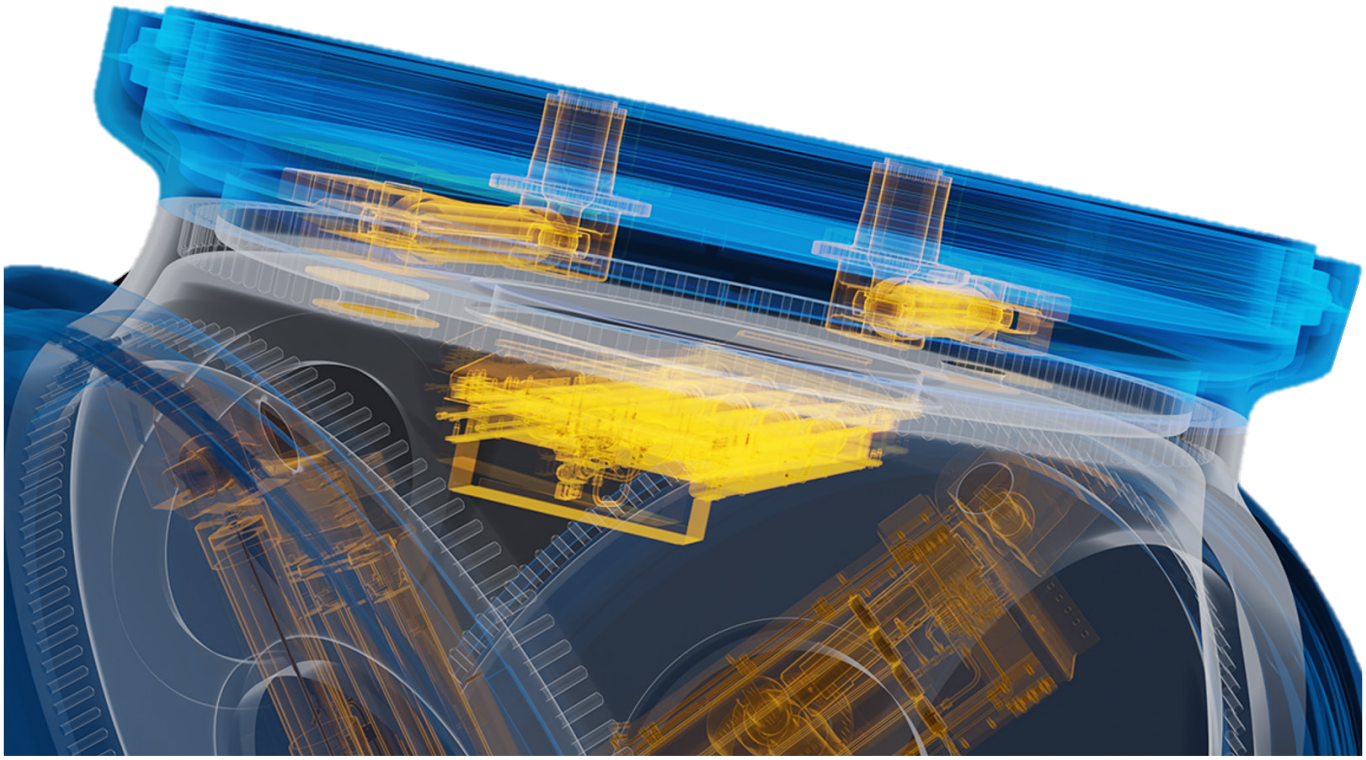
thyssenkrupp

HAWE HYDRAULIK



Problem solver for large hubs: Extender unit and pitch drive integrated into the blade bearing

Content:

Two trends in the technical development of wind turbines have an impact on the design and reliability of pitch drives and blade bearings: 1) the continuing growth in turbine size and 2) the increase in pitch activity.
At the same time, OEMs are under pressure to realize existing cost-saving potential. A higher degree of integration and targeted modularisation of components are seen as promising options. The Pitch Bearing Unit (PBU) provides the right answers to this as far as hubs and blade bearings are concerned.

New challenges due to ever larger wind turbines

Over the past 20 years, wind turbines continue to get larger. Rotor blade diameters and blade lengths have grown accordingly. This presents wind turbine OEMs with increasing challenges. Ever larger hub and rotor blade components not only increase the requirements in terms of machining, assembly and logistics. The mechanical loads in the hub and blade bearing area are also increasing. Increasingly complex design measures are required to ensure sufficient rigidity of the overall system, including: hub, blade bearing and rotor blades. This applies in particular to large multi-MW wind turbines.

A second trend is the continuous increase in pitch activity due to the use of individual pitch control (IPC). The permanent adjustment of the rotor blade pitch angle to changing wind directions and speeds improves the energy yield and reduces the dynamic structural loads and noise emissions of the wind turbine. On the other hand, it leads to higher cyclical loads in the track system of the pitch or blade bearings. In order to ensure the smooth operation of the turbine over its entire life cycle of 20 to 25 years, it is required to adapted the blade bearing and pitch drives to match the larger designs.

Lack of rigidity when hubs become too large

OEMs are therefore considering the use of three-row roller slewing rings instead of the four-point ball bearings that have been used up to now. With the same installation space - due to the line contact - these have a higher static and dynamic load-bearing capacity of the raceway system and are better able to withstand the higher pitch activities. However, they can cause problems if, for example, the hub has insufficient rigidity properties due to its size. This could be solved by additional stiffeners on the hub, either in the casting itself or by additionally mounted components.

However, hubs are not only getting bigger and bigger, they are also becoming increasingly complex and

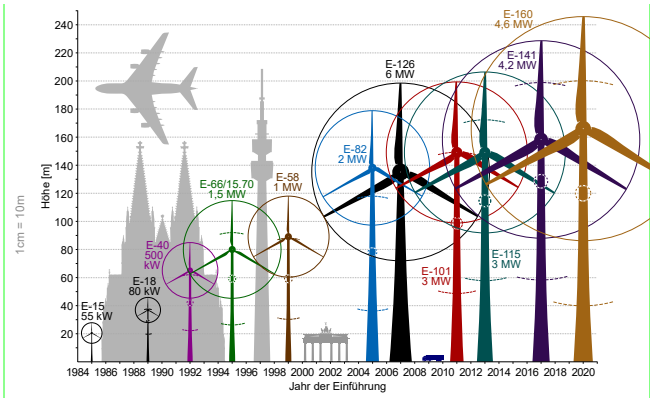


Fig. 1: Wind turbines are getting bigger and bigger (Image: Jahobr, CCO, Wikimedia)

expensive. This applies to production and subsequent machining as well as assembly, logistics and transport.

Further growth in the size of conventionally designed hubs can lead to problems, especially for onshore turbines. Hub bases with a diameter of more than four metres will no longer fit under any bridge and detours will have to be accepted. The costs for increasingly complex, special, and heavy transport are also increasing exponentially.

Fig. 2: The size of rotor blades and hubs are already causing high transport costs and expenses. (Image: AdobeStock_409306001)

Solution: Pitch Bearing Unit (PBU)

With this in mind, the development engineers at thyssenkrupp rothe erde, together with HAWE, have rethought the topic. The result is the pitch bearing unit (PBU), a ready-to-install system solution that provides answers to the challenges outlined above.

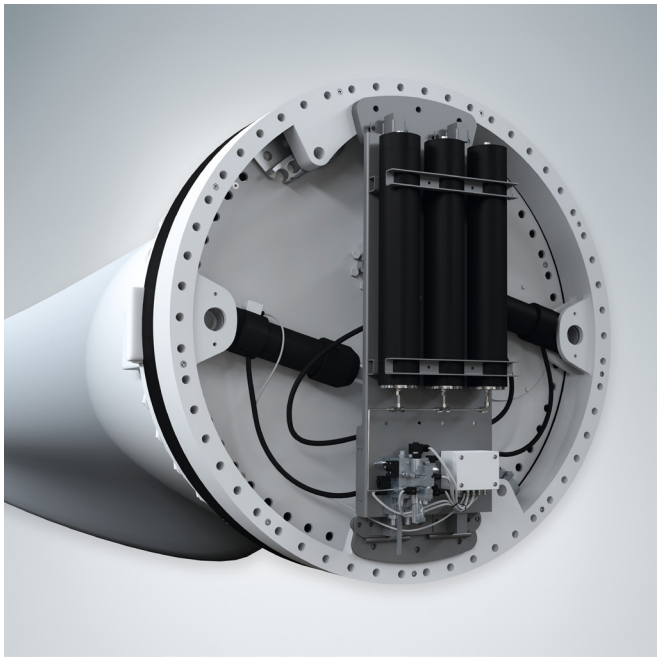


Fig. 3: One of several designs of the pitch module.

In principle, the PBU is an extender unit: with an integrated hydraulic pitch drive, which is integrated directly into the blade bearing as a prefabricated and tested unit, the so-called pitch module. This combination represents a ready-to-install system solution for the user. Nevertheless, the pitch module can also be seen as a stand-alone component.

It consists of the pitch cylinders for adjusting the blade pitch angle, hydraulic piston accumulators for supplying the required energy when needed, the control block with a highly dynamic proportional valve, the necessary pipework and, if necessary, an electronic control system. The pitch module can be used by the wind turbine manufacturer both for hydraulic pitch systems and as a retrofit replacement for electric pitch systems.

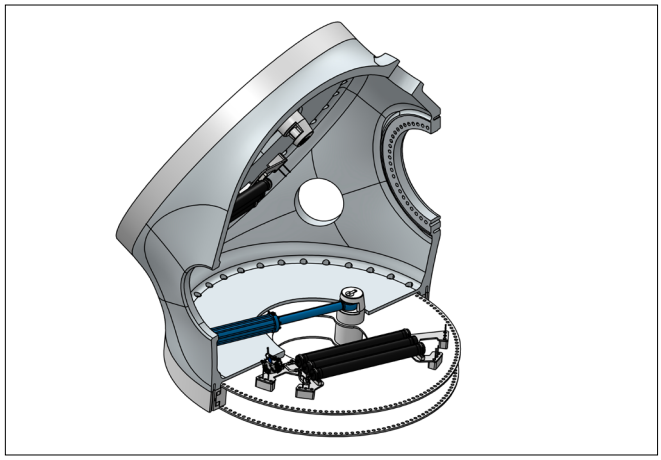


Fig. 4: Conventional hub of a 7 MW wind turbine with integrated pitch module

Constructive variants of the PBU

Thanks to the modular design, various constructive designs are possible. This allows customised solutions to be implemented for any size of wind turbine. HAWE and thyssenkrupp rothe erde have already realized three different design variants.

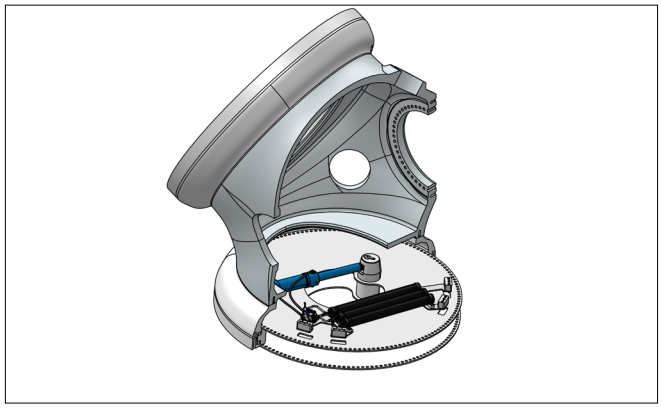


Fig. 5: New, scaled-down hub of a 7 MW wind turbine with integrated pitch-bearing unit (PBU)

Features and benefits of the pitch module:

- Simple installation
- Customized solutions for different rotor blade diameters
- High stability with a service life of up to 20 years
- Reliable function even under “cold climate“ conditions
- Controlled and damped blade angle adjustment
- Shortest possible stopping time for emergency stops

Conical shape creates advantages

The conical shape of the extender unit provides the design advantages. The flange-mounted hub can therefore be smaller overall and much simpler thanks to the relocation of all drive components to the PBU.

Conversely, the blade root diameter and thus the rotor blade length can be increased without changing the hub size. In both cases, the stiffness properties of the overall system improve, as the load transfer to the hub is more homogeneous. The need for hub-side stiffeners is reduced, which is particularly advantageous for roller slewing rings. The hub design is reduced in size and remains less complex, which has a correspondingly positive effect on the costs for production, processing and transport. The ready-to-run functionality enables simplified, module-orientated installation on site.

Proof-of-concept study quantifies potential savings

The potential savings effects were quantified as part of a proof-of-concept study by thyssenkrupp. Two different scenarios were simulated: a 7 MW onshore wind turbine and a 10 MW offshore wind turbine.

Example 1: For an onshore wind turbine with an output of 7 to 8 MW, the cost savings for hub production and processing as well as for transport and logistics were analysed in particular. The rotor blade diameter of this fictitious turbine, which could be located anywhere in Europe, is 172 meters with a blade-side connection diameter of approx. 4 meters. A conventionally designed hub for this rotor blade length would have a total weight of approx. 54 tonnes and external dimensions of approx. 5 x 4.9 meters (without blade bearings). OEM-specific deviations are possible. If the new hub with integrated PBU were used here, this would correspond to a saving of approx. 30% of the total weight of the hub. The external dimensions would be reduced to 4.3 x 4.4 meters. For delivery in this example, (i) the prefabricated hub was transported to the OEM without prior transport and (ii) the pre-assembled, tested PBU was

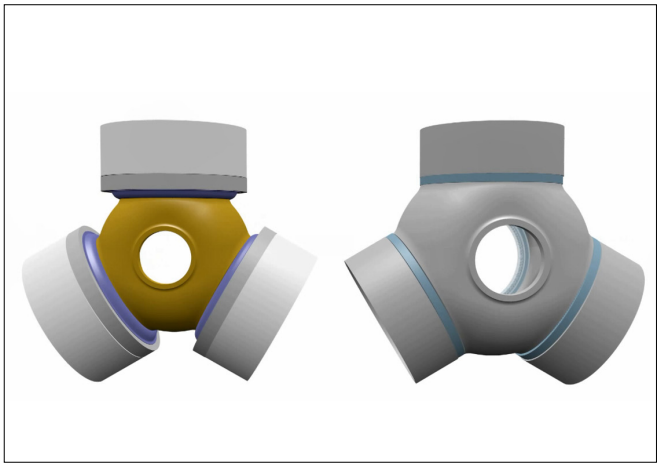


Fig. 5: Comparison of the two hub concepts (conventional on the right and with PBU extender unit on the left)

transported separately on two different vehicles for assembly on site. This led to a reduction in transport costs by a factor of two due to shorter distances and lower logistics costs. In addition, the hub costs are reduced due to the weight savings on the hub side and the less complex processing steps.

Example 2: In the case of an offshore wind turbine with an output of 10 MW, it would have been possible

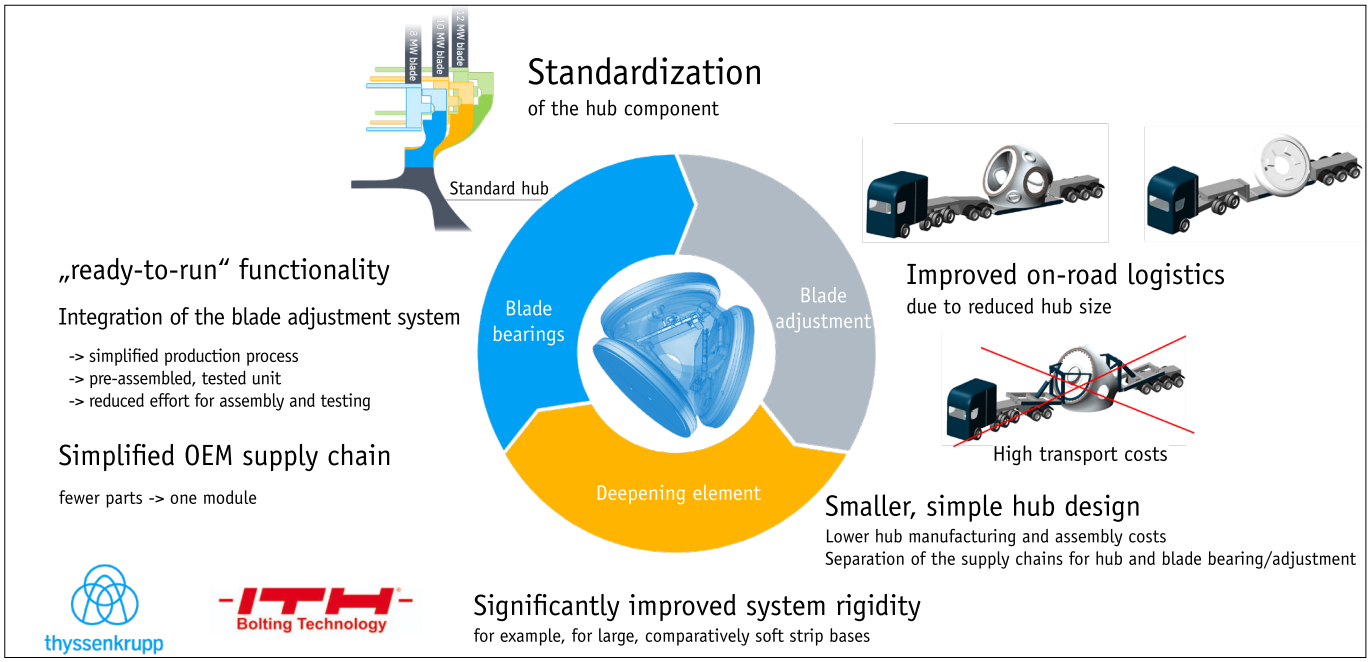


Fig.6: The advantages of the pitch-bearing unit at a glance (Image: © thyssenkrupp rothe erde Germany GmbH)

to reduce the hub diameter from 6 to 5 meters for a given rotor blade root diameter. If the values are compared with those of a conventional hub, the pitch circle diameter (BCD) could be reduced by 750 mm from 4,975 to 4,200 mm, while the rotor blade diameter remained unchanged at 4,600 mm. Even in conjunction with the smaller hub, the PBU provides significantly better system rigidity, which is essential for the reliable use of roller slewing rings with a long service life.

Conclusions

The hubs are still customized for each wind turbine project. However, the simplification of the hub design made possible by the PBU could pave the way for standardization in the current market environment. For example, it would be conceivable to develop a standard hub that is customized to the respective OEM requirements using different extender rings. A modification of the OEM supply chain away from customized production towards an off-the-shelf product, with corresponding economies of scale in terms of production volumes and costs, would also be conceivable. In addition, possible production bottlenecks and supply chain problems could be prevented if demand continues to rise rapidly.

Further advantages can be realised in specific projects.

For example, if the increase in blade root diameter made possible by the PBU is utilised for targeted upscaling of the rotor blade length. In this case, the projection surface of the rotor can be enlarged without the need for a new OEM development,

The pitch bearing unit (PBU):

- Enables a reduction in the total cost of ownership (TCO)
- Ensures improved rigidity of the overall system with a smaller, simpler hub design.
- Paves the way for long overdue standardization and modularization in this area.

as the established turbine design can continue to be used with just a few adjustments. This is particularly advantageous for wind turbines in low-wind locations.

Electric vs. hydraulic pitch drives

Hydraulic pitch systems are more cost-effective than electric ones in the medium term, as their components generally only need to be replaced once during their service life. They also have short response times, which minimizes the risk of overloading the wind turbine. You can find more information on this in our eBook "Hydraulic solutions for wind turbines" at:
https://www.hawe.com/de-de/unternehmen/news/ebooks/loesungen-fuer-windturbinen/

THE MARKET DEMANDS NEW SOLUTIONS

The increasing size of the hubs in combination with the OEM's effort for the hub-bound assembly of the pitch drive, which usually takes place in the factory, meets a competitive market that is under price pressure and demands cost savings.

A higher degree of integration and prefabricated assemblies or modules can also be the answer to improving the OEM's overall cost structure.

There is also the question of sufficient **production capacity:** Given the expected increase in demand, will there be enough foundries and subcontractors in the future that are able to cast, elaborately machine, and produce sufficient quantities of such XXL hubs?

HAWE Hydraulik SE
Einsteinring 17
DE-85609 Aschheim/München
Tel.: +49 89 379100 - 1000
info@hawe.de
www.hawe.com

thyssenkrupp rothe erde
Tremoniastrasse 5-11, 44137 Dortmund
Tel: +49 2941 741 - 3572
info.rotheerde@thyssenkrupp.com
www.thyssenkrupp-rotheerde.com