Design of Airfoils for Wind Turbine Rotors

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Situation

The turbine is a machine which converts rotational energy into usable work or usable energy. This change is initiated through mechanical gearing or because of electromagnetic induction, which results in electricity.

There are different types of turbines including: steam turbines, gas turbines, water turbines and wind turbines, a source of energy is that is becoming more widely used.

Wind turbines are powered by movement of air that propels the blades or rotors of the turbine, which are generally referred to as airfoils. They are designed to react with wind and capture energy.

The shape of the blade causes pressure to be uneven, higher on one side than on the other, making the blade spin.

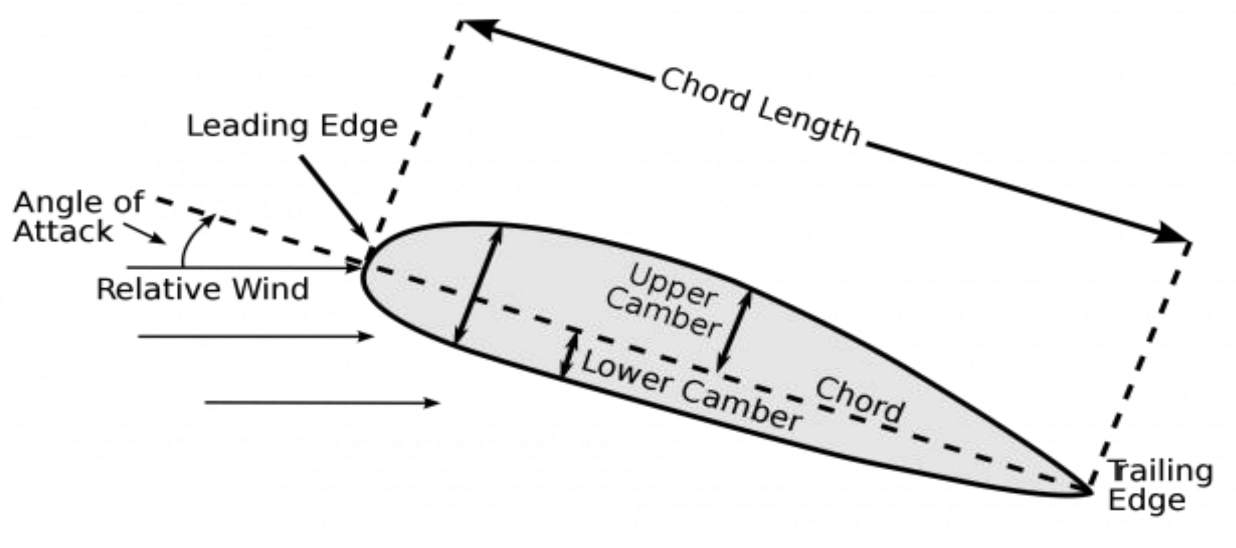


Figure1: Airfoil layout [7]

Problems

1. Prolonged exposure to wind leads to material fatigue
2. Using carbon fibre rather than fibre-glass is expensive
3. Large wind loads due to turbulence, wind gusts, and wind shear leads to bending stresses along the chord length
4. Larger blades harvest more energy, but have faster tip speeds and therefore, create more noise.
5. Large blades create stress on mechanical and gear components.

Solutions

1. Painting the airfoils with special materials such as protection tapes that will protect the leading edges from erosion and extend the lifespan of the airfoils, reduce maintenance costs and, most importantly, increase blade efficiency.

Figure2:Results of protection & non-protection on an airfoil [1]

2. Alternative materials can be used, that have the same properties as carbon fiber. An effective alternative is COC, cellulose nanocrystals which are stronger, lighter cheaper than carbon fiber.
3. Increasing the dimensions of the turbine blades will increase the surface area and distribute loads along a larger surface that will help in reducing the bending stress and wind shear.
4. To limit the noise from the rotor blades and gearbox a damping system can be installed that will produce counter vibrations to decrease the amount of noise produced.
5. Using large blades will cause micro-pitting on gear teeth . High performance gear oils that use advanced additive technologies can be used and will stop further micropitting formation.

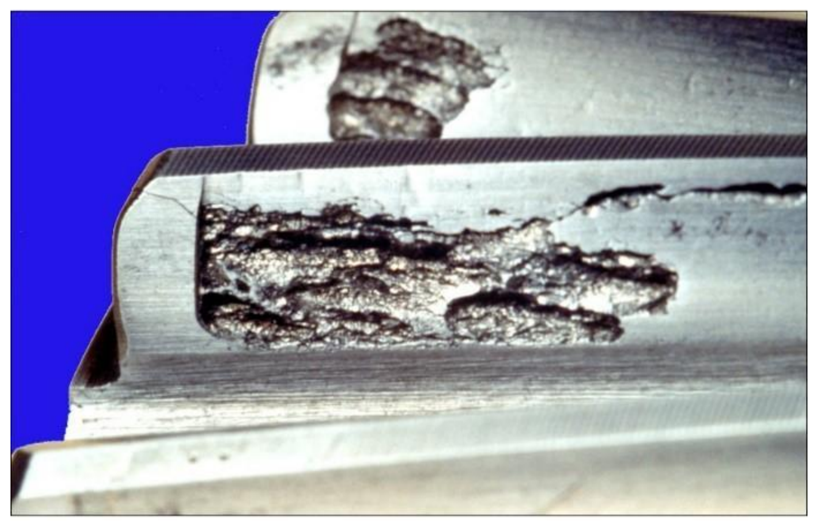


Figure 3: Macro-pitting on gear teeth [3]

Evaluation

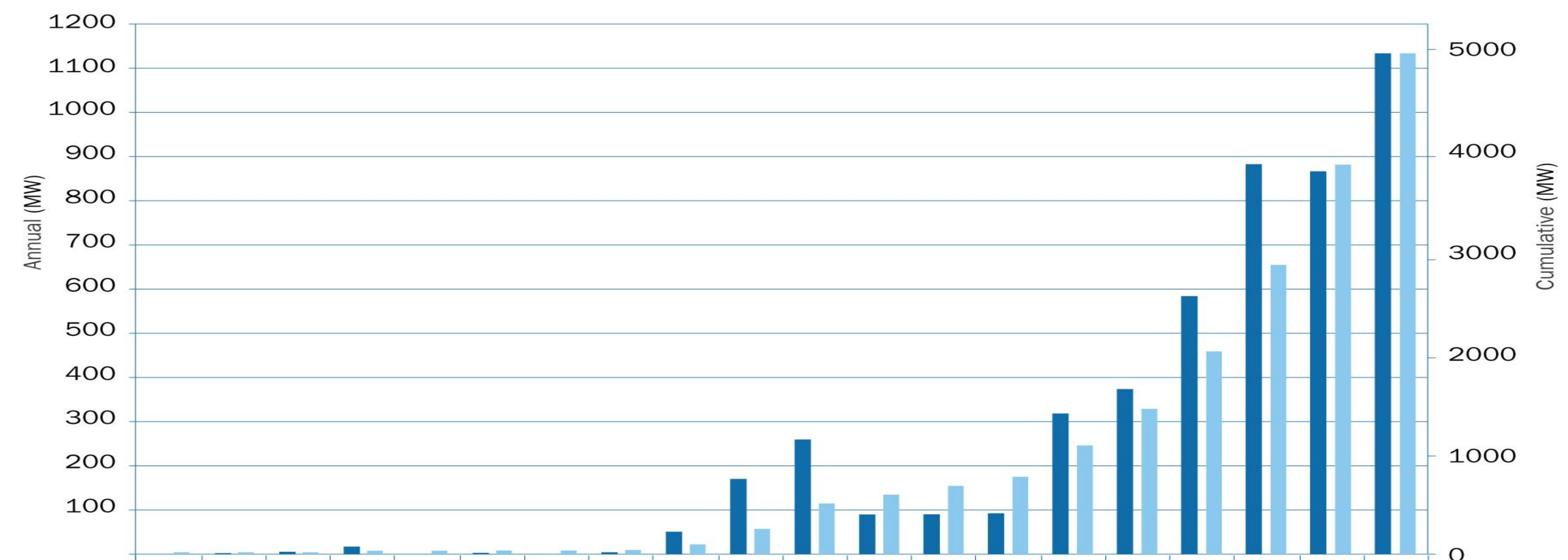
As the dimensions of wind turbines increase, new methods of load control are mandatory to decrease the stress levels on turbine blades.

Experimental studies in the field of wind turbine blade research have shown the morphing concept is significant for wind turbine technology because at critical loads it reduces stress levels. It allows for the creation of structures that have the conflicting abilities of being load carrying, lightweight and shape adjusted [2].

A composite plate is inserted into the airfoil section along the chord line and the leading edge of the composite plate is clamped at its center to a vertical spar. The trailing edge of the plate is hinged to a vertical web, which is also hinged to the airfoil surfaces in order to allow relative movement of the skins during rotation.

Rotation the composite plate, means the camber of the airfoil section is morphed between two different stable shapes [3].

Table1: Wind Installations (MW)



	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Annual	0	2	5	17	0	3	0	4	51	170	276	90	90	93	318	373	577	883	874	1,166
Cumulative	5	7	12	29	29	32	32	36	86	256	532	622	712	804	1,123	1,496	2,073	2,956	3,829	4,995

Source: EWEA [9]

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