Advanced Blade Pitch Systems - Insights and Trends

Making the right choices for modern wind turbine control technology

The latest developments in blade pitch technology have opened new opportunities for wind turbine manufacturers. In this white paper, Mita-Teknik, one of the world's leading designer and manufacturer of pitch systems, shares its view of the five key trends of this rapidly evolving technology. It also offers three important insights to keep in mind to make wise pitch system decisions, avoid pitfalls, and choose the right pitch partner.

We Make Wind Competitive

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Five Key Technology Trends to Watch

1 | Preparing for the Next Energy Storage Revolution

Energy storage is one of the important elements of the pitch system. In the past, all electrical pitch systems used batteries. However, over the last few years, the cost of ultra-capacitors has come down, in large part due to their broad adoption by the automotive industry. Ultra-capacitors, which have the major advantage of much longer maintenance intervals, have progressively taken on traditional batteries. They are likely to entirely replace batteries within the next few years as they continue to be increasingly cost-competitive.

But even as ultra-capacitors are seemingly here to stay, energy storage technology is in such high-speed development that there is no telling what the next innovation will bring. Since energy storage systems are components that wear out relatively quickly, they might need to be replaced during the lifetime of the turbine by newer, more competitive products. For that reason, choosing a pitch system that has the flexibility to open up to different technologies for energy storage will bring you a long-term advantage.

2 | Why Electrical Pitch Systems will Finally Take over Hydraulic Solutions

Over the last few years, electrical pitch systems have become affordable, reliable and safe. For these three reasons they are gradually replacing the traditional hydraulic systems at an increasing rate. Although hydraulic systems are extremely reliable and have fast pitching performances, their tendency to leak remains a significant downside, if not a deal breaker. Indeed, oil leaks are bound to occur during the lifetime of the turbine and cause significant disorder in the hub.

Anybody who is familiar with operating wind farms knows that nothing is more common than the sight of black patches of oil and grease leaking down through the space between the tower and the nacelle. The fear of leaks also explains why hybrid electric-hydraulic concepts have been almost entirely abandoned.

Key Technology Trends to Watch:

A vast majority of the newer turbine designs rely on electrical pitch systems. Specifically, all machines designed for extreme weather conditions or for offshore, two major areas of future wind power deployment, are better suited to electrical systems that can handle very hot or very cold temperatures and have lower maintenance requirements.

3 | Individual Pitch Control: A Genuine Technology Breakthrough

In the wind industry, the pressure to lower the cost of energy is high. Investors who focus exclusively on lowering CAPEX, and increasing the payback rate, too often choose to ignore the fact that turbines deliver their energy over 25 years. However, taking into consideration the total lifecycle of the assets in order to reduce the cost of energy is paramount if you are to lower the overall loads on the turbine as well as secure the optimal output.

During the last couple of years, a number of improvements have been introduced, helping to run the pitch systems more effectively, the most important being Individual Pitch Control (IPC). By reducing loads, this ground-breaking technology brings the full breadth of its benefits over the entire lifetime of the wind project.

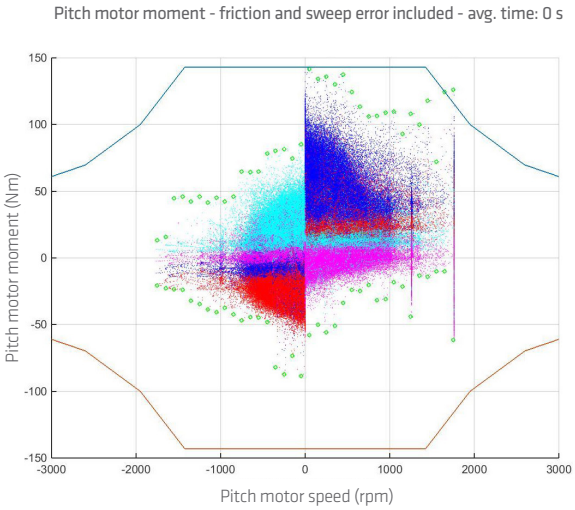


Figure 1: The Electrical Pitch System pitches the rotor blades collectively (CPC) or individually (IPC) to maintain the rotor speed at optimum, while at the same time keeping the rotor speed below the rotor speed limit.

Let us keep in mind that the pitch and turbine control systems together represent only 4 to 6% of the total turbine cost depending on the turbine size. This cost can be largely offset thanks to the benefits of IPC. Not only does IPC lead to more annual production, but this innovation can also, through the reduction of structural loads, extend the lifetime of the assets by up to five years. In addition, the reduction of loads allows for a lighter overall turbine design with a cheaper bed frame, or smaller tower. IPC can enable OEMs to increase blade length while keeping structural loads low. That is a key driver to help bring turbines to lower wind areas, which is another key trend in wind farm development.

The leading international OEMs understand the advantages of IPC very well, especially those that are experienced in delivering long-term O&M contracts. Unfortunately, this approach to long-term asset management is not widespread in the industry yet. Although everybody agrees on the benefits of IPC on a theoretical level, only a limited number of OEMs have already implemented it in their designs. One of the reasons for the relatively slow adoption of IPC is the initial installation cost of the additional hardware and software needed as well as its higher control complexity.

The second reason is the lack of empirical proof of the long-term indirect financial gains. The last reason is that most pitch systems in the market today are not fast enough to utilize IPC. Pitch speed is key to taking full advantage of the load reduction capabilities offered by individual pitch control.

Despite all this, IPC is bound to continue to be steadily integrated into modern turbine designs, especially for offshore turbine.

4 Pitch System Redundancy will Boost Offshore Availability

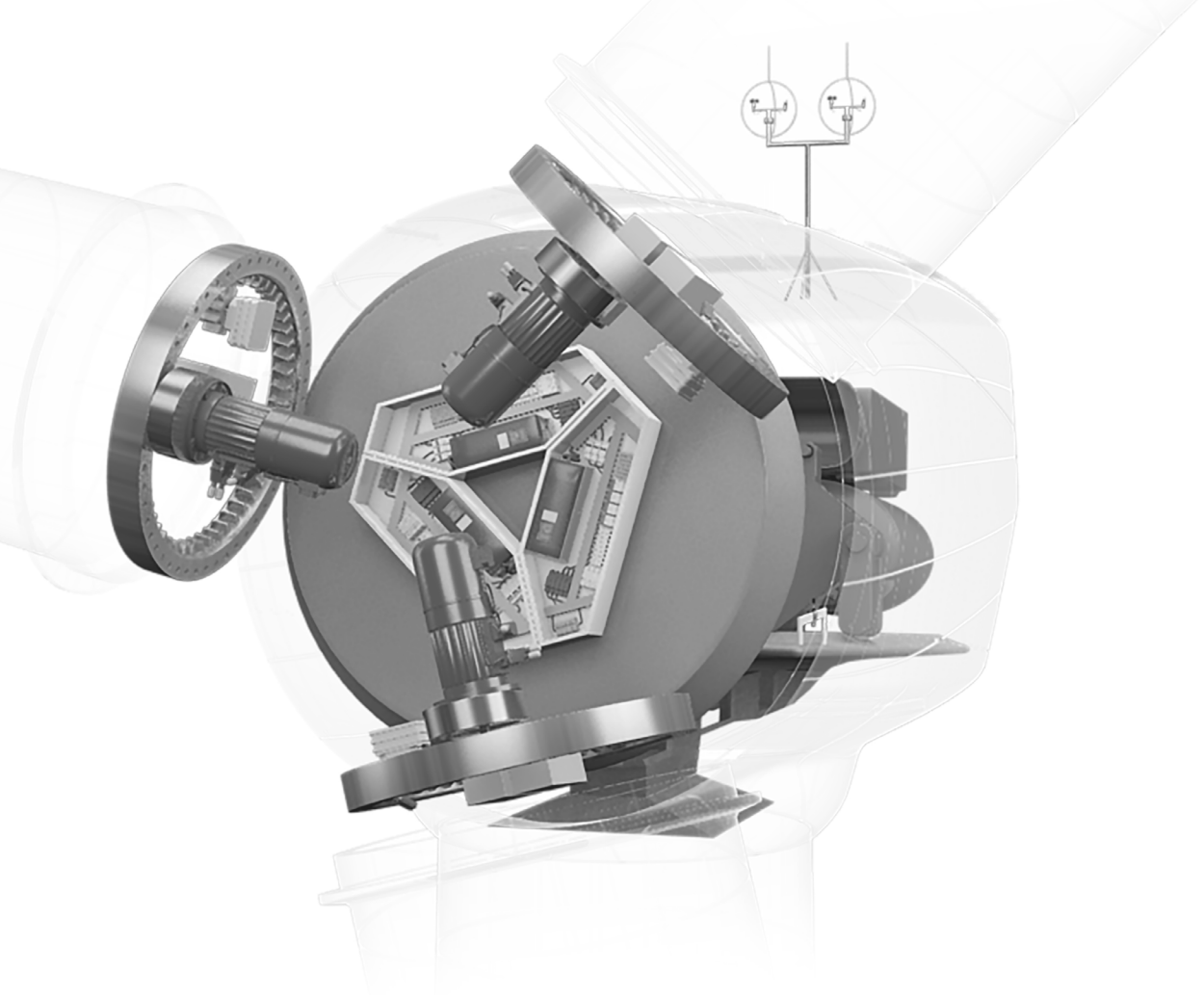
The continuous growth in turbine size, especially offshore, poses new challenges and opportunities for pitch control. As blades are getting longer, they are exposed to increasingly asymmetric wind forces across the sweep area, creating fierce demands on the pitch system. Downtime, which causes heavy financial losses, must be avoided at all cost. Due to the reduced accessibility of assets at sea, minimizing maintenance requirements as well as increasing availability have become decisive criteria for the project owner. For the same reason, the demand for remote troubleshooting is much higher than for onshore projects. And the key to achieving all this is redundancy.

Redundancy has been envisaged for a while, but excessive cost was the main impeding issue. Fortunately, offshore turbines offer significant economies of scale that should allow for the use of costlier, high-performance pitch systems, whilst still achieving the best overall cost of energy. These systems are set to deliver outstanding reliability through redundancy.

Challenges for Pitch Control:

The continuous growth in turbine size, especially offshore, poses new challenges and opportunities for pitch control. As blades are getting longer, they are exposed to increasingly asymmetric wind forces across the sweep area, creating fierce demands on the pitch system.

Essentially, the traditional single pitch motor design will give way to designs incorporating multiple smaller pitch motors. These motors will distribute the loads around the pitch bearing while reducing slack. Full redundancy will ensure continued availability even if one part of the system fails.



Pitch motors are heavy components and repairs in case of breakdowns are costly. However, if you have two pitch motors in working condition, your turbine can still deliver energy, albeit at a reduced load, until the weather permits the maintenance crew to reach the site. As the offshore wind industry develops, pitch control redundancy will play a key role in keeping very large turbines safe and running.

5 | Making Sense of Pitch Systems Retrofitting

Although only one-third of installed turbines globally are currently equipped with active pitch control systems, retrofitting them is less straight-forward than it seems. Turbines are often too small to justify the investment. In addition, old models often cannot be fitted with new pitch systems without upgrading the entire turbine control.

This situation is progressively going to change in the next five to ten years, as bigger turbine models are becoming eligible for retrofitting. However, currently only 1.5 to 2 MW turbines associated with a good Power Purchase Agreement can justify the replacement with a bigger rotor, along with an upgraded pitch system. The other exception concerns poorly performing wind farms, where defective pitch systems need to be upgraded even if the rest of the turbine operates as planned.

Three Key Insights to Make the Right Blade Pitch System Decisions

1 | Reliability Always Comes First

Any company looking to integrate a pitch system into its turbine design must, first and foremost, recognize that the pitch system is a central part of the turbine safety system. It has to work seven days a week, day in, day out. That's why OEMs should always select partners backed by a strong track record in system reliability.

Of course, cost is an important factor, as well as reducing structural loads and extending the turbine lifetime. Nonetheless, unwavering reliability is the very first consideration to take into account, because a failing pitch system can outright destroy the asset it was meant to protect.

One important element is the speed at which the system can pitch blades according to variations in weather conditions. This is vital when coping with extreme weather events that will eventually hit your fleet during its 25-year lifetime. When exposed to such events, lower quality blade pitch systems may not be able to cut out of the wind fast enough or as calculated, and damage the entire turbine.

The guarantee for reliability comes from the extensive field experience brought by thousands of pitch systems designed for different turbines, operating in different climates, and different countries. Only a handful of companies in the global wind industry have acquired such track records.

2 | 360° Understanding of Wind Turbine Control

Secondly, pitch systems are an integrated part of the overall turbine control system, which means that the continued cohesion of its various components must be ensured. Experience has shown that pitch failures often come from a lack of understanding of how intimately all the turbine control elements interact with one another.

Key Insights to Make the Right Blade Pitch System Decisions:

- Reliability Always Comes First
- 360° Understanding of Wind Turbine Control
- The Benefits of System Flexibility

To get the right pitch system for a turbine prototype, a complete set of simulations is required. This can be achieved by using "Bladed Models" with a full WTG model simulation. Combined with practice, know-how and a lot of field experience, thorough simulations can determine the optimal solution. It will also help to ensure that the turbine is suited to its operating conditions. In this instance, an extensive and diversified track record and the breadth of feedback data it generates, is important.

And yet, to build their turbine, some OEMs quaintly still imagine that they can save costs by shopping around for the cheapest off-the-shelf components. Lowering the turbine CAPEX becomes the only objective worth pursuing for them. Nonetheless, they are likely to learn that, for all the money it might save upfront, they will remain at the mercy of potentially downtime. When failure does occur, the odds are that the unfortunate OEMs will be looking for a recognized control expert within days.

Off-the-shelf products can do what they can do. At the very least, the entire control system must be thoroughly tested and assembly must be optimal. Even then, they are never going to be as well integrated as when both pitch and turbine control systems come from the same supplier.

The final advantage resulting from having a single technology partner for the combined control and pitch system is effective troubleshooting. It enables you to address all lines of inquiries to a single point of contact. It is especially useful since in most cases, OEM do not know which element of the system is actually causing the failure. Finally, it will help to resolve issues quickly as well as to maintain a well-optimized complete system.

3 | The Benefits of System Flexibility

Successful pitch control suppliers are, above all, technology companies that have demonstrated their ability to stay at the peak of innovation over time. The level of flexibility of the selected technology is a key parameter to take into account.

With regard to turbine development, OEMs must take a long-term view of pitch control, and look for a technology partner that can supply the system they need today, but also the system that will be needed in the future. Indeed, all the lessons learned from the first design can be drawn upon to create the next, more advanced system, instead of starting from scratch with every turbine prototype.

A flexible system can adapt more easily as the turbine design gets upgraded. Being flexible means staying clear of systems that have a low degree of versatility and adaptability, such as compact low voltage pitch systems, for example. Going with mainstream technology offers high sub-components availability over time, and will ensure you get the best long-term benefits out of your pitch control system.

Behind Every Successful Project, There is a Successful Partnership

Achieving optimal pitch control and minimizing structural loads requires a unique set of design and technology skills. It requires expertise in load simulation, control algorithms and wind turbine optimization. It demands a partner that can deliver a complete design process and run all simulations of the turbine to truly deliver the optimum pitch system that is needed for prospective field conditions. And above all, it demands a partner that can deliver the twin goals of optimal annual production and asset safety.