduces loads. If the blade twists to stall, the AoA increases and it is bound to increase loads.

By not considering the blade torsional flexibility one therefore run into risks. Some of the important risks are:

- Inaccurate calculation of power curve and hence AEP:
  - In the optimal performance region of power curve i.e. variable rotor speed zone, the blade twists less below design wind speed and it twists more above the design wind speed.
  - This often leads to in accurate calculation of power curve.
  - The optimal fine pitch-lambda table calculated torsion flexible blade is different in comparison to the table used for a torsion stiff blade.
- Prediction of instability due to flap-torsion and edge torsion coupling:
  - Instability arising due to resonance between rotor whirling modes and rotor speeds (1P & 3P).
  - Instability arising due to higher rotor speeds e.g. flutter instability.
- Large blade torsion cycles:
  - Each rotation of blade would see a torsion cycle.
  - If not captured blade torsion fatigue is under predicted.

Following are some benefits one would lose out by not considering torsion flexibility:

- Reduction of tilt-yaw loads on the turbine:
  - Load alleviation due to blade twist would reduce the asymmetry of loads on blades rendering reduction of tilt-yaw loads.
- Passive peak shaving near the knee region of power curve:
  - The blade twists under high thrust and alleviates the load.
  - Additionally, this reduces the propensity of stall in blade sections.
- Reduction of ultimate loads during events:
  - E.g. for EOG load cases, rotor loads would be lower in comparison to torsional stiff blade.
- Reduction of fatigue loads:
  - Operational flap bending loads in a torsional flexible blade would be lower.
  - Corresponding fatigue loads on blade and components would be less.
- Reduction of thrust in the Ct curves affecting turbine wake and park performance:

It is therefore important for any wind turbine designer to capture the necessary physics of modelling the torsion flexibility of blades. Apparently, there are a few commercial tools available which can render this without much efforts e.g. FAST, HAWC2, BLADED, SIMPACK-Aerodyn, ADAMS-Aerodyn, etc.

Snippets on Wind Power

World Bank to provide $250-million loan to Rajasthan to improve power distribution

The World Bank will provide a $250 million loan facility to Rajasthan for improving the performance of its electricity distribution sector, the Union Finance Ministry announced on August 29, 2018. An agreement was signed here among the Government of India, the Government of Rajasthan and the World Bank. The key areas that the programme will support include, strengthening governance in the distribution sector by establishing annual performance MoUs between the DISCOMs and the State Government. The loan from the International Bank for Reconstruction and Development, has a 3-year grace period, and a maturity of 21 years

ENGIE, STOA Tie Up to Develop Wind Energy Platform in India

Power firm ENGIE and French infrastructure and power equity investor STOA has announced a partnership to build a wind energy platform in India with a goal of setting up over 2 GW capacity over the next five years.

Source: PTI, September 13, 2018

High-End Vibration Analysis in Wind Turbines - Modular EtherCAT Terminals for Scalable Condition Monitoring Solutions

Ajey Phatak, Head Marketing
Beckhoff Automation Pvt Ltd, Pune, India. a.phatak@beckhoff.com

The Peakanalyzer which is universally applicable software for fully automatic vibration diagnostics & analysis, has been tried and tested for use in wind turbines. The raw data is processed by a Embedded PC with integrated high resolution Accelerometer input module with EtherCAT communication for Condition Monitoring (IEPE). The system monitors the entire wind turbine drive train, and optionally the wind turbine foundations, reliably and with high precision.

The analyser software specializes in vibration diagnostics for gear units mounted on roller bearings. The research and development work has always focused on the automation of diagnostic processes, since this is the key for widespread acceptance of these technologies. The combination of diagnostic services and device development is important for condition monitoring.

One of the devices that has benefited from this approach is the software designed for fully-automatic, high-end vibration diagnosis at up to 32 measuring points, with up to 32 further channels for slower process variables (1 kHz). At the heart is PC-based control technology which integrates Scientific Automation concepts for integrating measuring functions that go beyond standard automation, such as condition monitoring. In this way, the analyser software enables, among other things, order analysis through resampling for diagnostics of variable-speed drives, DVS (Drive Vibration Significance) analysis for automatic identification of significant spectra, characteristic value monitoring, and triggered data acquisition.

Figure 1: Testing acceleration sensors connected to the PC with analyzer software

Typical areas of application for vibration analysis and condition monitoring are for expensive, low-redundancy drives, such as those used in steel mills, heavy engineering machinery, for the structural strength of building materials, drives & gear boxes in conveyor systems, heavy duty electric motors, generators where higher availability is a critical requirement, or safety related applications like drives in cable cars, for example. The analyser software is also useful for drives that are difficult to access and for which condition-based maintenance is therefore a prerequisite. Wind turbines are a prime example for such applications.

Application-Specific and Comprehensive Monitoring of Wind Turbines

For monitoring wind turbine drive trains, analyser software & hardware should be capable for monitoring multi-channel inputs, which can optionally also be used to monitor the strength of civil foundations via two further channels, in order to detect loosening. The diagnostic device is required to be installed in the wind turbine nacelle, either in the control cabinet or in a dedicated housing. The system analyzes the drive train based on the signals acquired by eight IEPE acceleration sensors: one sensor for the main bearing, two for the generator, and five for the gear unit. If required, the analyzer software should be capable to integrate into the existing communication structure (LAN interfacing in the nacelle, VPN access), or communication can be established via wireless communication, optical fiber (tower), or via GHSDSL (copper cables between systems), as well as through DSL to the Internet provider.

The analysis software adds the direct benefits because of the underlying PC-based control technology: The modular control technology using PC-based Control platform enables system integrator to offer customized and cost-effective diagnostic solutions that are highly scalable, based on a freely programmable, open system, and with globally available and exchangeable spare parts, if required.

Here the distributed I/Os can be easily connected without affecting the cycle time because of the advantages of EtherCAT fieldbus & distributed clock feature of EtherCAT fieldbus system that uses standard CAT6 patch cables is another technical &

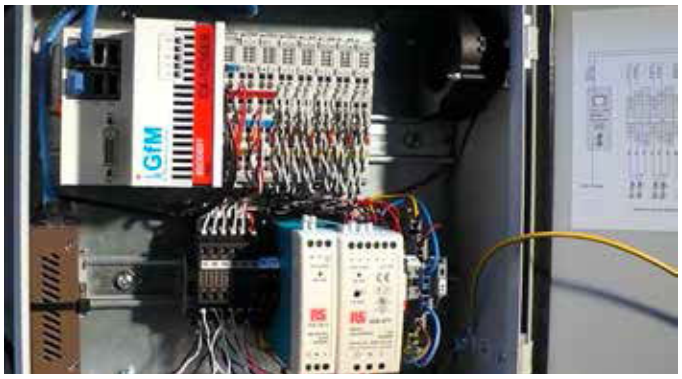


Figure 2: The Computerized Controller hardware used with input modules

commercial advantage for interconnecting node. The underlying eXtreme Fast Control Technology is based on an optimised control and communication architecture comprising an advanced Industrial computer, ultra-fast I/O terminals with extended real-time characteristics, the EtherCAT high-speed Ethernet system, and the windows based automation & control software. With this technology it is possible to achieve I/O update times/ I/O Cycle time of < 100µs. This technology opens up new process optimisation options for the machine designer or system integrator especially for vibration analysis that is not possible in the traditional control solution due to technical limitations.

Based on the high-performance communication of EtherCAT fieldbus, the software analyses up to 32 input channels for enhanced application flexibility. Moreover, a high channel sampling rate even with lower bus cycles can be achieved based on the oversampling functionality of the Accelerometer input sensor and Oversampling Input Module.

The DIN Rail Mounted Embedded PC performs measuring data acquisition and buffering based on the windows Control & Automation Technology software. The information is then passed via ADS (a communication protocol within the software) to proprietary analysis software for further processing. The advantage lies in the direct control of the PLC. That is, the communication, which is based on a universal PLC, so that different system configurations with different numbers of channels and terminal types only need to be distinguished in our software. Remote access is also possible, and to this end, the.NET application on the Embedded PC communicates with configuration and evaluation software on the corresponding network computer via TCP/IP.

Condition Monitoring Modules as Essential I/O Equipment

Sensor data for drive monitoring is logged with high precision via the two-channel High speed input Terminals and communicated over EtherCAT fieldbus to software and this is an essential component of the Peakanalyzer. The key for the implementation of the high-end vibration monitoring system is the acquisition of the IEPE sensor signals with a sampling rate of 50 kHz. An additional factor is the very wide sampling range between 1 Hz and 1 kHz, which enables the device to measure low-frequency vibrations (e.g. tower oscillations) and high-frequency vibrations (e.g. vibrations at the actual wind turbine) at the same time. In order to obtain a high-quality envelope signal for detecting roller bearing and gearing damage, all channels almost exclusively measure with a clock frequency of 50 kHz. Particularly in the wind industry, the 0.1 to 10 Hz mode is additionally used for logging characteristic values according to VDI 3834.

A direct benefit of the windows control software particularly during commissioning, is the breakage detection feature offered by the Condition Monitoring input module.

The Input / Output range of the analyser software can be complemented by further interfaces, according to customer requirements. Here, the user benefits from the wide range of solutions in the modular DIN Rail mounted I/O system. For example, via pulse time measurement, the incremental encoder interface module enables very precise speed measurement with several, non-equidistant pulses per revolution. The analogue input module with oversampling is ideal for recording oscillation movements via inductive displacement sensors for monitoring slowly moving roller bearings.

Digital input terminals are used for triggering measurements, and digital output modules handle the signalling of characteristic values and process parameter alarms. Important process variables such as power, wind, and torque can be integrated in the diagnostic system as analogue voltage signals (±10 V) or current signals (0 to 20 mA) via the EtherCAT Slave Input /Output Modules. In addition, the eXtreme Fast Control strain gauge analysis units are available for torque measuring points, and high-precision RTD (PT100) input modules are applicable for temperature measurements.

Extreme Fast Control Technology

The underlying control for realising the high speed data acquisition and analysis condition monitoring analysis software is based extreme fast control technology.

Features like Distributed Clock, Time-Stamp / Multi-Timestamp, Oversampling are the underlying technologies that need to be used.

The crucial factors for the control process are: minimum response time, deterministic actual value acquisition (i.e. exact temporal calculation must be possible), and corresponding deterministic set value output. At what point in time the communication and calculation occurs in the meantime is irrelevant, as long as the results are available in the output unit in time for the next output, i.e. temporal precision is required in the I/O components, but not in the communication or the calculation unit.

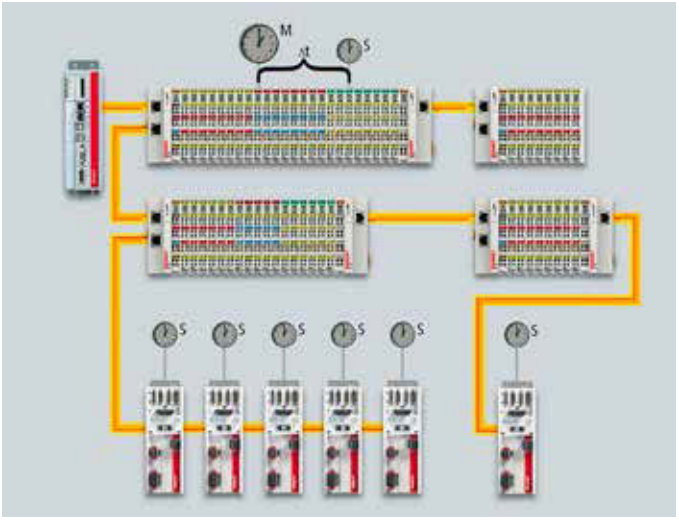


Figure 3: Distributed Clock

In a normal, discrete control loop, actual value acquisition occurs at a certain time (input component), the result is transferred to the control system (communication component), the response is calculated (control component), the result is communicated to the set value output module (output component) and issued to the process (controlled system).

The distributed EtherCAT clocks therefore represent a basic XFC technology and are a general component of EtherCAT communication. All EtherCAT devices have their own local clocks, which are automatically and continuously synchronised with all other clocks via the EtherCAT communication. Different communication run-times are compensated, so that the maximum deviation between all clocks is generally less than 100 nanoseconds. The current time of the distributed clocks is therefore also referred to as system time, because it is always available across the whole system.

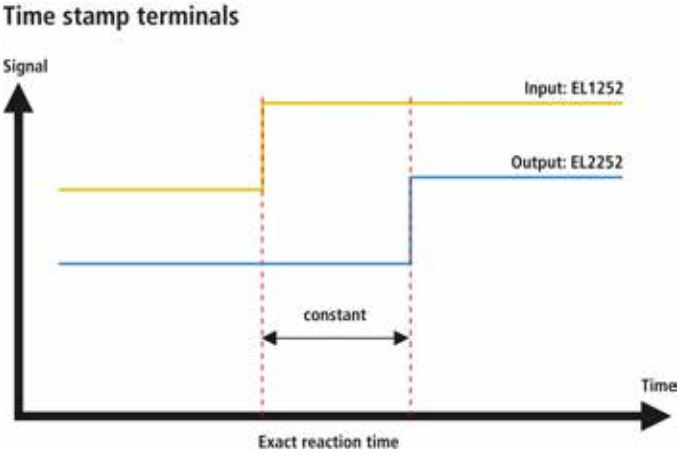


Figure 4: Time Stamp Terminals

Time Stamp/Multi Time Stamp

Process data is usually transferred in its respective data format (e.g. one bit for a digital value or one word for an analog value). The temporal relevance of the process record is therefore inherent in the communication cycle during which the record is transferred. However, this also means that the temporal resolution and accuracy is limited to the communication cycle.

Timestamped data types contain a timestamp in addition to their user data. This timestamp – naturally expressed in the ubiquitous system time – enables provision of temporal information with significantly higher precision for the process record. Timestamps can be used for inputs (e.g. to identify the time of an event occurred) and outputs (e.g. timing of a response). This way it is possible to determine, for example, the precise point in time when an output is to be switched. The switching task is executed independently of the bus cycle.

While timestamp terminals can execute one switching task or switching event per bus cycle, multi-timestamp terminals can execute up to 32 switching tasks or switching events per cycle.

Oversampling

The concept of oversampling is that the input signals (Digital or Analogue) are oversampled with an adjustable, integer multiple (oversampling factor: n) of the bus cycle time (n microcycles per bus cycle). For each microcycle, the Input Module generates a process data block that is transferred collectively during the next bus cycle and this is how the Peakanalyzer is able to support such accurate vibration recording and evaluation.

Oversampling data types enable multiple sampling of a process record within a communication cycle and subsequent (inputs) or prior (outputs) transfer of all data contained in an array. The oversampling factor describes the number of samples within a communication cycle and is therefore a multiple of one. Sampling rates of 200 kHz can easily be achieved, even with moderate communication cycle times.

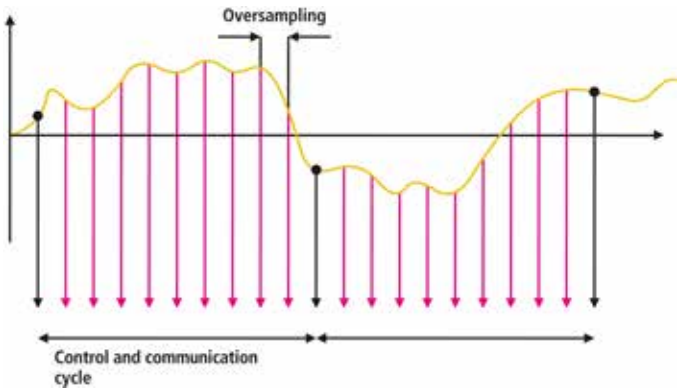


Figure 5: Oversampling

Picture Credits/Copyright: GfM

Integrating Renewable Energy at Exchange Platform

Contributed by Indian Energy Exchange

Day-Ahead Market (DAM)

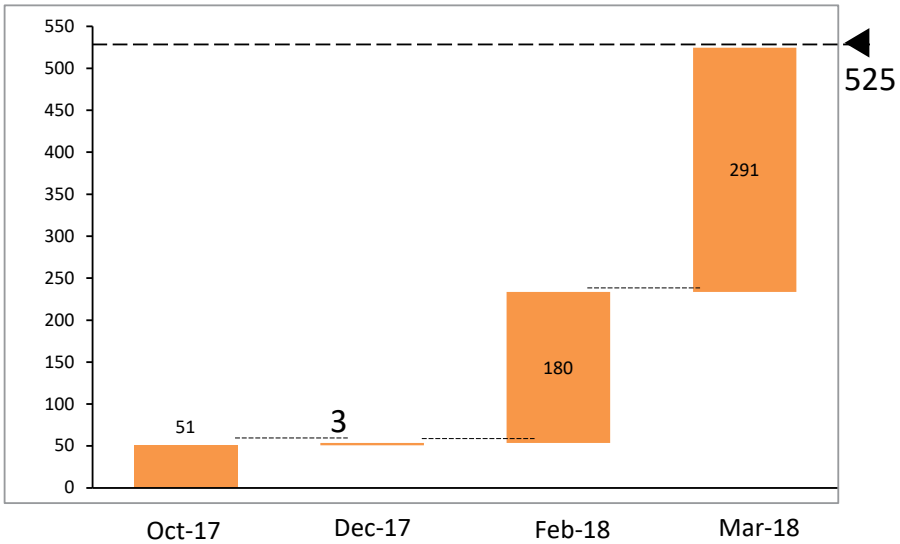
The Day-Ahead-Market (DAM) offers standardized contracts of 15 minutes allowing participants to trade in electricity a day in advance. In fiscal year 2017-18, the DAM traded 44.8 BUs at an average price at Rs. 3.19 per KWh registering volume growth of 13% over the previous fiscal. So far only the conventional power generators were leveraging exchange markets, but now, selling renewable power in the day-ahead market on the exchange is a viable proposition. Already, several renewable generators have been selling on exchange platform at attractive prices compared to competitively bid tariff.

Power Market goes Green

The exchange has been enthusiastically working towards integrating renewables generator - solar, wind and biomass generators on its platform. From October'17 to March'18, 14 solar generators constituting 525 MW of capacity sold about 59 MU of solar electricity in the day-ahead market. The renewable energy generators presently selling on the Exchange are primarily doing so prior to declaring full commercial operations / commissioning and upon commissioning the generator exits the Exchange and opts to sell power under the contractual commitments.

Addition in Solar Capacity Registered in DAM (October - March'18)

The renewable generators are able to bid and schedule power through the Exchange platform with very precise forecasting and minor deviation with their net commercial realization being considerably higher vis-à-vis prices discovered in the recent solar and wind auction. Below is an indicative profile of average scheduled and actual generation of a 51 MW solar generator based in Madhya Pradesh indicating the precision with which solar generator can schedule power and minimize the deviation on real time basis and increase their net realisation.



Solar Capacity Addition at IEX from October – March'18

Key Statistics
Day-Ahead Market
[FY 2017-18]

Registered Participants

- 6200 + participants
- Discoms from 29 states and 5 UTs
- 3900 + open access participants
- 400 + electricity private generators
- 14 solar projects constituting 525 MW of capacity

Market Highlights

- 1,22,854 MWh: Average Daily Volume
- 182,992 MWh: Highest Volume on delivery day – 14th Sep'17
- 887 Average number of participants in single day
- >230 BU cumulative cleared volume in electricity market since inception in year 2008

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the new ReGen make
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wind generator platform with a rotor diameter of 121m. The evolution of our highly successful 1.5 MW and 2 MW wind platforms, the new WD 121 2.8 MW IEC IIIB provides unparalleled performance at high efficiencies even in low and medium wind sites.

- Advanced technology with gearless direct drive, variable speed Synchronous generator with permanent magnet excitation
- No reactive power, no dependence on grid for excitation.
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- Full 900 pitchable blades offer aerodynamic breaking.
- Generator has concentric winding with flux concentration which boosts generator performance and efficiencies.
- Maintenance free highly reliable three independent pitch system

The 2.8 MW platform offers the lowest cost of energy generation and offers the highest yield in its class earning the highest return on investment. To learn more about our new platform, please visit www.regenpowertech.com or send an enquiry to info@regenpowertech.com

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Chennai – 600 031, Tamilnadu, India
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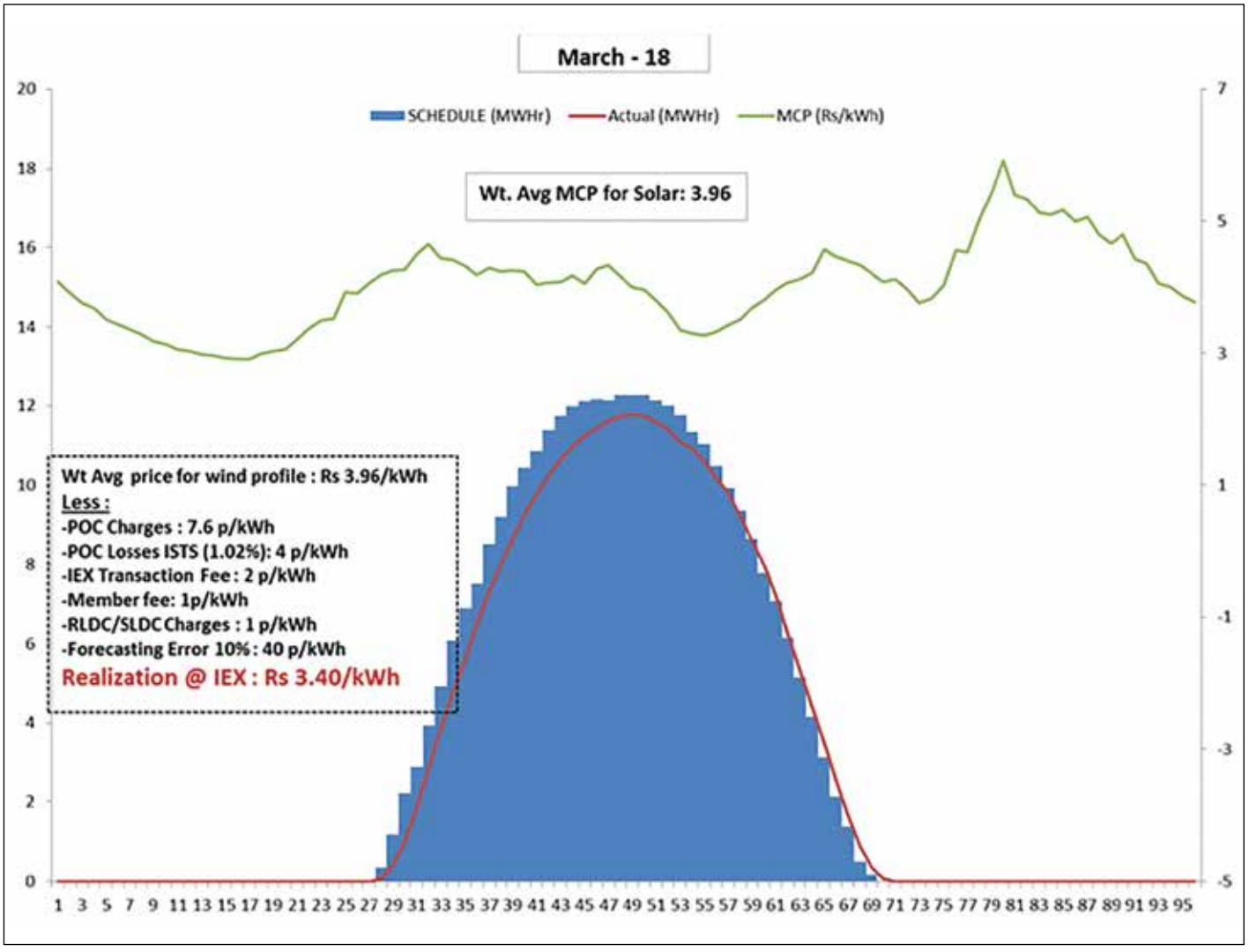
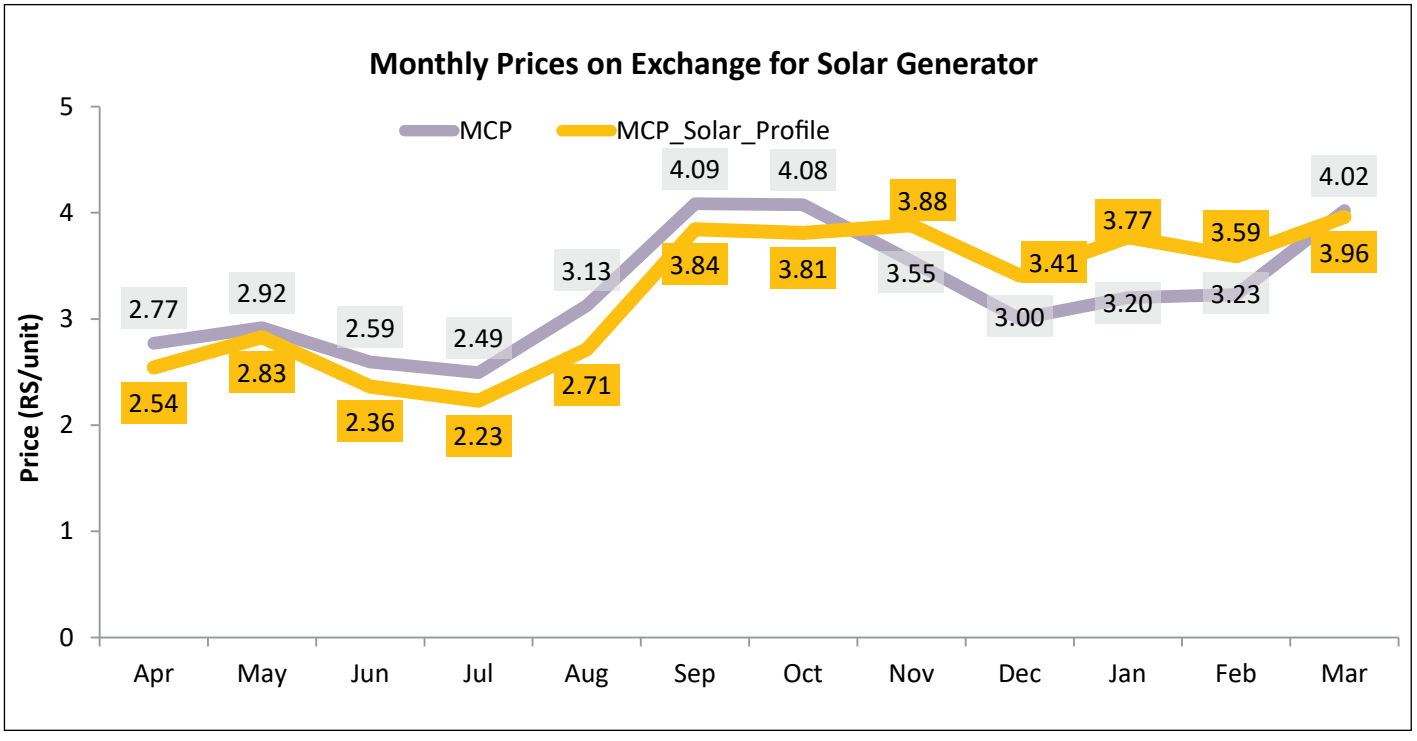
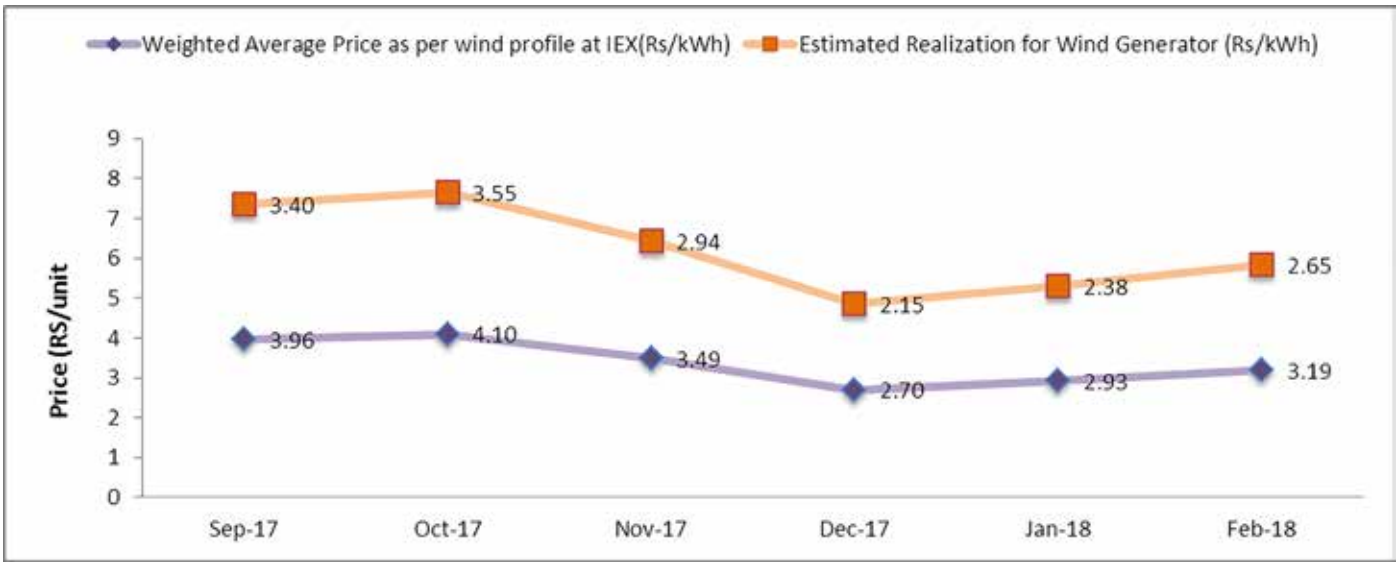
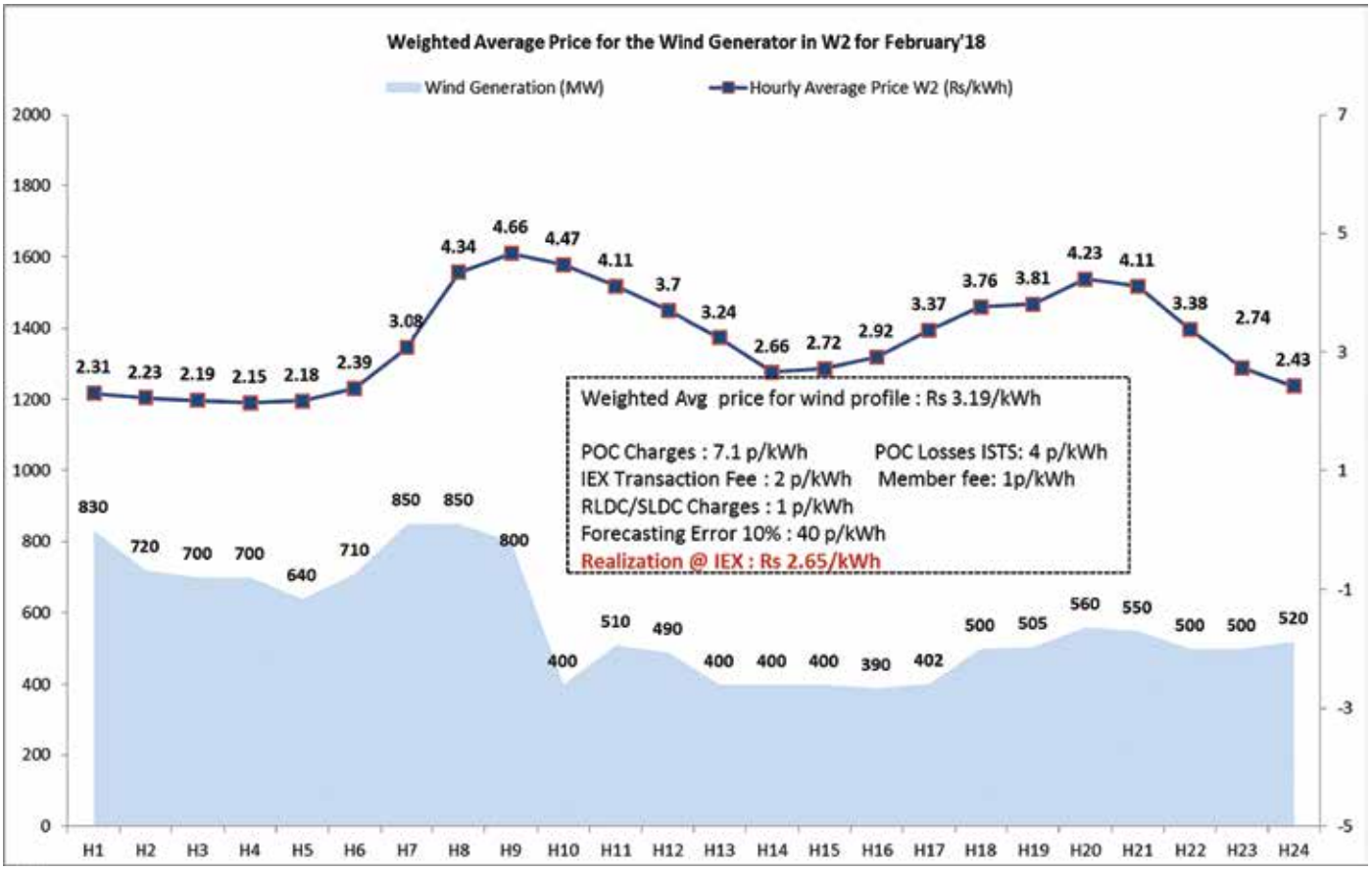
Email : info@regenpowertech.com

www.regenpowertech.com


March - 18
SCHEDULE (MWHr)
Actual (MWHr)
MCP (Rs/kWh)
Wt. Avg MCP for Solar: 3.96
Wt Avg price for wind profile : Rs 3.96/kWh
Less :
-POC Charges : 7.6 p/kWh
-POC Losses ISTS (1.02%): 4 p/kWh
-IEX Transaction Fee : 2 p/kWh
-Member fee: 1p/kWh
-RLDC/SLDC Charges : 1 p/kWh
-Forecasting Error 10% : 40 p/kWh
Realization @ IEX : Rs 3.40/kWh


Monthly Prices on Exchange for Solar Generator
MCP
MCP_Solar_Profile
Price (RS/unit)
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
2.77
2.92
2.59
2.49
3.13
4.09
4.08
3.55
3.00
3.20
3.23
4.02
2.54
2.83
2.36
2.23
2.71
3.84
3.81
3.88
3.41
3.77
3.59
3.96





Snippets on Wind Power

Wind, Solar farms could bring rains to Sahara Desert

"Previous modeling studies have shown that large-scale wind and solar farms can produce significant climate change at continental scales," said Yan Li, a postdoctoral researcher at the University of Illinois in the US. The rainfall increase is a consequence of complex land-atmosphere interactions that occur because solar panels and wind turbines create rougher and darker land surfaces. "The increase in rainfall and vegetation, combined with clean electricity as a result of solar and wind energy, could help agriculture, economic development and social well-being in the Sahara, Sahel, Middle East and other nearby regions," said Safa Motesharrei from University of Maryland.

Source: PTI, September 10, 2018

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Prevent Turbine Breakdown by Right Choice of Lubricants

Siva Kasturi, Asia Pacific Regional OEM Manager
Shell Global Lubricants

India's power sector is one of the most diversified in the world. Sources of power generation range from conventional sources such as coal, lignite, natural gas, oil, hydro and nuclear power to viable non-conventional sources such as wind, solar, and agricultural and domestic waste. Electricity demand in the country has increased rapidly and is expected to rise further in the years to come. To meet the increasing demand for electricity in the country, massive addition to the installed generating capacity is required.

Lubricant technology plays a vital role in keeping wind turbines running reliably and efficiently. The OEMs and customers today are constantly striving to improve efficiency and operational reliability, and enhance competitiveness by avoiding loss of output and increased maintenance costs. Besides reducing friction and offering strong reliability to equipment, lubricants also play a vital role in terms of energy efficiency. For power generation industries or plants, reliability and uptime are considered extremely important factors for both traditional and renewable forms of energy, including gas turbines, nuclear turbines, wind turbines or HFO fuel based engines.

Poor lubricants and lubrication practices can cause equipment downtime which can lead a firm to losses. In today's operations, lubricants become a critical element in the lifespan of a turbine where severe conditions and cyclic peak loading are the new norm.

The wind industry has traditionally believed that value creation is concentrated in manufacturing and wind farm development. One of the most important aspects of a wind turbine is the reliability of its 'critical' components (gearbox, generator, blades, etc.). These parts need to be properly conserved and maintained to achieve an optimum level of performance and reduced need for costly maintenance. Typically, in wind turbines, large components' failures such as those of gearboxes, main bearings, etc. take about eight to ten weeks or even longer to repair or replace. Especially in today's scenario of high demand, component lead time represents more than 80 to 90% of total downtime.

Small failures are frequently the most common cause of unavailability. The following are some of the challenges faced by wind industry and suitable O&M trends need to be adopted accordingly.

1. Remoteness of wind turbines and harsh conditions both on- and off-shore
    - Difficulty with maintenance – reliance to on-board sensor technology
    - Low temperature start-up procedures and need for excellent low temperature fluidity
    - Potential for accelerated corrosion/rusting, especially in offshore application
    - Increased interest in lubricant design in relation to white etching failures
2. Design of wind turbine gearboxes
    - Compact design creates additional lubrication challenges – air entrainment
    - Surface finish and manufacture of gears critical for long term service life
    - Demands for lubrication of bearings and tighter product cleanliness targets – move to finer filtration
3. Expectation for longer oil service life
    - Synthetic gear oils offer benefits in reduced frequency and cost of oil change-outs
    - Provide protection for bearings and gears over service life
    - Better life of filters and breathers

One can describe maintenance practices on wind turbines as either 'preventive' actions performed at routine intervals as per the manufacturer's specification, or 'reactive' when a turbine's component is damaged causing the machine to shut down.

Today, new 'preventive' maintenance practices are being developed, using high tech condition monitoring technologies, which aim to reduce the overall turbine O&M lifetime costs.

Wind OEMs are now focusing more on predictive maintenance techniques which have arisen to maintain, visually inspect, measure, and analyse the condition of the turbines and perform required repairs through technology called Condition Monitoring System (CMS). This technology, which is expensive

at first, is said to lower the overall O&M costs of a turbine over its lifetime.

Wind turbine O&M practices are facing diversified challenges with respect to operating costs, asset management, reliability and component failures and right know-how on maintenance strategies.

Wind OEMs are increasingly getting familiar with component performance trends, seal compatibility issues, filtration challenges and basis of the new compliance of IEC 81400-4.

OEMs are continuously focusing on design, reliability of their equipment and component performance through strong asset management diagnostic tools. The trends are more focused towards operational issues, troubleshooting challenges and unscheduled maintenance planning, etc. Lubricant technology plays a vital role in keeping wind turbines running reliably and efficiently. The customers today are constantly striving to improve efficiency and operational reliability, and enhance competitiveness by avoiding lost output and maintenance costs. Poor lubricants and lubrication practices can cause equipment downtime which can lead a firm to losses. Hence, in today's operations where severe conditions and cyclic peak loading are the new norm, a lubricant becomes a critical element in the lifespan of a turbine.

Some major global lubricant manufacturers have a deep understanding of the product demands in the wind industry. Additionally, they are quite familiar of the pressing need to ensure enhanced protection of critical components to reduce replacement costs; extend turbine life; and improve operational efficiency through synthetic oil technology.

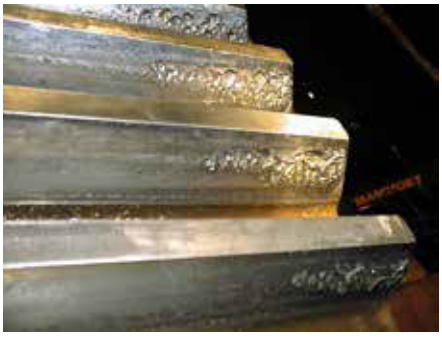
Shell is proactively working with OEMs and end customers in terms of enhancing reliability and about introduction of new technology gear oils as per revised IEC 61400 specifications and introduction of next generation synthetic greases for wind turbine applications.

Lubricants can have a huge impact on the operations of a customer's business. Choosing, using and managing them correctly can bring significant rewards in terms of improved efficiency and profitability. OEMs should choose the right partner to choose because which provides OEM approved products and services to ensure appropriate reliability and efficiency.

Gear Failures

Surface Damage: Scuffing is a local welding together or breaking away of two reciprocally moving machine parts - in this case, gears - due to insufficient or incorrect lubrication. It occurs most often in roughness peaks in the tooth contact. The cause can be found in very high temperatures, also known as "flash temperatures" that are based on the load, the peripheral speed and not least on the temperature of the oil sump area.

1. Adhesive wear produced by bonding of surface asperities.
2. Observed where there is a high component of sliding.
3. High loads and poor lubrication.
4. Local high temperatures.



Pitting: Generally modern gears are surface hardened. Pitting occurs when fatigue cracks are initiated on the tooth surface or just below the surface. ... Pits are formed when these cracks break through the tooth surface and cause material separation. When several pits join, a larger pit (or spall) is formed.

https://www.engineersedge.com/gears/gear_pitting_lubrication.htm

Miropitting: In a normal bearing the surfaces are separated by a layer of oil, this is known as Elastohydrodynamic (EHD) lubrication. If the thickness of the EHD film is of the same order of magnitude as the surface roughness, the surface topography is able to interact and cause micro pitting. A thin EHD film may be caused by excess load or temperature, a lower oil viscosity than is required, low speed or water in the oil. Water in the oil can make micro pitting worse by causing hydrogen embrittlement of the surface. Micro pitting occurs only under poor EHD lubrication conditions.

Micropitting is a localized surface damage phenomenon that occurs under mixed film lubrication conditions. Identification: Micropitting results in a frosted or matte surface finish. Use an oil with high micropitting resistance.

https://www.engineersedge.com/gears/gear_pitting_lubrication.htm

Preventive Maintenance of Wind Turbines

Srikaanth Sarangapani, Wind Energy Consultant
srikanths_2k1@yahoo.com

An operations and maintenance (O&M) strategy is important for a wind-farm owner because of the long-lasting impact it can have on the profitability and efficiency of a wind site's operations. Larger wind farm owners often pursue self-perform (maintenance) strategies to fully control their assets, trim costs, and optimize O&M practices. Good O&M planning prevents equipment decline or failure while it increases long term, wind-farm efficiency and energy production. Smaller owners, however, may not be able to justify the capital expense required to self-perform and instead rely on services offered by OEMs. Although at a cost premium, these services provide minimal risk strategy to troubleshoot turbine performance issues, offer access to spare parts, and ensure high technical availability. On the other hand, many service providers can offer maintenance services at a discount, but may not be able to provide all elements covered under the scope of the O&M. Large components, such as gearboxes, generators, blades, and bearings, are expensive to repair and may result in significant downtime and lost production.

Concept

Preventive Maintenance means changing or repairing a component preventively i.e., before it breaks. Advantage is to avoid unplanned down time due to sudden failure. Maintenance costs tend to increase as the length of time from commissioning increases. This is due to an increasing probability of component failures and that when a failure does occur it will tend to be outside the manufacturer's warranty. O&M is the key to maximizing profitability of wind energy assets.

Operating and Maintaining the Wind Assets

Improved O&M could account for nearly 20% increase in the Equity Internal rate of Return (IRR). There are three control mechanism which allow improvement of wind farm O&M.

1. Availability
2. Efficiency
3. O&M costs

1. Availability

A 3 percent increase in availability can yield a 1.2 percent increase in IRR. Although, availability levels of 95-96% are common in wind industry, performance typically varies widely. In practice, only one third of wind parks operate above 98.5% proving that such level of performance is achievable. More than 40% of the farms however operate below 97% and some parks as low as 92% availability creating significant potential for improvement. In the current tight market, large component failures take 2 to 8 weeks or even longer to repair or replace. Component lead time represents more than 80-90% of the total down time. Small failures are frequently the most common cause of non-availability.

There are number of different ways to optimize the output:

- Eliminating root cause of underperformance starts with identifying the issues that are causing the huge loss of output. For example, in one wind farm, a high temperature in turbine transformers was causing most of the unavailability. Replacing them was too expensive but increasing mechanical ventilation inside the tower proved extremely effective.
- Optimizing preventive maintenance begins with reviewing on regular basis which components are failing and reason for failure. Preventive maintenance need to be adapted based on experience and failure statistics.
- Optimizing logistics of components begins with having an optimal stock of components available.

2. Efficiency

Efficiency is measured by the amount of power generated by the operating turbine compared with the theoretical output it should provide according to OEM specifications.

- First step is to analyze the power curve for suspect turbines. Lost production in the range of 10-20% is common in underperforming turbines.
- The cause of turbine inefficiency can vary significantly include the wind wane malfunction, dirty blades, etc.

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NGC is a global leader in wind gearbox development and production with high performance product which provides complete main gearboxes, yaw and pitch drive product for wind turbine. NGC high reliability products are adapted to various working conditions, low/high temperature, low wind speed, high altitude, offshore and others. By far, over 55,000 NGC main gearboxes have been operating globally with excellence performance, contributing to the continuous power supply for green energy.

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3. O&M Costs: Different Types of O&M Model

- Renewal of the existing full O&M service agreement ideally with a certain guarantee over performance. This is after the expiry of the initial contract given by the turbine manufacturer at the time of purchase.
- Completely internal O&M including its own teams to conduct all maintenance activities.
- A hybrid model in which the owner performs certain tasks while sub contracting others to third parties. In-house activities could include O&M Intelligence (Data Analysis, Failure Prioritization and Root Cause Analysis) and Maintenance Planning (when and in which components to conduct preventive maintenance). Neither of these activities requires huge resources but both are critical to maximize output. Other activities such as Spare Parts Management are partially outsourced but under strict specification from the owner. Labour intensive field activities which involve complexity in people management are also sub contracted.

Pictures 1 to 4: Training for O&M Personnel for Working on Heights

The Challenge: Continuous Improvement

- Establish the correct Management Information System (MIS): This system requires ensuring that all data generated by the SCADA (Supervisory Control and Data Acquisition System) is continuously registered, any work conducted in the wind farm is codified and stored in central data bases and that reports are automatically generated to identify underperformance and root cause of the failure. This process is best conducted through a remote controlled centre that centralizes information from and allows real time monitoring of turbine alarms so that issues can then be solved remotely or by sending people on to the site.
- Developing a culture focused on O&M improvement

Types of O&M Costs

A. **Fixed O&M Costs:** Insurance, Administration, Fixed grid access fees, Servcie contracts for scheduled maintenance.

B. **Variable O&M Costs:** Scheduled and Unscheduled maintenance not covered by fixed contracts, as well as replacement of parts and other labour costs.

Wind Asset Management

- Maintenance check list need to be properly updated at regular intervals based on the experience of field staffs, changing documentation requirements of individual supplier parts
- Design change requests implementation
- Cost out activites identification
- Wind Turbine Generator Downtime summary
- Why the Breakdown occurred (Root cause), maintain records of errors and breakdown
- Error master
- Material master
- Service reports for the maintenance of electrcial and mechanical equipments
- Daily Generation Reports
- Scheduling and Executing Preventive Maintenance
- Visual Inspection: This will significantly reduce wind turbine maintenance costs and will help to identify potential loose bolted joints before expensive breakdowns including preventing accidents.

Mitigating Turbine Downtime with Proper Lubricant Care

Proper lubrication is fundamental to wind-turbine component reliability, and implementing the right lubrication strategy can help deliver long-term results.

When choosing a wind-turbine lubricant, formulation matters. To optimize gearbox performance, look for advanced synthetic lubricants that are formulated with base stocks and additives that offer:

- High performance in extreme temperatures
- Enhanced oxidation and water resistance
- Protection against wear and micro pitting
- Long equipment life
- Energy efficiency benefits

Condition Monitoring System

To know what component/s need upkeep or repair, earlier required a wind technician to climb up-tower and reach to the nacelle. Now a days, companies offer wind farm owners a new way to approach operations and maintenance called "Condition Monitoring and Advanced Prognostic Systems". It is an O&M tool that helps wind-farm owners and operators monitor the health of turbine components and related electrical systems with the purpose to predict maintenance issues so site operators can conduct repairs and replacements only when needed to avoid unnecessary and costly up-tower jobs.

Why Condition Monitoring System (CMS)?

- No catastrophic failures
- More efficient use of cranes
- Reduction of down times
- Early detection of fault – critical input to O&M's planning / scheduling process
- Diagnose top component failures of generator, main bearing and gear box

Few maintenance actvities that need to be carried out for achieving best results in preventive maintenance:

Service Portfolio during Operation:

- Acceptance testing/periodic inspections
- Noise measurements
- Gear oil analyses
- Expert assessments of damage (e.g. corrosion)
- Basic and advanced training (e.g. service fitters, service mechanics, safety courses, repair coaching)
- Inspection prior to expiry of the warranty

Maintenance

- Due diligence
- Valuations
- Condition-based maintenance
- Rehabilitation concepts
- Use conditioning monitoring - check for Gear box oil temperatures
- Check grease quality
- Install vibration sensors
- Check for dirt/metal particles on blades and clean them
- Check for ambient temperature and regulate WTG generation
- Check tower bolts and torque them
- Regularly check pitch angle
- Check cable twist if any.

Various O&M companies are offering various types of maintenance services packages.

Preventive Maintenance Innovative Techniques

• Drone-based Inspections

Drone-based inspections for blade inspection provide cost reduction and revenue enhancement opportunities when compared with ground based inspection in the following ways:

- Will enable automation of field inspection
- Improvement in safety and more accurate measurement
- Reduction in hazardous field hours
- Digital asset management
- Drone is an effective way to inspect and manage wind turbines
- Inspect up to 15 cm deep into a wind turbine blade with Proprietary Thermal Technology
- Higher-resolution visual drone inspections than ground-based inspections
- Greatly reduce man hours and costs by automating inspections
- Safely assess the condition and orientation of various components of wind turbines
- Wind farm remains functional during inspection
- Drones enable collecting the needed data for identifying and mitigating risks in power distribution in advance
- Safety of personnel – no need for them to ascend to height
- Real-time images and video feed can be transmitted to ground control station
- Thermal and LIDAR can be used to aid in inspecting and monitoring wind turbine blades and the general structure

Figure 1: Use of drone is now increasing to check blade damages, crack, and lightning damage

- ## Wind Tower Retrofit with Service Lift

Operations, maintenance, service and replacement of wind turbine parts may require climbing the ladder 50 to 100 meters and remaining in various unusual postures by the technicians, which is very risky and can create musculoskeletal disorder, knee and low back pain. One of the solutions to avoid such ladder climbing is fitting/upgrading the wind tower with a service list.

The benefits of the upgrading the wind tower with service list are:

1. Time reduction (downtime, malfunctions, climbing, rests, etc.) the lift reaches 80-100 meters in 4-5 minutes.
2. More turbines can be maintained by the same team of technicians in a given time.
3. Provides quick and reliable access
4. Health protection of employees and less insurance premium.
5. Cost reduction on various aspects.
6. Reducing down time with quick repair/service/change of parts.
7. Material transport is easy and fast.
8. Can handle unattended material transport
9. Technician can concentration on main job
10. Mid- to long term cost reduction
11. Retention of the O&M employees

The existing Winch (Chain Hoist) in the nacelle of wind turbine for lifting the materials can be replaced with service lifts, which would be cost competitive and serve the dual advantage of material movement as well as used by the manpower for doing the trouble free O&M service for 25 + years of turbine operation.

Figure 2: Wind Tower Retrofit with Service Lift

Snippets on Wind Power

Panel on Power Mulls Payment Security Mechanism for Private Players

A high level panel for power sector is considering payment security mechanism for private sector power generators, which has been the main cause of stress in the sector as they are not paid for more than six months in some cases. This results in default on loan servicing. The High Level Empowered Committee is headed by the Cabinet Secretary with representatives from the Ministry of Railways, Ministry of Finance, Ministry of Power, Ministry of Coal and the lenders, having major exposure to the power sector. The committee is looking into the various issues with a view to resolve them and maximise the efficiency of investment, including changes required to be made in the fuel allocation policy, regulatory framework, mechanisms to facilitate sale of power, ensure timely payments, payment security mechanism, changes required in the provisioning norms/Insolvency and Bankruptcy Code (IBC), Asset Restructuring Company (ARC) Regulations and any other measures proposed for revival of stressed assets so as to avoid such investments becoming NPA (bad loan).

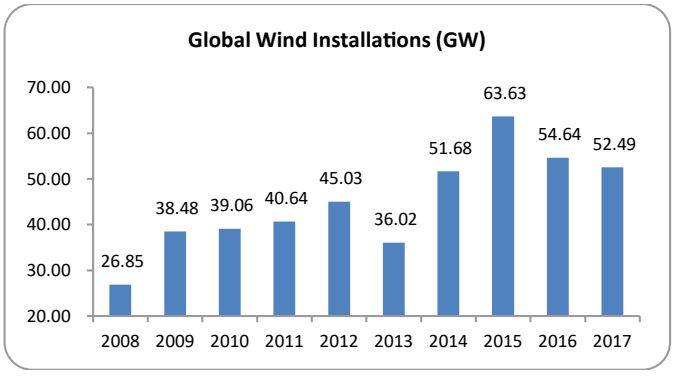
Source: PTI, September 12, 2018

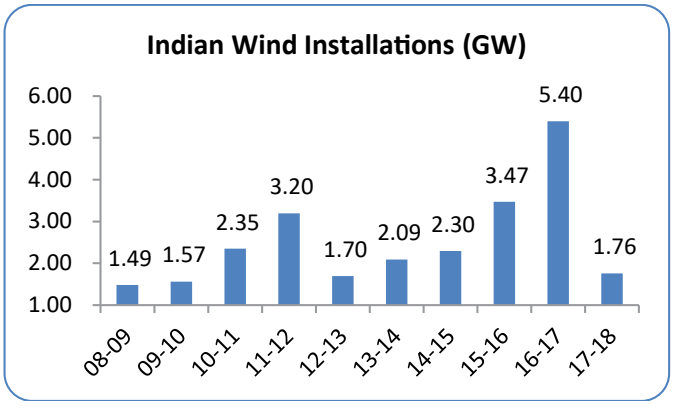
Heavy Castings in Wind Turbines

V. Srinivasa Reddy, Executive Director
Synergy Green Industries Limited, Kolhapur, Maharashtra. vsr@synergygreenind.com

1. Introduction

Discovery of competitive power tariffs through reverse bidding and government policy support is giving an opportunity for the Indian wind turbine industry to cross 10 GW of annual installations very soon. Following are the Global & Indian wind installations during last 10 years.





Figures 1 and 2: Hub Castings

Figure 3: Moulding Shop for Wind Mill Castings Needs Large Space

Casting is one of the critical components for the wind turbine and gear box assembly. Each MW of turbine requires around 20 MT of castings and contributes 5% of turbine cost.

Indian wind turbine casting foundries are primarily dependent on domestic market. Even though industry is growing at very fast pace, every five years once there is a significant drop in domestic installations and this is seriously affecting stability of wind casting industry.

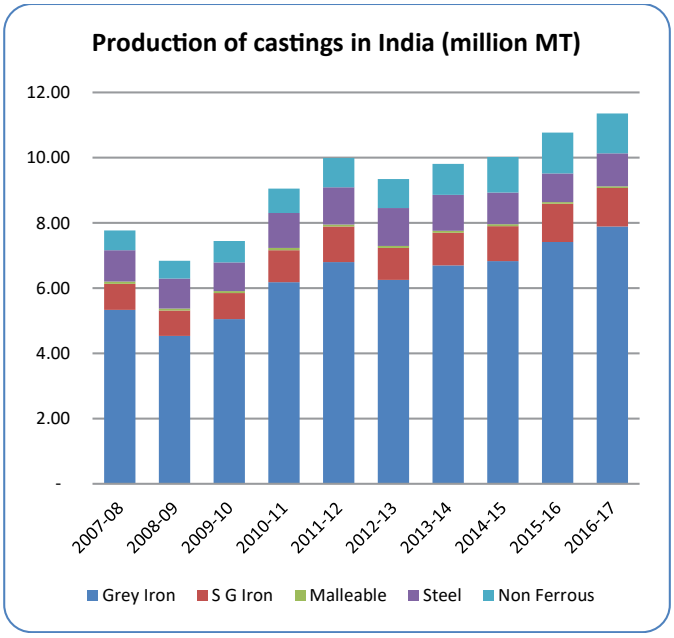
India is being discovered as one of the globally competitive manufacturing country in the world for wind turbines. Major wind turbine manufacturers are in the process of converting India as global manufacturing hub.

With Indian wind industry positioned to double its installations and global demand coming to India should offer great amount of stability to the Indian wind casting industry along with tremendous growth opportunity.

2. Indian Foundry Industry

India is the second largest casting manufacturer in the world with 11.35 million metric tons of production valued at US $19 billion.

Presently, Indian foundry industry is doing extremely well with exceptional demand generated from auto sector, capital



goods and agriculture industry. Every single foundry is reported to be operating above 90% capacity utilisation and majority of foundries are going for big expansions with stable growth forecast.

Figure 4: Liquid Metal Tapping

3. Wind Casting Demand

With 50 GW plus global installations, casting requirement is around one million MT. Wind casting demand contributes 1% of global casting production. At 5 GW of Indian installations, local demand is 100,000 MT which is 1% of present Indian casting production as well. This demand is likely to go up by three folds with doubling of Indian installation to 10 GW and another 5 GW of global production is being met through made in India turbines.

4. Casting Technology

Historically foundry production remained as an art due to large number of variables involved and heavily dependent on human skills. Typical large scale foundry consists of 300 plus people, 200 plus raw material, 200 plus equipments, 100 plus processes and 100 plus measurements takes the potential variables to over 120 billion.

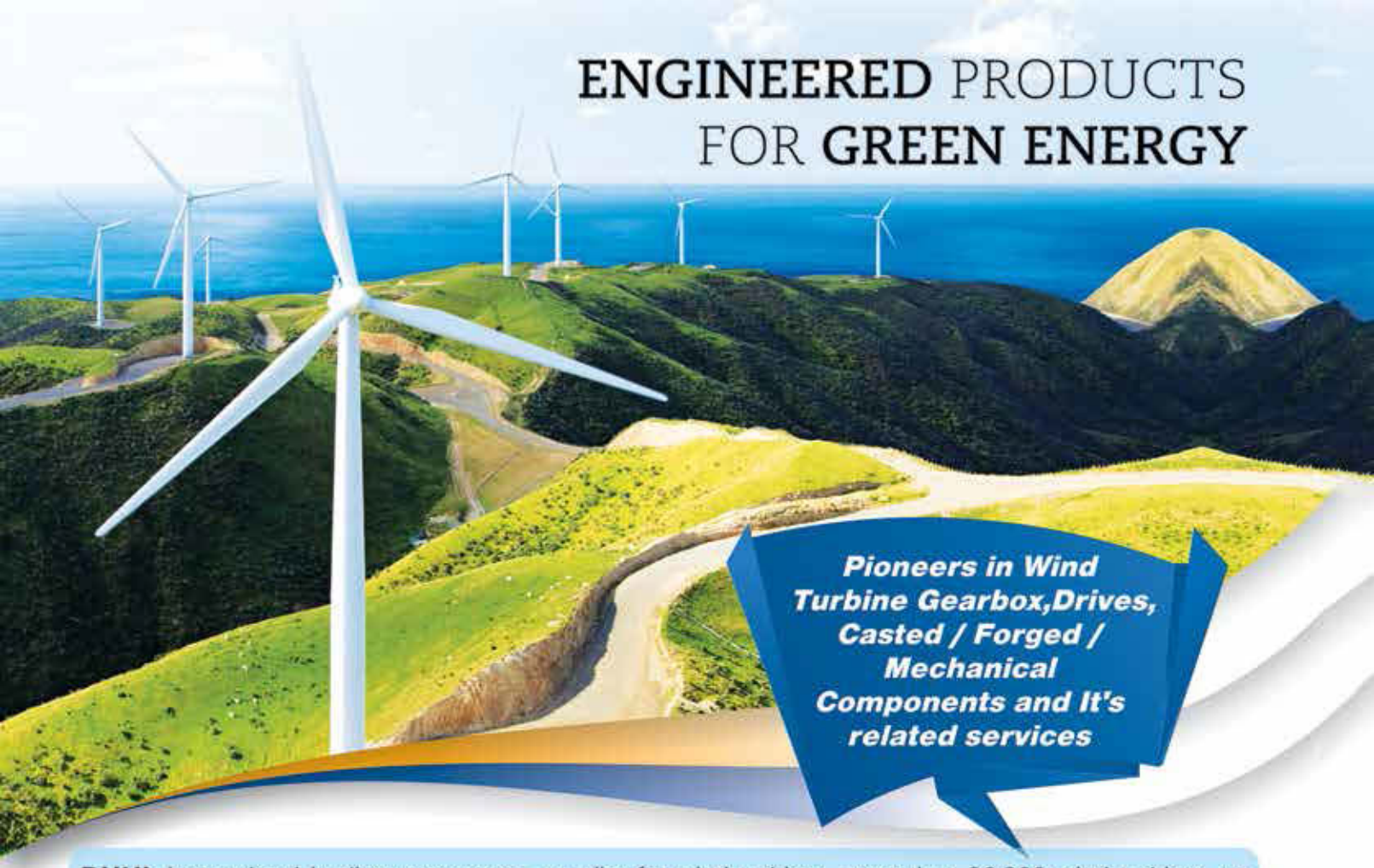
Over a period of time this art is being converted to science with technological advancement but still 30% art is left in the foundries. Majority of small casting foundries like automobile parts are enabling automation because of its smaller sizes and supported by large scale volumes. This remains a big challenge with large size casting like wind parts with relatively lower volumes.

Industry 4.0[1] should be boon for the foundry industry in bringing down the variables and achieve significant process reliability. With the combination of India being world leader in software industry and second largest manufacturer in foundry industry has got potential opportunity to reach global leadership in large size castings.

Figure 5: Mould Preparation for Windmill Shaft

1 Industry 4.0 is a name given to the current trend of automation and data exchange in manufacturing technologies. It includes cyber-physical systems, the Internet of things, cloud computing and cognitive computing. Industry 4.0 is commonly referred to as the fourth industrial revolution.

ENGINEERED PRODUCTS FOR GREEN ENERGY



Pioneers in Wind Turbine Gearbox,Drives, Casted / Forged / Mechanical Components and It's related services

DHHI: International leading components supplier for wind turbines, more than 30,000 wind turbines are operating with DHHI products worldwide, ranging from 225KW to 6MW.

Products: Main Gearbox, Hub, Main Frame, Shrink disc, Lube system, Pitch & Yaw drives, Yaw rims, Slew Bearings, Hydraulic system, Brakes.

Design: R&D center in Germany and China.

Service: "Where the products sold, where the service goes", service setup in India, Germany, Australia and Brazil.

Aim: Providing reliable, excellent quality products and service to the esteemed wind market customers.

Target: Have a better future for next generations by providing more contribution to the green energy worldwide.

DHHI

DALIAN HUARUI HEAVY INDUSTRY GROUP CO. LTD.
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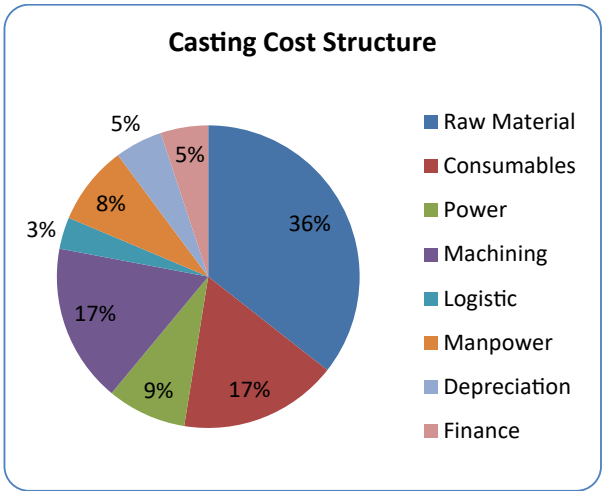
Mobile : 91-7042889767 / Email : info@dhhiindia.com

www.dhhiindia.com

Figure 6: Pouring of Windmill Shaft Casting

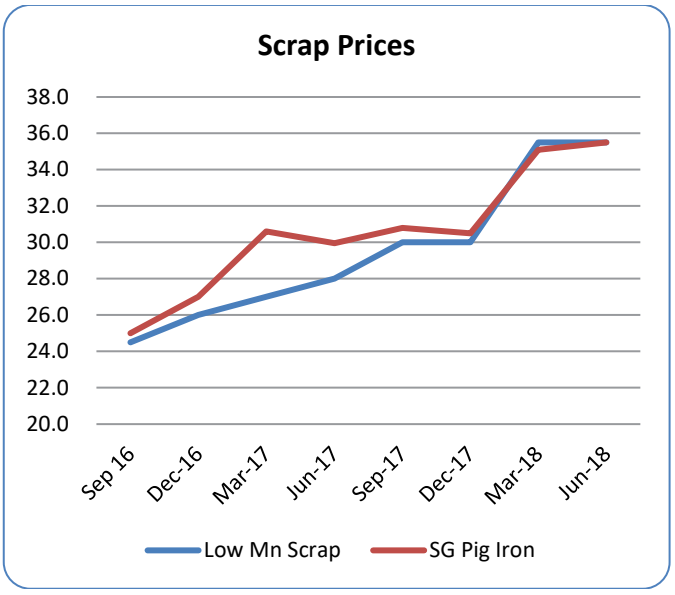
5. Casting Costs

With significant drop in renewable power tariffs, there is an urgent need for the wind industry to optimise the costs. Typical large castings cost consists of the following.



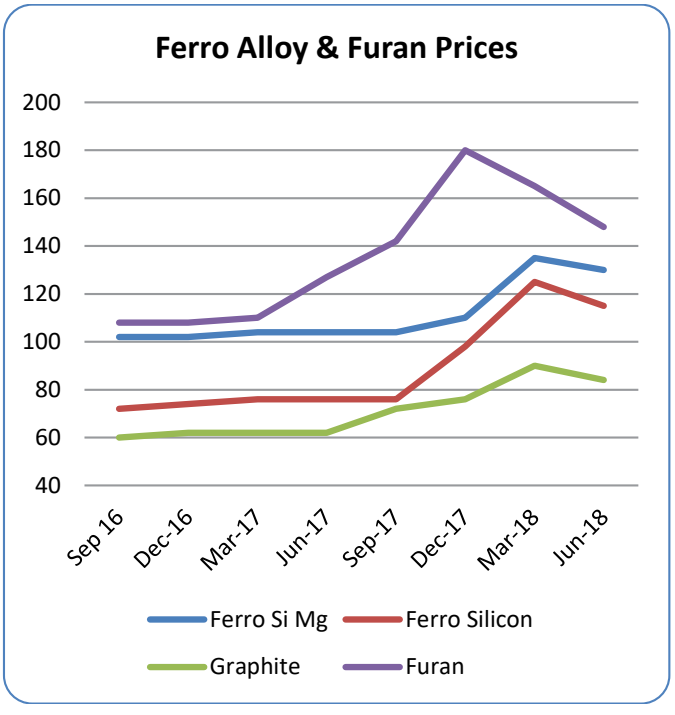
During last one year there is a significant upward movement in input costs due to hardening of commodity prices and healthy demand from domestic foundry industry. Following is the key inputs price trend.

Figure 7: Dimensional Inspection of Wind Gearbox Torque Arm



Scrap prices have gone up by 50% during Sept. 16 to June 18 period and same is directly impacting the casting prices by 10%. Looking at strong demand for the commodity, there may not be any relief from scrap prices.

Following are the Ferro alloy and furan binder prices.



Due to clamping down of polluting industries in China, there was significant mismatch in demand & supply of Ferro alloys and furan binder. These prices have shot up by 60 to 80% during Dec 18. Even though there is a marginal consolidation during last one quarter but still staying at 30 to 50% higher than base levels. This is impacting casting costs by another 5%.

Figure 8: Main Frame Casting

All the good work done by wind foundry industry during last 5 years in optimising the costs supported by good volumes has been taken away by 15% increase in input costs.

Presently significant portion of the foundry costs (79%) are occupied with direct costs which are primarily driven by the market conditions. Going forward following options are left in optimising the costs.

a. Optimisation of casting weights with joint exercise between foundry and casting designers.

b. Exploring the possibility of introducing new materials like Solution Strengthened Ductile Iron (SSDI) which offers higher properties with marginal increase in manufacturing costs and can help in optimising casting weights.

c. Optimisation of foundry costs by improving raw material yield, sand to metal ratio, power consumption and productivity.

d. Economy of scale should help the foundry industry in further optimisation of overall costs.

e. Realistic forecasts by WTG manufacturers will help foundries in optimising the inventories costs.

Figure 9: Moulding Shop for Windmill Castings

6. Conclusion

I. Indian wind casting annual demand to go up three folds from 100,000 MT to 300,000 MT during next 3 to 5 years.

II. There is a need for the foundries to improve reliability and efficiencies with further technological advancement and adapting of Industry 4.0.

III. Partnering between foundries and WTG manufacturers will help in optimising the costs.

Prevent Turbine Failures by use of Robust Spherical Roller Bearings

Harsha Kadam
President Industry, Schaeffler India Limited

Newly Designed Rotor Bearings Improve Wind Power Economy

In order to increase the reliability, availability and therefore to improve the economy of wind turbines, we have revised our portfolio of spherical roller bearings for main rotor bearing supports by introducing a range of design measures. Using operating data from approximately 10,000 wind turbines, the reliability of spherical roller bearings which are used as the main bearing in many applications has been investigated. The engineers discovered a typical pattern of damage and developed appropriate countermeasures. The result is spherical roller bearings optimized for use as the main bearing with revised micro and macro geometry. The development of an asymmetrical spherical roller bearing also represents a significant step towards greater robustness.

Customer benefits

- Longer operating life thanks to higher performance capability in the same design envelope
- Downsizing is possible thanks to the same performance capability in a smaller design envelope
- Lower Levelized Costs of Electricity (LCOE)

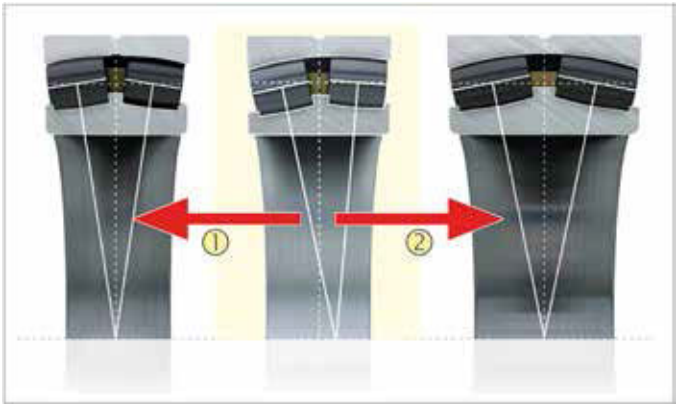


Figure: 1

While wind turbine manufacturers benefit from a reduced design envelope, a high-performance upgrade product is also available to wind turbine operators.

Robust Design for Less Wear

The rotor shaft bearing support is a vital component in wind turbines with the locating bearing being subject to particularly high axial loads. With this in mind, proven standard spherical roller bearings have been optimized in order to provide a better response to the specific demands which arise from their use in wind turbines. The measures introduced by the engineers focused on two areas: On the one hand, they matched the micro-geometry of the bearings and optimized the contact pressure between the rolling bearing ring and the rolling element roller. On the other, they increased the axial rigidity in the macro-geometry by developing a solid central rib. By introducing these two measures, the engineers have succeeded in increasing the robustness of the bearings with respect to the wear which is largely the result of axial displacement. These bearings successfully completed a comprehensive range of tests as part of their validation for the Schaeffler "X-life" quality seal. The validation steps required for this have been certified by Germanischer Lloyd (GL certificate GL-CER-002-2015).

Furthermore, an asymmetrical design has been developed. This significantly increases the axial load carrying capacity and thus the operating life of the main bearing in wind turbines as the asymmetric spherical roller bearing has a larger contact angle on the bearing row subject to axial loads and a smaller contact angle on the bearing row subject mainly to radial loads.

Comprehensive Investigation of Operating Data

The operating data from approximately 10,000 turbines throughout the world with a range of different powertrain configurations provided important initial values for the project. These were assessed by the engineers who allowed them to confirm three theses:

- The vast majority of failures occurred in locating bearings and almost never in non-locating bearings.
- Furthermore, primary failures were concentrated on the axially loaded row in the locating bearings.
- Thirdly, the resultant damage occurred most frequently in the load zone of the bearings.

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ENERGY FOR EVER

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- 4th largest wind installations in the world
- One of the largest solar programs in the world with planned capacity of 100 GW by 2022
- CO_2 — All IREDA funded projects are helping in avoiding CO_2 emissions

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On the other hand, there were several theories that could not be verified by the team of analysts. They found failed locating bearings in both three-point and four-point supports in bearings with single and two-piece cages.

The damage in the bearings examined occurred to a large extent near the surface. As the engineers also analyzed bearings at the very early stages of failure, they were able to allocate the damage occurring near the surface to two significant groups in accordance with ISO15243; fatigue occurring near the surface and abrasive wear.

Abrasive wear under the operating conditions occurring in wind turbine main bearings is already widely recognized. One of the main reasons for this is the low shaft speed which can lead to a low lubricating film thickness and therefore to inadequate lubrication. This was effectively countered by selecting a suitable lubricant and lubrication system, by matching the surface roughness or by coating the surface, as well as through greater bearing cleanliness as a result of appropriate mounting processes, seals and lubricants.

The research team had to carry out various simulations to find a solution to the damage profiles for the fatigue occurring near the surface. They calculated the product of the contact pressure p and the slippage speed v using the Schaeffler multi-body simulation program CABA3D along the lateral axis of the pressure ellipse and found a clear correlation with the profile of the fatigue occurring near the surface. This phenomenon was also clearly visible on spherical roller bearing inner rings which had been etched before running.

Based on this observation, the engineers examined an extremely diverse set of movements in a series of multi-body simulations. Here, the axial thrust movement from the powertrain represented a further significant influence on the damage profile, in some instances during extraordinary events such as emergency stops, but primarily from the dynamic thrust during normal operation. The axial position of the power train varies due to external wind loading and tower shadow effects. The displacements are therefore relatively small. However, they are a permanent feature and accumulate over the operating life of the turbine to extremely high values.

Measures in Macro- and Micro-Geometry

With this in mind, the developers optimized the p*v parameter as well as the axial displacement in both the macro- and micro-geometry. Adjustments in the macro-geometry centered around three points:

- Firstly, the engineers reduced the initial internal bearing clearance, thus improving the operating clearance. This reduced the rolling element forces and the axial thrust from the power train.
- Secondly, they used a solid central rib in the locating bearing support of the wind turbine rotor, thus increasing the axial rigidity which reduces the axial displacement of the power train. Furthermore, the contact pressure can be distributed better along the roller by using a solid central rib, thus minimizing the p*v parameter.
- Thirdly, they matched the pressure angle to the external loads by using an asymmetrical geometry in the spherical roller bearings. This produced improved load distribution, lower contact pressures and a significant reduction in the axial displacement.

The developers also improved the micro-geometry of the surfaces to produce a more uniform pressure distribution. In addition to this, they matched the osculation in order to transmit the rolling element normal forces over a large area, thus reducing the contact pressure. The most important modification to the micro-geometry was the end-profiling of the rolling elements which reduces the p*v parameter in the critical area.

Intensive Validation

The new bearing designs were subjected to an intensive validation at both a component and bearing level in the shape of actual tests in different sizes. The methods used were certified by Germanischer Lloyd.

At the end of the validation process, the tests had a scale of 1:1. The diagnostics from the bearings clearly showed that the black oxide coating added to the rolling elements for test purposes was still completely visible on the ends of the profiled rolling elements. However, there was virtually no evidence of the black oxide coating on the non-profiled design due to over-rolling. This corresponds with the results from the CABA 3D calculation and the p*v evaluation.

Figure: 2

The asymmetrical spherical roller bearing significantly increases the axial load carrying capacity and thus the operating life of the main bearing in wind turbines. It has a larger contact angle on the bearing row subject to axial loads and a smaller contact angle on the bearing row subject mainly to radial loads.

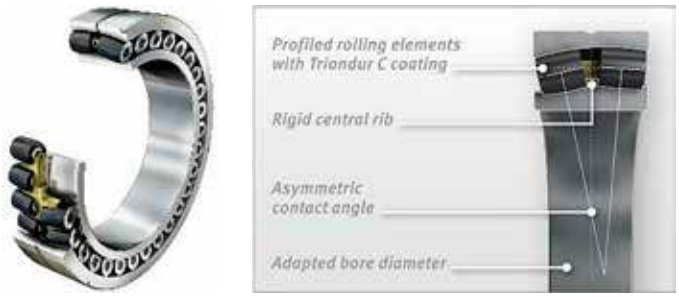


Figure: 3

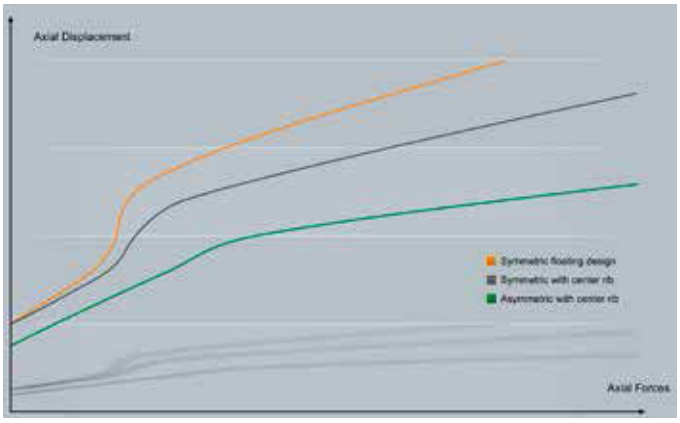


Figure: 4

This graph–shows the axial displacement as a function of the external axial forces for various bearing designs. The curves for each design show the difference in the load zone Fax/Frad ≈ e. As locating bearings in wind turbines frequently operate in this range, a simulated accumulation of the axial displacements shows significant differences. The higher the value, the greater is the risk of fatigue close to the surface.

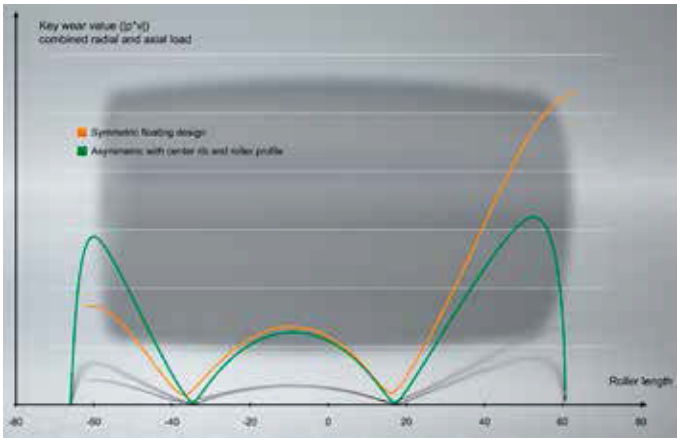


Figure: 5

The effectiveness of the profiled rolling elements could be clearly seen both in the calculation and in the customer test rig on a 1:1 scale.

Figure: 6

The rotor shaft bearing support is subjected to a range of dynamic loads with particularly high axial loads on the locating bearing. With this in mind, we have optimized its proven standard spherical roller bearings in order to provide an even better response to the specific demands which arise from their use in wind turbines.

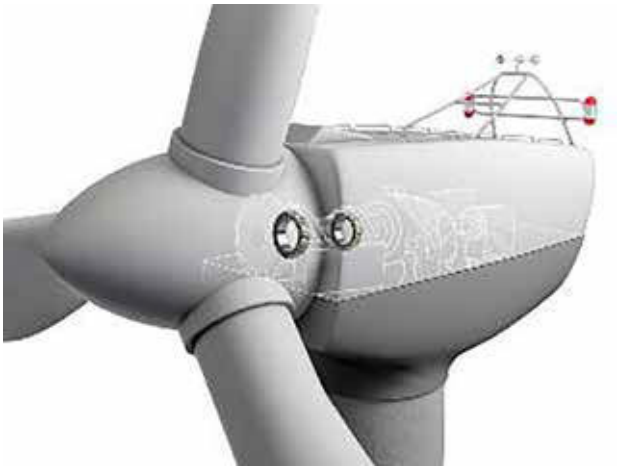


Figure 7: Rotor Shaft Bearing Support in a Wind Turbine

Condition Monitoring for Wind Turbines

Digital services for condition monitoring customized for the requirements of wind turbines are also available. Modular sensor systems in the drive train, specially adapted for low rotating frequencies on the main bearing and the gearbox input side, gather information about the condition during operation by means of vibration measurements and process it in real time. The digital "automated rolling bearing diagnosis" service permits operators and maintenance personnel to monitor the condition of individual bearings and entire units worldwide via an Internet connection. They receive a plain text message regarding the analyzed damage and are able to rely on the support of experts via remote analysis.

At the end we can summarize that by use of proper robust spherical roller bearings a number of turbine failures cab be prevented.

Importance of Integrated Reliability Preventive Maintenance for Wind Turbine

Ramesh Krishnamurthy
Regional Manager (IRM)

T. Jayaram
Head of Technical Services

MVS ACMEI Technologies Private limited, Hyderabad

- Reliability is important with all rotating machinery. In the case of wind turbines, if the turbine stops then it is no longer generating electricity, and therefore it is not earning revenue for the wind farm owner.
- Random wind speeds, and occasional high wind speeds affect the input-side of the gearbox. Changing load conditions on the generator affect the output-side of the gearbox. Wind turbines must potentially operate in corrosive sea air or in freezing conditions where icing becomes a problem.
- Resonance of the blades and tower can contribute to reliability issues, and misalignment is a significant issue given the flexibility of the foundations.
- Wind turbine operators can cut costs and raise uptime by moving from a reactive maintenance strategy to one where interventions are planned in advanced and failures are anticipated through new condition monitoring technologies.
- There's an old saying "If it isn't broke, don't fix it". However, in the renewable world this philosophy leaves too much to chance. Failure is not an option and if it does occur it can be very costly for the operator.
- So how can you put failsafe WTG O&M procedures in place to minimize the risks of things going wrong? And what are the latest trends in proactive maintenance for wind farms?

There are broadly three approaches to WTG maintenance:

- Reactive maintenance (run to failure)
- Preventive maintenance (time-based)
- Predictive maintenance (condition-based)

Currently, the wind energy industry uses only reactive maintenance (that is, fix it when it breaks) and preventive maintenance (by following the servicing procedures set out in the WTG).

Preventive Maintenance

Preventive – or time-based – maintenance activities should, as a minimum, be carried out in accordance with the OEM manual for that turbine. This should be supplemented by additional time-based items as dictated by real-world experience of the maintenance contractor.

These activities would normally include a time-based turbine visit every six months and comprise mechanical checks of fluid levels, greasing, bolt torque checks, filter changes and inspection of blades and brake pads.

In addition, there are routine electrical checks such as inspection of cable connections, fuse checks, voltage level checks, battery inspections, trip tests and electrical cable inspections.

While all of these activities are essential, they can be greatly enhanced by the feedback produced from coordinated predictive maintenance activities. It is even possible that some time-based activities might be reduced in frequency and scheduled only when the test results from predictive maintenance activities dictate that they are required.

This case study illustrates how being vigilant of minor changes can be of considerable significance. By monitoring the parameters such as temperature data you can reduce the risk. The temperature traces over a month period on one wind turbine indicated an explicit trend in increased oil temperatures, despite no reduction in power output.

The servicing personnel were sent in during a low wind period to check on this turbine. Further investigation found a small oil leak and in spite of a malfunction of the low oil level alarm, the problem was repaired with negligible downtime and almost no loss in production.

It is apparent that the outcome could have been rather worse resulting in catastrophic failure of the gearbox.

State of the Art Integrated Reliability Preventive Maintenance Technology used in WTG's.

➢ Ultrasonic Inspection – For Pitch & Yaw bearings, Main Gearbox bearings, Electrical & Mechanical Components of WTG's

Advantages:

- Directional
- Locatable
- Multiple Applications
- Utilizable in All Environments
- Indication & warning about early failure
- Supports Other Technologies

Mechanical Inspection

- Lack of Lubrication/Failure
- Beginning of Fatigue Failure
- Brinelling of Bearing Surfaces
- Slow speed/VFD
- Prevent Over Greasing

Electrical Assets Condition Monitoring

- Partial Discharge
- Corona
- Tracking
- Arcing

➢ Winding Circuit Analysis for Generator Stator, Rotor, Winding, Inductance, Capacitance, Dynamic Eccentricity, Contamination health condition analysis & percentage of deviation monitoring.

Advantages:

- Stator winding health
- Rotor health
- Air gap and dynamic eccentricity
- Coupling health, including direct, belted and geared systems
- Load issues
- System load and efficiency
- Power Quality
- High Resistance or loose connections
- VFD and/or DC Controller Faults
- Mechanical Problems in the entire motor system

➢ Vibration Analysis-For WTG Drive train components (Main Bearing, Gearbox & Generator Bearings) using Multichannel Vibration Anlayser.

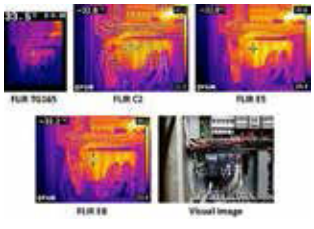
Advantages:

- Unbalance (static, couple, quasi-static)
- Misalignment (angular, parallel, skew)
- Mechanical looseness, structural weakness, soft foot.
- Bend shaft, Rotor eccentricity.
- Mechanical rubbing
- Antifriction bearing defects (inner race, outer race, cage, rolling elements).
- Hydrodynamic & Aerodynamic forces (blade of vane, flow turbulence, cavitations)
- Gear problems (tooth wear, tooth load, gear eccentricity, backlash, gear misalignment, and cracked or broken tooth.

➢ Infrared Thermography - For Transformer, Generator, Electrical panels.

Advantages:

- Safety from hazardous accident.
- Non-contact method. Useful for far away targets.
- Can be done from safe distance.



- Night viewing possible.
- Done on live equipment.
- Time saving method.
- The infrared camera evaluates and converts heat energy into meaningful temperatures. Components in various states of failure will emit more heat as a direct result of more energy dissipated into the component.
- This extra energy is caused by increased friction in mechanical devices, and higher resistance in electrical devices.

➢ Laser Alignment- For correcting the misalignment in WTG drive train components.

Advantages:

- Precision Alignment will help in energy efficiency the by way of Power saving.
- Protects the WTG assets and increases product quality as the vibrations are reduced to very low levels.
- Extends the machine availability as the mean time between failure increases.

- Increase in maintenance savings as spare parts consumption is reduced.
- Increase in time savings and Decrease in consumption of manpower for carrying out alignment.

➢ Endoscopy Inspection – To identify & confirm the internal damage condition of the Gearbox & Main Bearing

Advantages:

- Endoscopy inspections are visual inspections in places inaccessible to the human eye with the help of an optical device, the endoscope.
- The endoscope, also called videoscope or video boroscopy, a device is long and thin, flexible tube. Inside this tube is a telescopic system with many lenses, which provide a high image definition. It is also equipped with a powerful light source.

- The resulting image can be seen in the apparatus main lens, on a monitor, or recorded on a video recorder for later analysis.

➢ Blade Inspection – for knowing the condition of the blades through Drone Camera.

Advantages:

- Safe working environment
- Reduced down time
- High quality images & video
- Access to otherwise inaccessible areas.
- Dynamic surveying / inspection, reveals cracks / dust deposits / damages.

- Preventive maintenance planning.

➢ Gearbox Oil level, Gearbox Oil & Main Bearing Grease sample and analysis by laboratory.

Advantages:

- Oil analysis is well established as a routine tool to optimize maintenance activities, improve reliability and equipment life and prevent component failures.

- As part of a comprehensive Condition Based Maintenance program, lubricant analysis is an effective complement to other diagnostic technologies such as vibration analysis, infrared thermography, ultrasonic detection.
- However, when the component is grease lubricated rather than oil lubricated, the important lubricant analysis piece is often left out of the mix. The reasons for this include challenges in obtaining samples that can be trended, as well as the large sample volumes required for most current standardized tests for greases.

Summary:

1. This Integrated Reliability Preventive Maintenance Platform with listed services in this article from MVS ACMEI is the most powerful tool in the Preventative Maintenance platform for WTG's.
2. This preventive capability allows forward planning of intervention in the wind turbine with the necessary corrective action thus preventing major or critical failure in the WTG, thereby provides the following benefits to the wind turbine owner.
   - Reduces costs
   - Reduces downtime
   - Increases profitability

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Maximize Turbine reliability with IMx-8

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In sync with the Industry 4.0 philosophy SKF Multilog IMx-8 is a state of the art solution that predicts bearing failures before they occur. Developed using complex simulations IMx-8 helps increase turbine reliability and minimize downtime. With IMx-8 you can check the health of your turbine bearing at the click of button using SKF's Remote Diagnostic Services. Max reliability with IMx-8

SKF Multilog IMx-8 benefits:

- Book-sized unit with 8 analogue and 2+ digital channels
- Easy to set up and use
- Bluetooth configuration
- Access data via iOS and Android device apps (standalone mode)
- Compact and cost-effective solution

IMx-8

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