Abstract: A wind turbine blade comprising a shell with an internal side defining an interior cavity and with an exterior defining a pressure side (17) and a suction side (16), wherein the pressure side (17) and the suction side (16) extend in a chordwise direction between a leading edge (15) and a trailing edge (14) and in a spanwise direction between a root and a tip, a spar cap (31) disposed on the internal side of the shell, and a reinforcement beam (20) attached on the spar cap (31), wherein the reinforcement beam (20) has an arch shaped cross section, such that the reinforcement beam (20) has a concave side and an opposite convex surface, said reinforcement beam (20) being attached onto the spar cap (31) along the length of the reinforcement beam (20) with the concave side facing the spar cap (31).
Reinforced wind turbine blade

The present invention relates to a reinforced wind turbine blade, a method for reinforcing a wind turbine blade, a wind turbine comprising a reinforced wind turbine blade and use of said wind turbine.

Wind power is considered one of the most reliable renewable energy sources and has therefore gained immensely in popularity with the increased demand for alternatives to fossil fuel based energy.

The wind turbine blades are a crucial and elementary part of a wind turbine, as the length of the wind turbine blades determines how large an area the wind turbine blades can sweep and thereby the amount of energy the wind turbine blades can transfer to the power generator of the wind turbine. The desire to increase the output from wind turbines has led to an up-scaling in the size of wind turbines including an increase in the length of the wind turbine blades.

Although the main objective, when designing the wind turbine blade is to provide the aerodynamic profile, it is also crucial to consider the forces which the wind turbine blade has to withstand to maintain structural integrity.

During operation, the shell will experience flapwise bending, i.e. perpendicular to the plane of the airfoil, caused by the wind acting on the wind turbine blade, and chordwise bending, i.e. in the direction of the chord of the airfoil, caused by the force of gravity and the rotation of the wing.

With the continuous increase in the length of the wind turbine blades, meeting the strength and stiffness requirements to ensure that the wind turbine blades can withstand these bending moments has become a major concern in the structural design of a wind turbine blade.

A first issue when increasing the length of the wind turbine blade is that while the area swept by the wind turbine blade increases quadratically with the length of the wind turbine blade, the mass of the wind turbine blade increases cubically. This puts an immense load on the root section of the
wind turbine blade which has to carry the chordwise forces caused by the gravitational and rotational forces acting on the wind turbine blade.

Secondly, wind turbine blades are usually made of composite materials, which are molded into a shell. The shell in itself is generally a relatively lightweight structure that is not well suited for the before-mentioned upscaling of the wind turbine blade and the increased forces this brings.

To increase the stiffness of the wind turbine blade, the shell is typically reinforced using a spar, so that the wind turbine blade can better withstand shear forces and flapwise bending moments. The spar is located within the cavity defined by the shell and usually comprises two spar caps which are disposed on the inner sides of the pressure and the suction sides, respectively.

Although the spar provides an increased stiffness to the shell structure, the wind turbine blade will still to some degree bend along the length. This bending leads to a large amount of internal stress within the composite materials of the wind turbine blade and the spar caps, which may cause the wind turbine blade and spar caps to buckle locally, known as micro-buckling, leading to a less efficient aerodynamical profile and eventually structural damage.

Previously, reinforcement of the spar cap has been done by providing a thicker spar cap or attaching a reinforcement element such as an I-beam or an omega-beam onto the spar cap.

The drawback of thickening the spar cap is that it leads to an unwanted mass increase of the wind turbine blade. This greatly increases the load requirements of the root of the wind turbine blade and limits the length of the wind turbine blade.

The alternative solution of applying a reinforcement element also increases the mass of the wind turbine blade, but it does so to a considerably lesser extent. However, while reinforcement elements such as I- or omega-beams are excellent at withstanding unidirectional bending moments, they fail when subjected to multidirectional forces.

On this background, it is the object of the invention to provide a rein-
forced wind turbine blade with an increased resistance against micro-
buckling, which thereby allows an increase of the blade length with only a lim-
ited increase in mass.

According to the invention this is achieved by a wind turbine blade
comprising, a shell with an internal side defining an interior cavity and with an
external defining a pressure side and a suction side, wherein the pressure
side and the suction side extend in a chordwise direction between a leading
edge and a trailing edge and in a spanwise direction between a root and a tip,
a spar cap disposed on the internal side of the shell, and a reinforcement
beam attached on the spar cap, wherein the reinforcement beam has an arch
shaped cross section, such that the reinforcement beam has a concave side
and an opposite convex surface, said reinforcement beam being attached
onto the spar cap along the length of the reinforcement beam with the con-
cave side facing the spar cap.

The advantage of using a reinforcement beam with an arch shaped
cross section, is that this profile shape is more effective at resisting multi-
directional stress. In contrast, previously used reinforcement beams, e.g. I-
or Omega-beams, are only optimized for withstanding bending moments in a
few discrete directions.

The arch of the reinforcement beam spans between the two bases of
the arch to define a width of the reinforcement beam, and the reinforcement
beam extends along its length direction. The apex of the arch defines the
height of the reinforcement beam.

In an embodiment of the invention the cross sectional shape of the
reinforcement beam is semi-elliptical. That is, the beam has a profile shape of
an ellipse cut along one of its major axes. This includes the case wherein the
cross-sectional shape of the reinforcement beam is semi-circular.

The advantage of having a beam with a profile shape of an ellipse
cut along one of its major axes or a reinforcement beam which is semi-
circular is that the moment of inertia is optimized for multi-directional bending
moments, making these beams in particular well suited for withstanding non-
predictable bending moments, i.e. the reinforcement beam is stiffer than for
example an I-beam with regards to bending in several directions but less stiff in certain discrete directions.

According to an embodiment of the cross-sectional shape of the reinforcement beam has at least one leg extending from the concave side of the reinforcement beam to the spar cap.

By adding one or more legs which connect the concave side of the reinforcement beam to the surface part of spar cap enclosed by the reinforcement beam, it is ensured that the forces acting on the wind turbine blade are transferred to the reinforcement beam. Ideally, the legs connect the surface of the spar cap to the concave side of the reinforcement beam in such a way, that the cross-sectional shape of the reinforcement beam is center symmetrical. In the case where the reinforcement beam has one leg it preferably extends substantially orthogonally from the spar cap to the apex of the concave side of the reinforcement beam.

In an embodiment of the invention the reinforcement beam has a flange along the base of the arch-shape and/or at the at least one leg.

The flanges increases the contact area between the reinforcement beam and the surface of the spar cap, making the bonding between the two stronger to ensure that the reinforcement beam does not separate from the spar cap during operation of the wind turbine.

According to an embodiment of the invention, the reinforcement beam extends substantially in the spanwise direction of the shell and preferably extends substantially along the entire length of the spar cap.

The advantage of using a reinforcement beam that extends substantially in the spanwise direction of the shell and preferably extends substantially the entire length of the spar cap, is that the beam may be molded in a single molding process and that only one bonding process is needed, thereby facilitating production of the wind turbine blade. It should be noted, that a reinforcement beam extending along the length of the wind turbine blade may have varying dimensions along its own length, such as to conform to the dimensions of the inner cavity, e.g. the reinforcement beam may taper towards the tip of the wind turbine blade.
According to another embodiment of the invention, several smaller reinforcement beams may be arranged side-by-side, extending substantially in the spanwise direction of the wind turbine blade. By using several smaller reinforcement beams, the contact surface between the spar cap and the reinforcement beams may be increased, thereby ensuring that the spar cap is properly stabilized.

In an alternative embodiment, several reinforcement beams are arranged side-by-side extending in the chordwise direction of the wind turbine blade. In such an embodiment each reinforcement beam may vary in width and length to conform to the varying dimensions of the wind turbine blade.

In embodiments where several reinforcement beams are arranged side-by-side, these may be joined at the flanges at the base of the arches to form one reinforcement beam with several arches.

In an embodiment of the invention, the reinforcement beam is made from a fiber-reinforced composite, such as fiber-reinforced plastics with e.g. carbon, glass, or Kevlar fiber. The fiber-reinforced composite material can be prepared by hand layup, which typically consists of laying dry fabric layers or pre-impregnated layers, by hand onto a tool to form a laminate stack. If using dry fabric layers, resin can be applied after layup is complete, e.g., by means of resin infusion. Such materials are well suited as they can be made highly rigid and lightweight.

The second aspect of the invention relates to a method for reinforcing a wind turbine blade using a reinforcement beam as described above. Said process can either be performed during manufacture of a new wind turbine blade or for retrofitting a reinforcement beam to an existing blade turbine blade to stiffen it.

According to the invention this is accomplished by a method reinforcing a wind turbine blade with a shell with an internal side defining an interior cavity and with an exterior defining a pressure side and a suction side, the pressure side and the suction side extending in a chordwise direction between a leading edge and a trailing edge and in a spanwise direction between a root and a tip, and a spar cap disposed on the internal side of the shell, the
method comprising the steps of providing a reinforcement beam having an arch shaped cross section with a concave side adapted for facing the spar cap, positioning said reinforcement beam on the spar cap with the concave side facing the spar cap, and attaching said reinforcement beam along the length of the reinforcement beam to the spar cap.

The present invention will now be described in greater detail based on preferred embodiments with reference to the drawings on which:

- Fig. 1 shows a perspective schematic view of a wind turbine blade,
- Fig. 2 shows a cross-sectional side view of a wind turbine blade according to the invention,
- Fig. 3 shows a cross-sectional side view of another wind turbine blade according to the invention,
- Fig. 4 shows a perspective side view of a section of a wind turbine blade according to the invention,
- Fig. 5 shows an exploded perspective side view of a section of a wind turbine blade according to the invention,
- Fig. 6 shows an enlarged, cross-sectional view of a reinforcement beam according to the invention,
- Fig. 7 shows an enlarged, cross-sectional view of another reinforcement beam according to the invention,
- Fig. 8 shows an enlarged, cross-sectional view of another reinforcement beam according to the invention,
- Fig. 9 shows an enlarged, cross-sectional view of another reinforcement beam according to the invention,
- Fig. 10 shows an enlarged, cross-sectional view of another reinforcement beam according to the invention, and
- Fig. 11 shows an enlarged, cross-sectional view of another reinforcement beam according to the invention.

Turning first to fig. 1, this shows a conventional wind turbine blade 10. Wind turbine blades 10 are usually made from two shell halves of composite materials, which are molded separately and then coupled together along the corresponding edges of the wind turbine blade 10 to form one complete
The assembled shell shown in fig. 1 as well as in the embodiments of the invention illustrated in figs. 2 to 5 has an internal side defining an interior cavity and an exterior defining a pressure side 17 and a suction side 16. The pressure side 17 and the suction side 16 extend in a chordwise direction C between a leading edge 15 and a trailing edge 14 and in a spanwise direction S between a root 11 and a tip 13. The shell thereby constitutes an aerodynamic profile, which when affected by the wind generates a force that drives a generator of the wind turbine. The length of the wind turbine blade 10 is defined as the distance between the root 11 and the tip 13, and the chord width is defined as the distance between the leading edge 15 and the trailing edge 14 at a given position along the length of the wind turbine blade 10.

The shell can be divided into three sections, the root section 11, the mid span 12, and the tip 13. Of these, the root section 11 is by far subjected to the heaviest loads. The root section 11 is therefore composed of a circular mount with no aerodynamical profile, which serves to connect the wind turbine blade 10 to the hub of the wind turbine. Between the circular mount and the mid span 12, the root section 11 has a thick aerodynamic profile with a low aerodynamic efficiency. The excessively thick aerodynamical profile at the root section 11 is not only provided in order to improve structural integrity at this load intensive section, but also due to a relatively low wind velocity caused by the short distance to the hub of the wind turbine at the root section 11. The low wind velocity leads to reduced efficiency of the aerodynamic profile making large chord widths necessary to avoid stalling.

The mid span 12 and the tip 13 are subjected to a significantly smaller chordwise stress than the root section 11, while they also generate most of the energy. Therefore, the mid span 12 and the tip 13 are designed to optimize the lift to drag ratio by making the chordwise width as short as structural considerations will allow. However, as the mid span 12 and the tip 13 generate most of the energy they are subjected to large bending moments in the flapwise direction F. This is usually compensated for by stiffening the shell in the spanwise direction so that it may withstand the flapwise bending and/or by
pre-bending the wind turbine blade 10.

Figure 2 shows a schematic side view of a cross section of a wind turbine blade 10 according to the invention. To stiffen the wind turbine blade 10, the shell will generally be assembled around a spar 30 which extends inside the internal cavity in the spanwise direction of the wind turbine blade 10. The spar 30 usually starts in the mid span section 12 and extends the entire length of the mid span 12 before it terminates in the tip section 11.

The spar 30 comprises two spar caps 31 disposed on the internal surface of the pressure side 17 and the suction side 16 of the wind turbine blade 10. The spar caps 31 can either be built as part of the shell during molding of the shell halves, or it can be manufactured separately and bonded to the internal surfaces of the shell after the molding process.

In general, the spar caps 31 are connected by a shear web 32 to strengthen the wind turbine blade 10 by absorbing the shear forces acting on the two sides of the wind turbine blade 10. There are two common configurations for the shear web 32 connection, either one shear web 32 spans centrally between the spar caps 31 so that the spar 30 resembles an I-beam, or two shear webs 32 spans between the sides of the spar caps 31 to form a box-spar.

The figures show a wind turbine blade 10 with a box-spar configuration with two shear webs 32. The two shear webs 32 span the internal cavity, connecting the two spar caps 31 to support the structural integrity of the wind turbine blade 10. In alternative versions of the box-spar, the shear web can be made from two opposing trough-shaped elements (not shown) with a bottom and two walls, which are disposed on respective spar caps 31, such that their walls extend into the internal cavity and meet inside the cavity to form the box-spar together with the spar caps 31. In such embodiments the bottom of the two trough-shaped elements will be sandwiched between the spar cap 31 and the reinforcement beam 20, so that the reinforcement beam 20 are not be disposed directly onto the surface of the spar cap 31, but rather on the bottom of the trough-shaped element.

Although the spar 30 provides a significantly stiffer wind turbine blade
the wind turbine blade 10 will still bend under the massive flapwise forces to which it is subjected. As described initially, the bending of the wind turbine blade 10 may lead to local deformations, known as micro-buckling, which cause the shell to buckle.

To counter the effect of micro-buckling, the spar cap 31 on the suction side 16 of the wind turbine blade 10 according to the invention has been reinforced using a reinforcement beam 20 with a semi-circular profile shape.

While the reinforcement beam 20 shown in fig. 2 spans almost the width of the spar cap 31, so that only one reinforcement beam 20 is needed for each spar cap 31, the wind turbine blade 10 may alternatively, be reinforced using several smaller reinforcement beams 20 placed side by side as shown in fig. 3. The advantage of this is that the contact area between the spar cap 31 and the reinforcement beams 20 is increased and that the flapwise bending moments are more effectively transferred to the reinforcement beam 20.

Figure 4 and 5 show a perspective cutaway and an exploded view of part of the mid span 12 of the wind turbine blade 10. In the shown embodiment, the spar caps 31 are arranged extending in the spanwise direction of the wind turbine blade 10. Alternatively, the wind turbine blade 10 could also be reinforced by arranging several reinforcement beams extending in the chordwise direction side by side.

When arranged in the spanwise direction of the wind turbine blade 10, the width and the height of the reinforcement beam 20 may vary along the length of the wind turbine blade 10 to conform to the narrower airfoil at the tip section 11. However, the profile shape maintain the arch-shape throughout the length of the reinforcement beam 20.

As shown in figure 5 the reinforcement beam 20 can be a separate element, which can be manufactured or acquired independently of the molding of the wind turbine blade 10. This is advantageous as it does not require the manufacturer of the wind turbine blade 10 to modify their molding process significantly to incorporate the reinforcement beam 10 into the production line.

As the reinforcement beam 20 can be made separately from the re-
maining wind turbine blade structure, it need not be of the same material as the shell or the spar cap 31. While the wind turbine blade is usually made from glass fiber materials due to the cost of manufacturing such a large structure in carbon fiber, the reinforcement beam 20 being much smaller may be molded from more expensive and stiffer materials.

The reinforcement beam 20 will usually be made from a fiber-reinforced composite, such as fiber-reinforced plastics with e.g. carbon or glass fiber. The composite may contain other fibers, such as an aramid, e.g. Kevlar or Twaron, aluminium, ultra-high-molecular-weight polyethylene (UHMWPE), organic fibers, etc., or a combination of fibers. The binding polymer is often a thermoset resin such as epoxy or polyester, but other thermoset or thermoplastic polymers, such as polyester, vinyl ester or nylon, are sometimes used. The fiber-reinforced composite material can be prepared by hand layup, which typically consists of laying dry fabric layers or pre-impregnated layers, by hand onto a tool to form a laminate stack. If using dry fabric layers, resin can be applied after layup is complete, e.g., by means of resin infusion.

Figures 6 to 11 show various cross-sectional profiles of reinforcement beams 20 according to the invention. In general, the cross section of the reinforcement beam 20 has two contact points 24 connected by an arch. The arch has a concave side 21 adapted for facing the spar cap 31 and a convex side 22 adapted to face the internal cavity of the shell.

In the embodiment shown in fig. 6 the profile shape of the reinforcement beam 20 is semi-circular, thereby providing a nearly continuously rotational symmetric moment of inertia along the length axis of the reinforcement beam 20.

The reinforcement beam 20 has an apex at the top point of the arch shape and a width direction W extending between the bases of the arch, a height direction H extending orthogonally from the spar cap 31 to the apex of the reinforcement beam 20, and a length direction L.

The reinforcement beam 20 has flanges 25 at the contact points 24, which extend the entire length of the reinforcement beam 20. The flanges 25
provide and increased contact area between the spar cap 31 and the reinforcement beam 20 to ensure that the bonding between the spar cap 31 and the reinforcement beam 20 is strong enough to handle the forces experienced during operation of the wind turbine.

Fig. 7 shows a cross sectional view of another semi-circular reinforcement beam 20. The cross sectional shape of the reinforcement beam 20 has a leg 23 extending from the apex of the concave side 21 towards the spar cap 31. The leg 23 is adapted to connect the surface of the spar cap 31 the reinforcement beam 20 to transfer forces to the reinforcement beam 20. The leg 23 extends downwards in the height direction of the reinforcement beam 20 in a direction so that it is orthogonal on the surface of the spar cap 31 when the reinforcement beam 20 is bonded thereon. The leg 21 may also have flanges 25 at to ensure that it has sufficient contact area for bonding it to the surface of the spar cap 31.

Fig. 8 shows a cross sectional view of another semi-circular reinforcement beam 20. In the shown embodiment, the reinforcement beam 20 has two legs extending orthogonally from the concave surface 21 towards the spar cap 31. This further ensures that the stress in the spar caps 31 is transferred efficiently to the reinforcement beam 20. The reinforcement beam may be provided with as many legs 23 as required to transfer the forces acting on the spar cap 31 to the reinforcement beam 20. While the reinforcement beam 20 shown in fig. 8 does not have any flanges at the legs 23, the skilled person would know this as a possibility in alternative embodiments.

Fig. 9 and 10 show embodiments of the reinforcement beam 20, wherein the arch of the profile shape has been stretched in the height direction of the reinforcement beam 20 and the width direction of the reinforcement beam 20, respectively. Such semi-elliptical shapes may be desirable if the reinforcement beam 20 is optimized for absorbing bending moments in one discrete direction, e.g. the direction normal to the surface of the spar cap 31, while still having an improved resistance to multi-directional stress compared to conventional beams, such as I-beams.

Fig. 11 show an embodiment of the reinforcement beam 20, wherein
several reinforcement beams have been joined to form one reinforcement beam 20 with several arches. Such a reinforcement beam 20 provides the same effect as placing several single reinforcement beams 20 side-by-side, but it can be molded in a single molding process, and it facilitates the bonding process between the reinforcement beam 20 and the spar cap 31, as it assures that the arches are aligned. It should be noted that the reinforcement beam 20 could be integrated with the spar cap 31 by molding the two together, such as to form a reinforced spar cap. Furthermore, the wind turbine blade 10 may be reinforced using a combination of the above-described reinforcement beams 20.
P A T E N T  C L A I M S

1. A wind turbine blade comprising:
   a shell with an internal side defining an interior cavity and with an exterior defining a pressure side and a suction side, wherein the pressure side and the suction side extend in a chordwise direction between a leading edge and a trailing edge and in a spanwise direction between a root and a tip;
   a spar cap disposed on the internal side of the shell; and
   a reinforcement beam attached on the spar cap, wherein the reinforcement beam has an arch shaped cross section, such that the reinforcement beam has a concave side and an opposite convex surface,
   said reinforcement beam being attached onto the spar cap along the length of the reinforcement beam with the concave side facing the spar cap.

2. The wind turbine blade of claim 1, wherein the cross sectional shape of the reinforcement beam is semi-elliptical.

3. The wind turbine blade of claim 1 or 2, wherein the cross sectional shape of the reinforcement beam has at least one leg extending from the concave side of the reinforcement beam to the spar cap.

4. The wind turbine blade of any one of the previous claims, wherein the reinforcement beam has a flange along the base of the arch-shape and/or at the at least one leg.

5. The wind turbine blade of any one of the previous claims, wherein the reinforcement beam extends substantially in the spanwise direction of the shell and preferably extends substantially along the entire length of the spar cap.

6. The wind turbine blade of any one of the previous claims, wherein the reinforcement beam is made from a fiber-reinforced composite.
7. A wind turbine comprising at least one wind turbine blade according to any one of the previous claims.

8. Use of a wind turbine according to claim 7 for generating electricity.

9. Method for reinforcing a wind turbine blade with a shell with an internal side defining an interior cavity and with an exterior defining a pressure side and a suction side, the pressure side and the suction side extending in a chordwise direction between a leading edge and a trailing edge and in a spanwise direction between a root and a tip, and a spar cap disposed on the internal side of the shell, the method comprising the steps of:
   providing a reinforcement beam having an arch shaped cross section with a concave side adapted for facing the spar cap;
   positioning said reinforcement beam on the spar cap with the concave side facing the spar cap; and
   attaching said reinforcement beam along the length of the reinforcement beam to the spar cap.

10. The method of claim 9, wherein the cross sectional shape of the reinforcement beam is semi-elliptical.

11. The method of claim 9 or 10, wherein the cross sectional shape of the reinforcement beam has at least one leg extending from the concave side of the reinforcement beam to the spar cap.

12. The method of any one of claim 9 to 11, wherein the reinforcement beam is attached such that it extends substantially in the spanwise direction of the wind turbine blade.
A. CLASSIFICATION OF SUBJECT MATTER
INV. F03D1/06
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F03D

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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<td>X</td>
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<td>1, 2, 4, 5, 7-10, 12</td>
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<td>Y</td>
<td>us 2010/068065 AI (JENSEN FIND MOLHOLT [DK]) 18 March 2010 (2010-03-18) paragraph [0094]; figure 3b</td>
<td>6</td>
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<tr>
<td>WO 2009153344 A1</td>
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<td>EP 2109713 A2</td>
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<td>US 2010068065 A1</td>
<td>18-03-2010</td>
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<tr>
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<td></td>
<td>WO 2008092451 A2</td>
<td>07-08-2008</td>
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