Harnessing nature’s power
Hexcel’s composite materials, processes and solutions for wind turbine blades
Hexcel is a leading global supplier of advanced composite materials to the wind energy market and has supplied more than 100 million square metres of composites to wind turbine blade manufacturers over the last 25 years. Our composite technologies have enabled blade lengths to increase to over 80 metres, supporting the growth of wind power around the world.

We work closely with our customers to develop products and processes that are tailored to their specific requirements. This approach has enabled us to develop technologies such as:

- Prepreg materials and process solutions to optimise throughput by faster curing at lower temperatures.
- Fibre-reinforced matrix solutions for rapid cost-effective processing.
- Unidirectional (UD) carbon prepregs for critically loaded structures.
- Materials for root ends and Polyurethane solutions for cost efficient manufacturing of nacelle housings.

Hexcel is one of the few suppliers of composites for wind energy to manufacture carbon fibre in-house. This knowledge, combined with our dedicated weaving facilities, enables us to design composite reinforcements in carbon and glass, or hybrids of the two. We are the composite specialists, with dedicated R&T facilities in Europe and the USA. Our global technical support team assists with material selection, processing and can provide training to those who are new to composites technology.
Hexcel has developed a broad range of products and solutions benefiting from synergies with other cutting edge technology markets for composites including aerospace, space and defense.

During the rapid growth of the wind energy market Hexcel has been at the forefront of developments supporting expansion by supplying technology solutions rather than just materials. To support the wind energy market Hexcel has dedicated manufacturing facilities in Asia, Europe and the USA.
Manufacturing a large composite structure

A wind blade is a component for a machine designed to direct and concentrate energy from the air into a wire that connects the turbine generator to an electrical grid. The cost of such energy depends on advanced and cost-effective solutions to manufacture very large composite structures like wind blades.

Prepreg is a glass or carbon fibre reinforcement that is impregnated with a resin (e.g. epoxy). Prepreg is supplied in roll form and cured by applying heat and pressure to produce high quality laminates with superior stiffness and strength – at low weights. Prepreg is an ideal economical technology for manufacturing large composite parts, as the process is readily automated and the materials are easy to handle.

Carbon fibre prepregs are a cost-effective option for very large diameter blades, as less material is required to achieve the strength and stiffness of glass structures. Hybrid reinforcements of glass and carbon are also a potential option.

Hexcel has extended its resin range for wind energy to meet customer requirements for shorter cost-efficient cure cycles. HexPly® M9G is a formulated epoxy resin suitable for low pressure moulding. This versatile resin system cures at a range of temperatures from 85°C to 150°C. HexPly® M9G is a further development of Hexcel’s well established M9 range, already widely used to manufacture wind turbine blades.

Hexcel has introduced HexPly® M79 to further support customers with prepregs that cure more quickly at lower temperatures.

Benefits of HexPly® M79:
- lower temperature cure
- low exotherm – suitable for the co-cure of thin and thick sections
- low pressure processing
- suitable for a wide variety of production techniques
- excellent tack and outlife
- excellent mechanical and visual properties after curing
- UD, woven and non-woven glass or carbon reinforcements possible

Hexcel ahead of the game
Benefits of HexPly® M9-family prepregs:

- Optimised structural design
- Consistent fibre volume ratio
- Lower and consistent blade weight
- Pure UD materials with optimised performance/cost ratio
- High strength and fatigue properties
- Short total processing and cure cycle
- Clean working environment
- Low exothermic properties – enabling curing and co-curing of multi-ply laminates, e.g. carbon with glass
- Minimise stresses caused by differences in thermal expansion
Carrying the load

Spar/Shear Web

A wind blade is a structural beam that throughout its operating life is subjected to considerable lift forces on its aerodynamic profile. Stiffening of the blade is therefore essential to resist bending.

Sometimes two strips of reinforcing materials are used to provide local stiffening – one on the upwind face and one on the downwind face. However, to provide the essential shear strength these two strips need to be structurally joined by a construction called a shear web.

There are different ways of designing a spar/shear web – either as a girder-structure connected by one or two shearwebs or as a full box-like beam structure. The longer the blade, the higher the performance demands on such load carrying structures. The stiffness of the material in the structural beam is crucial as it prevents the blade from striking the tower when rotating. The structural integrity of the wind blades depends on the combination of composites used to build the load carrying structures and the highest quality materials are therefore required for such applications.

Hexcel has developed an optimised range of prepregs and other fibre-reinforced composites for spar/shear web construction, including UD reinforced carbon and glass materials as well as our HexPly® SuperCap™ products.

Hexcel’s innovative and patented carbon UD materials utilising Grid Technology allow very thick carbon UD laminates to be manufactured by vacuum bag, resulting in excellent void-free laminate quality.

Hexcel’s leadership in carbon fibre, means that we have the knowledge and experience to assist with the introduction of carbon fibres into large scale structures, including those requiring lightning-strike protection.
The **shell** provides the aerodynamic shape of the blade and plays a role in stiffening and strengthening the spar, as the fibre orientation in the construction helps to resist torsion. Blade shells are usually quite thin as the requirements for strength in a shell structure are relatively low. However, to prevent large flat laminate areas from flexing – which could affect the aerodynamic shape and lead to buckling – certain areas are designed as a “sandwich” construction with laminated skins and a core (e.g. low density rigid foam or balsa wood). As blade shells provide the outer surface of the blade, they must resist harsh environmental conditions. A composite shell has a streamlined aerodynamic design and provides excellent environmental resistance.

Hexcel has an optimised range of prepregs and other materials for shell construction including our surfacing prepreg that produces a fine surface ready for painting without the need for a gel coat.

The **nacelle** sits on top of the tower and contains all main technical parts of the wind turbine. Usually made of fibreglass, the nacelle contains the low- and high-speed shafts, the gearbox, the brake and the generator. It also contains the blade pitch control, a hydraulic system that controls the angle of the blades and the yaw drive, which controls the position of the turbine relative to the wind. As the nacelle holds hardware, which is responsible for transforming the dynamic energy of the wind into electricity, the typical weight of the nacelle structure can exceed 500 tons. Due to the size of the housing panels sandwich structures are typically used for the nacelle walls using wet resin technologies and foam core materials.

Hexcel has developed a range of **PUR foam core material** for nacelle construction.

Effective **mould** design is the key to successful blade manufacture. To improve cycle times and process control, a quick heat-up and cool-down rate is necessary. For over 20 years Hexcel has supplied drilled honeycombs for use in lightweight tooling. The combination of composite tooling material with aluminium honeycombs provides long life tooling that withstands over 800 cycles despite the difference in thermal expansion between the core material and the laminate. Drilled honeycombs result in very light weight moulds with very high stiffness with faster heat-up and cool-down rates for quicker processing. The high stiffness of the honeycomb means less weight is required in the supporting structure and it is easier to lift. All of this results in a lower thermal mass of the tooling which gives higher throughput. The main application for drilled honeycombs is for hot air heating and cooling – new designs are using the same concept for liquid and electrical heating.
The blade root is usually circular in cross section to connect to the pitch bearing in the hub. The wind blades are fixed to the hub via a bolted connection that allows them to be removed. Most blade roots consist of a thick solid laminate with studs or T-bolts either screwed or bonded in. The girder structure (or box section) of the load carrying spar must be joined to the cylindrical laminate at the root. Normally this is done by incorporating a smooth curved transition area.

Care must be taken during the curing of the composite structure as the high thickness in the laminate sections could lead to a build-up of high exothermic temperatures. For this reason many manufacturers make the root as a separate component and bond it into the structure. The bonding of this joint is critical and concentration of stress in this area must be avoided.

Roots are therefore a critical area of the blade, requiring a very high quality of laminate. Hexcel has developed an optimised range of prepregs and other fibre-reinforced composites for root construction which allow the manufacturing of root sections in a controlled and cost efficient way. This allows smaller root diameters and lighter root ends due to superior mechanical performance from the prepreg construction, resulting in potential savings in hub design.
Optimising thick structures

Polyspeed® pre-cured glass/carbon/epoxy laminates are used in conjunction with prepreg in a vacuum bag lay-up to improve the quality and optimise the structure of cured stacks.

Polyspeed® pre-cured laminates are available in woven or unidirectional constructions fully supporting the mechanical performance of vacuum bag cured structures.

As the materials are already cured when introduced in the lay-up the final exotherm upon curing can be reduced, additionally buckling, waviness of long lay-ups can be avoided completely thus providing optimised fibre orientation in large scale unidirectional lay-ups.

Our Polyspeed® grid laminates, which are woven glass fibre epoxy laminates with an open grid structure allow liquid resins or reactive foams to flow through the lay-up structure. Grid laminates are ideal for combined technologies where reactive liquid systems need to be combined with solid, already cured, composite parts. They enable large structures to be manufactured cost-effectively by combining infusion technology with laminates or other pre-cured load carrying structures such as pultruded components.

Grid laminates provide mechanical fixing for dry reinforcements which need to be infused and contribute to the final mechanical performance. They reduce the use of auxiliary materials and can also reduce the amount of dry reinforcement required in wet processes as grid laminates contribute to the structural performance.

Polyspeed® laminates are available in a wide range of fibre areal weights from 500g/m² to 1600g/m² with flexibility on mesh size of the grid pattern and in widths from 38mm to 1270mm.
HexPly® SuperFIT™ is a range of glass and carbon fibre reinforcements that have been partially impregnated with epoxy resin. SuperFIT™ is processed by applying heat and vacuum, which activates the resin, enabling it to flow and infuse the reinforcement. SuperFIT™ provides a quick and cost-effective way of producing large, thick laminates minimising porosity.

HexPly® SuperCap™ is a range of heavy UD epoxy prepregs in glass and carbon fibre, with 32% resin content, ideal for thick load-carrying parts in wind blades. HexPly® SuperCap™ allows the advantages of prepreg and infusion technology to be combined, providing the best of both worlds.

**Adantages of SuperFIT™**

- easy positioning of the materials in the mould and holding the plies together thanks to a high resin content of the tacky face
- facilitates repositioning of plies due to the dry face, especially in the case of large structures
- facilitates the draining of air or volatiles inside the laminate
- reduces voids to a minimum
- can be used in conjunction with standard prepregs
- hygiene and safety, reduction or elimination of direct contact with resin

**Benefits of SuperCap®**

- quick lay-up using heavy UD HexPly® prepregs
- perfect fibre alignment in the prepreg
- no stitching means no fibre damage or buckling of materials
- no risk of dry unimpregnated reinforcements
- superior laminate performance for structural parts of wind blades
- uses less material and saves costs
- easy to introduce carbon fibre into the blade design
Other Hexcel wind energy products

Hexcel formulates a range of Modipur® Polyurethane (PU) core foams for wind energy applications and has access to a wealth of history and experience in PU technology built up over 30 years. PU foams are recommended for nacelle, shell and mould applications.

Hexcel offers a wide range of industrial non-metallic Honeycombs (HexWeb® HRH78 and A10) in a variety of cell configurations and densities to support wind energy applications. Hexcel produces a range of HexForce® biaxial and triaxial reinforcements in glass and carbon fibre that are ideally suited for wind blade manufacturing.

HexForce® Fabrics are available in a wide range of weights from 50gsm to 600gsm and weave styles (plain weave, twill weave, satin weave, etc...). Woven fabrics provide strength and stiffness in two directions and have good handling characteristics and good drapeability depending on weave style.

Hexcel also supplies Peel Ply Fabrics in the form of finely woven lightweight polyamide. These are applied to the composites surface prior to curing laminate and removed after cure for a clean surface ready for adhesive bonding. HexForce® T470 is commonly used in wind energy due to the product purity and mechanical properties, better tear resistance and lower water uptake. The heat-sealed edges mean that no fibres are left behind in the laminate.

Hexcel has supplied structural Adhesives for decades and offers a range of Redux® hot melt film adhesives for bonding and foaming adhesives for gap filling and insert bonding. Adhesive bonding is an efficient way to construct large parts and ensure structural integrity. Hot melt film adhesives are easy to apply to large surfaces, offer good bond line control, have long life at room temperature and present minimal chemical handling hazards.

Other Hexcel wind energy products

a wealth of history and experience
Materials processing and testing

A world leader in prepregs and composites for wind turbine blades, Hexcel is also a specialist in integrating materials into customer processes.

Large scale components like big wind blades cannot be manufactured by purely manual processes anymore due to the vast dimensions of parts. Hexcel has a wide range of expertise in the integration of automated technologies into manufacturing processes and is focused on providing innovative solutions to the wind energy industry.

Hexcel has also developed strong partnerships with a number of companies and institutes including universities and internationally acknowledged composite testing companies for developing, demonstrating and proving novel materials and concepts. Hexcel material testing facilities have achieved GL accreditation.

For more information and the full range of data sheets for Hexcel’s composite materials for wind energy please visit www.hexcel.com

To contact us please find our list of sales offices at: www.hexcel.com/OurCompany/sales-offices

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