



Lightning Protection



Dr: Ulrich Ringleb

12.11.2010



With the actual edition of our Technical Information we would like to highlight the topic **“Lightning Protection for Wind-Turbines.”** It doesn't matter if a specific wind turbine uses a doubly fed induction generator or a synchronous generator – **every turbine needs an efficient lightning protection system.**

Lightning strokes are a wind turbine's worst enemy! Due to their height of over 100 meters and location mostly in remote areas, wind turbines are exposed to lightning strokes up to 10 times a year. In the 1990s that quite often caused heavy damages. In 1995 approx 80% of the damages registered by insurances were caused by lightning.



Since insurance companies demand for proper lightning defence, lightning has nowadays lost its terrifying effect for the users. Even retrofitted turbines withstand lightning strokes without serious problems.

According to statistics annually only 4-8% of modern European wind turbines get damages induced by lightning. The majority of the faults is caused in the control device, the generator and on the blades.



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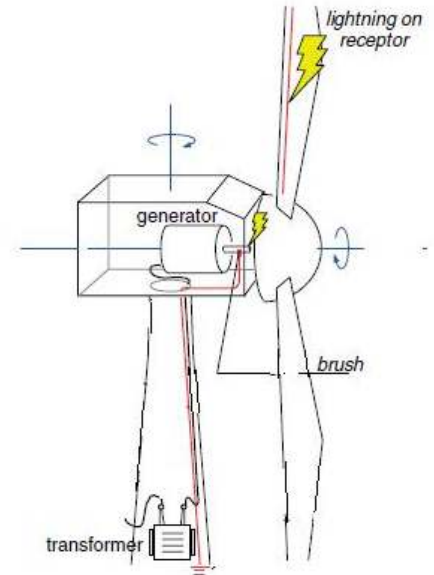
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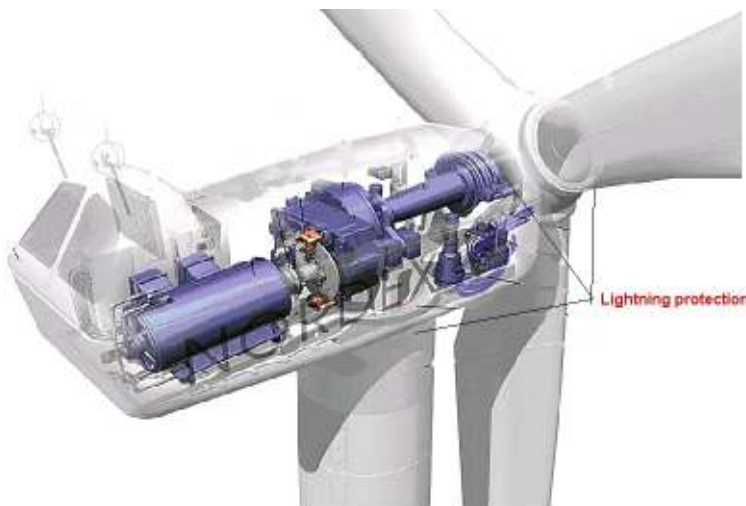
Wind turbines have the specialty that the blades and the nacelle rotate and change position during their function. Significant parts of lightning current passes through or near to all wind turbine components and also passes electronic equipments, which contain control or measuring devices.

The most vulnerable parts of the turbine for direct lightning strokes are the blades, the tower itself, the hub, the frame of the nacelle and the lightning receptors on top of the nacelle.

Most likely is the direct hit into the rotor blades. Depending on the direction and kind of the lightning stroke the current is between 20.000 Amperes and 300.000 Amperes.



The rotor blades consist of glass-fibre reinforced plastic or carbon-fibre reinforced plastic. As lightning protection either metallic receptors on the top of the blade or metallic aluminium meshes, incorporated into the blade material, are used. Combinations of both methods are possible



SCHUNK products, i.e. carbon brushes and brush holders are used to protect, the blades the bearings and the parts behind it, i.e. gear box and generator. They should bypass the bearing and conduct the lightning current from the blade via the shaft to the tower and to the ground.

There are 3 areas to be protected

- Connection between blades and hub
- Main shaft
- Yaw bearing



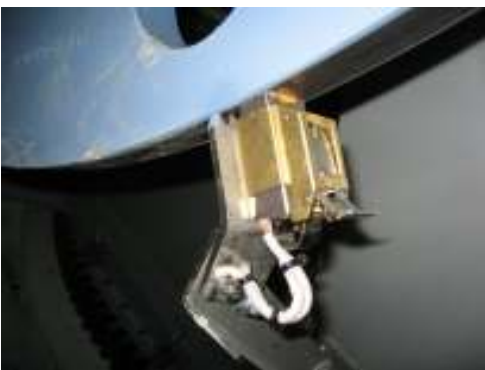
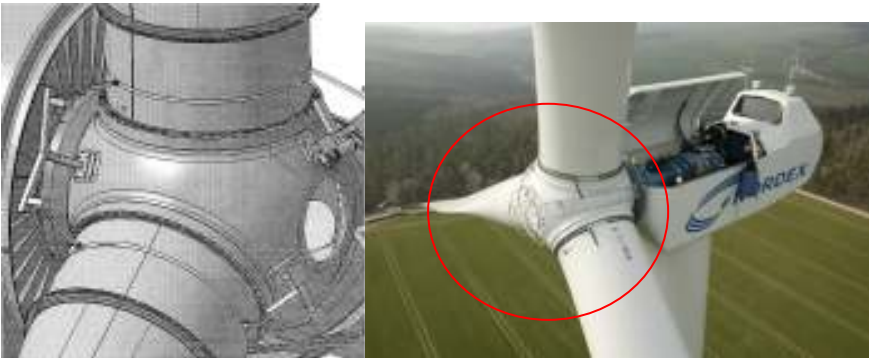
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The first area to be protected is the connection between blades and hub.

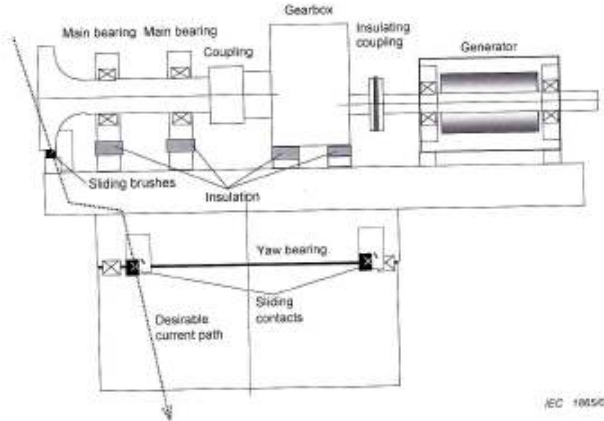
The bottom of the blade is covered by a ring of stainless steel. The receptors from inside the blade are connected to that ring. The lightning current is transferred from the ring via carbon brushes to the hub.



The second field is the connection between hub and main shaft.

Normally the brushes are fitted at the side surface of the disc, but may also run on the top surface.

Since the shaft speed is approx 2 m/s only, the brush life is considerably longer than 1 year. But the brush clearance etc. should be checked during regular maintenance stops.



For proper function the bearings, couplings, gear box and the generator are additionally insulated against the nacelle frame.



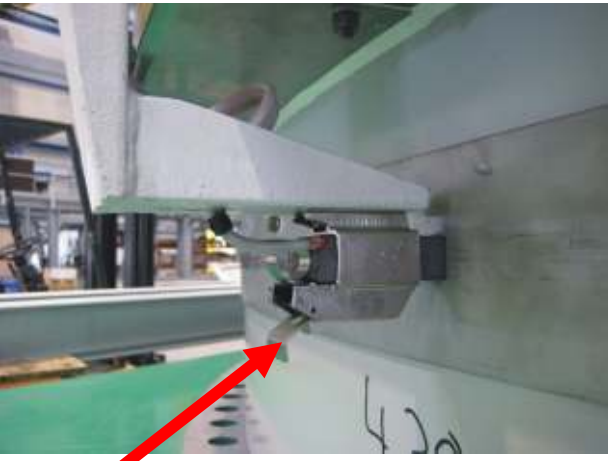
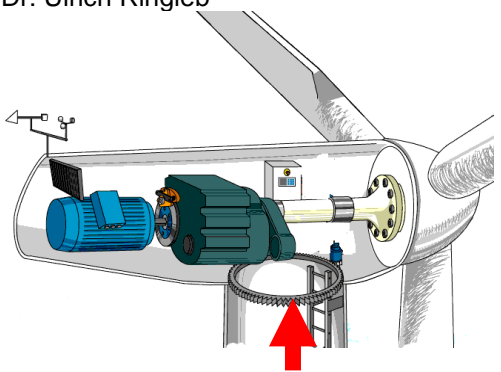


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The third place to be protected is the bearing on the yaw between nacelle and tower. The same or similar conventional systems as the above mentioned are in use. Since the nacelle is very rarely turning, the wear rate of the brushes is negligible



Lightning protection brush

In total there can be up to 15 brushes in operation - 3 each for blade/hub, 3 for the main shaft and 3 for the yaw bearing.

Lightning will take the shortest route to earth. The lightning defence systems and specifically brushes function is to divert its path away from the bearings.

The main features of a suitable brush grade are:

- Low voltage drop
- No swelling in case of the extremely high surges
- Wear resistant

Presently SCHUNK can offer four (4) different designs for the lightning protection of wind turbines.





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1. Brush Grade -K14Z3- & Brush holder



Our standard system is a quite simple one. A brush $32 \times 20 \times 64 \text{mm}^3$ ($1,18 \times 0,79 \times 2,36 \text{in}^3$) is directly fixed on the shaft. The best compromise between safety requirements, low voltage drop and brush wear is grade -K14Z3-. But other grades like -C40Z3- or -A20- are in service as well.

Also available in corrosion protected design

The system is successfully tested at the German University of Kiel, one of the leading institutes for lightning research.

With a special spark gap attachment the holder, brushes and shunts withstand surges up to 200.000A within 2 milliseconds. That corresponds to lightning class 1





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Due to asymmetries in current flow, it is advisable to use **at least three brushes** for a complete lightning protection system at each point, which has to be protected. Regarding the state of the counter material there are the same requirements for optimal brush performance as for carbon brushes in other applications:

- Surface roughness 5 - 8 $\mu\text{m R}_z$
- No oil or grease



For off-shore application the use of standard metal brush grades is not possible. As the picture shows the brushes will have heavy corrosion, get stuck in the holder and will lose its function. SCHUNK has developed special off-shore usable brush grades, e.g. **-E43-** and brush designs.

2. Brush grade **-B20-** & Brush holder

This system is similar to the a.m. conventional carbon brush system. But the carbon brush dimension is slightly bigger (40x32x50mm³ - 1,57x1,18x1,97in³) and the brush holder is a double clamp brush holder.





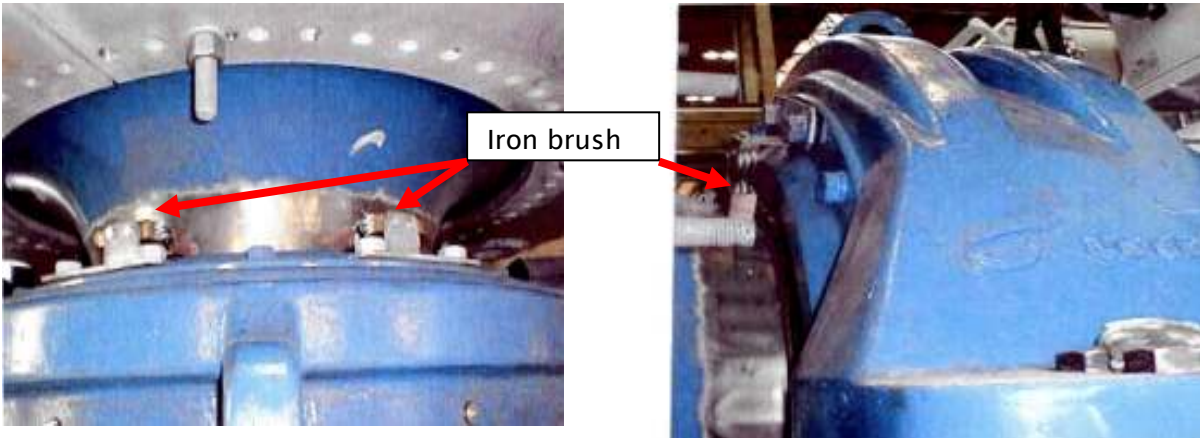
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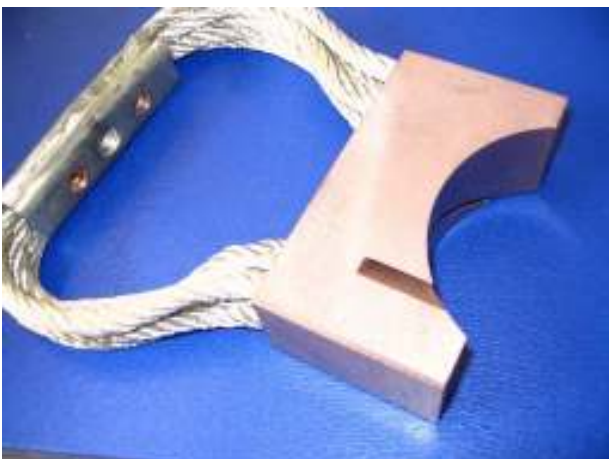
3. Iron / purse brush - System "Nordex"

The function is the same, but the design is different. For instance Nordex uses the well known iron (purse) brush for lightning protection.



Normally two of these brushes are sufficient for efficient protection. Here generally brush grades with a high metal content, like -C50- are in service.

SCHUNK is able to supply the brushes including the brush holder.





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4. Earthing/Grounding-Roller system

Some users are afraid of brush dust possibly entering the bearing.

Some years ago SCHUNK has developed the revolutionary carbon/carbon earthing contact for traction application. That system is used for an alternative protection system on wind turbines.



A steel roller has direct contact to the shaft. Incorporated is a carbon/carbon contact which leads the current away from the shaft and the steel wheel.

Since the carbon/carbon contact is completely sealed and has an extremely low wear rate anyway, there is no carbon dust that could harm the bearing.

Three of these roller systems are advisable for lightning protection. The system is field-proven.

The same system can also be used for shaft grounding, specially also for synchronous generators. Two units are sufficient for that application.



Amongst others the following famous wind turbine manufacturers rely on SCHUNK carbon brushes and holder systems for efficient lightning protection: Clipper Wind, GE, Multibrid, RePower, Vestas, DongQi, Shanghai Electric and Sinovel.

Heuchelheim, October 2010