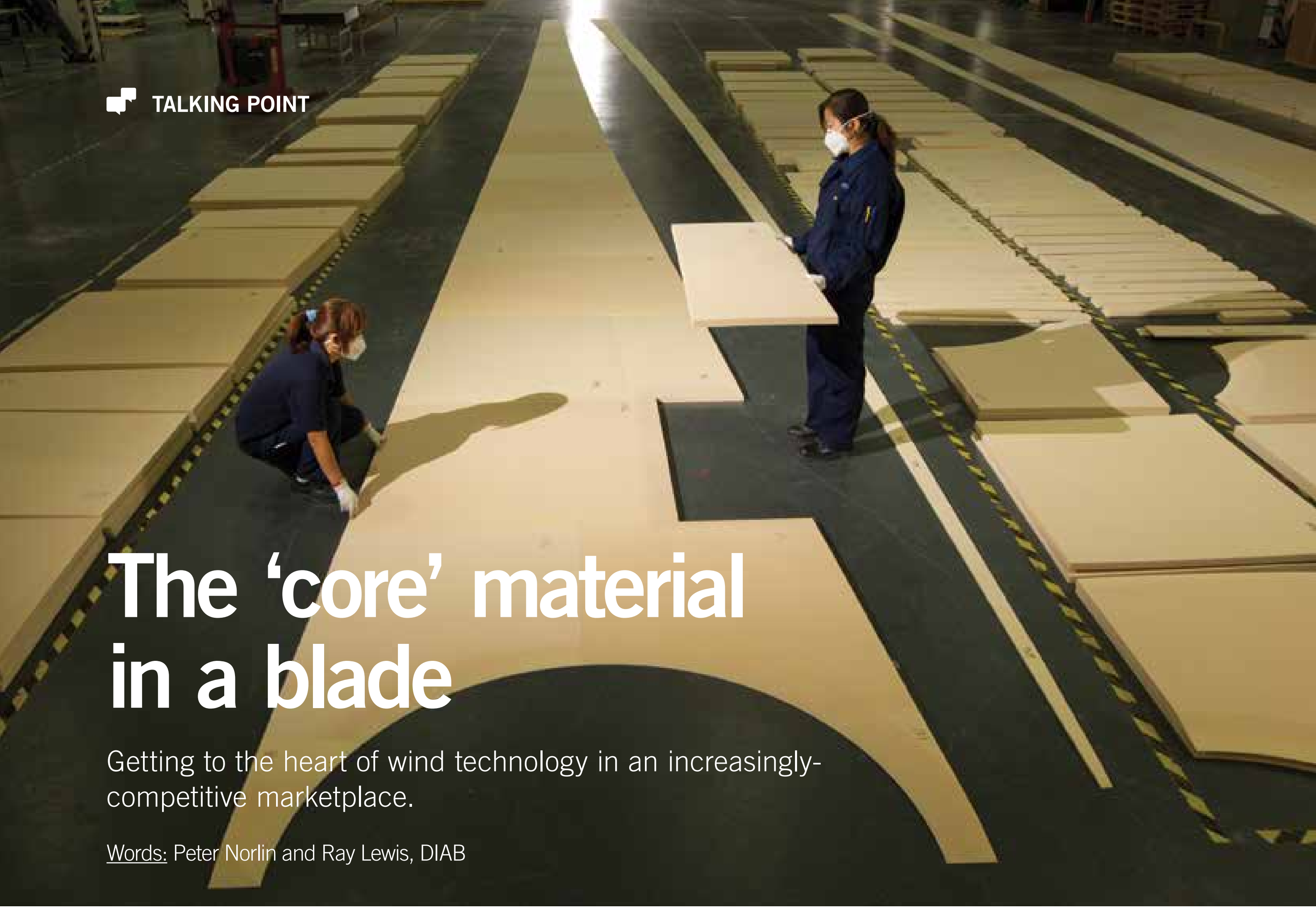

TALKING POINT

The 'core' material in a blade

Getting to the heart of wind technology in an increasingly-competitive marketplace.

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Introduction

The Wind Turbine Generator (WTG) is the key focal point of any wind farm. The blades themselves are the key operational element of the WTG, as their performance in capturing the wind enables each manufacturer to optimise the availability and yield of their turbines. DIAB is a leading manufacturer of core materials, which is one of three primary materials used in the construction of composite wind blades and nacelles since the 1980s. Along with the resin and reinforcement, they combine to provide the final sandwich laminate structure and the resultant technical properties of the blade.

The authors of this article, Peter Norlin and Ray Lewis, have together over 40 years of experience from the industry and have seen the market develop from its cradle through a rapid growth to a global and maturing industry

This article reflects on the past, present and future challenges, which seeks to broaden knowledge so that the best solutions are chosen to make wind an even more competitive energy technology and bring the associated benefits to its supply chain.

The challenge for wind energy

Renewables and within that, wind, today provide a relatively small amount of the world's increasing domestic and industrial energy needs. Traditional energy sources of gas, coal, oil and nuclear dominate with their selection based upon history, local demographics, cost of energy and political drivers.

Whilst the environmental benefits of wind, as a renewable energy, are obvious, and highlighted in recent years with clarity on carbon targets, fluctuating fossil fuel prices and nuclear (following the Fukushima disaster), considerable challenges remain for it to 'break through' and secure a double-digit market share.

Technology changes are essential to advancement, but they take time and increase financial risk, overcoming as they must the inevitable inertia and resistance to change from various market forces and certification organisations. One composite-related example is that of aircraft.

In the last 25 years the use of composites in primary structures has progressively increased, replacing traditional metals, to provide weight and production benefits. Whilst there are many obstacles facing a new technology such as wind, they can be classified and addressed in terms of the real priorities needed. The key one undoubtedly is the Cost of Energy (CoE) per KW/hr and will always be cited, even if all else is addressed. The following focuses on composite wind blades and linked to it, nacelles in that respect.

Composites as a technology

Historically, the original composite laminate was most probably a mud hut. It sought simplistically, to combine the best properties from two (or more) materials into one and created a simple composite This philosophy has carried through to today into more complex engineering structures such as aerospace (composite wings, helicopter blades), automotive (high-end vehicles, recent electric types) and marine (boat hulls) to name but a few.

Within these and other niches, each has relative drivers, volumes and resultant costs. Satellite dishes for example are built in low numbers, but with high accuracy and though-life performance critical, are relatively expensive. On the other hand, glass reinforced plastics (GRP) panels for industrial applications are high volume – low cost. In between these extremes has fallen several markets, the most interesting and arguably challenging being wind energy.

The rise (and fall) of the market

With focus on achieving political targets, wind demand grew rapidly through the late 80s, 90s and early 2000s and demand often outstripped supply throughout the supply chain. In parallel to this growth, the market also 'globalised', placing on it an increased logistical and cost demand brought about by freight, duties and lead times. This period could be referred to as a 'build to stock' period for many in the chain, in order to meet customer needs and avoid contract penalty clauses.

With these relatively high volumes of units and continuously growing unit size, the consequential high materials material usage meant that wind blade volumes became attractive to material producers, at a time when many other related markets have declined or seen low growth rates. With the volume, globalisation and cost pressures increasing, supply chain managers have seen an influx of alternative suppliers and materials, not to mention existing ones multiplying volume to meet demand.

Following this rapid growth, we have since seen a fall, for most coming in two distinct waves, the first of these being China, as a result of a change in government policies and secondly, in America, with the Production Tax Credit (PTC) renewal delay. The impact of these has been significant and caused an almost immediate surplus of supply, systematically leading to a massive overcapacity throughout the market. Supply Chain Managers have now found themselves in a 'buyers' market', which has understandably been a method of securing lower cost materials, to support the overriding objective to contribute towards lowering the cost of (wind) energy.

This refocus of the wind supply chain led to an industry-wide efficiency gain as manufacturers reduced waste, increased efficiency and took time to reflect on market positions. For some the market tightening proved too much at a time where growth investments were still fresh – and the supply market thinned slightly as a result.

Looking ahead

Whilst the above 'adjustment' has had a positive cost effect, it is unrealistic to expect that this is sustainable, as profitability levels are low in the supply chain today. The road forwards requires significant effort from both supplier and customer, as new technology and price-driven initiatives from suppliers need to be accepted into new designs and manufacturing.

Therefore, if the market is to make the necessary step-change to achieve grid parity, it needs to do so through a combination of technology, processes and logistic initiatives with a fully aligned supply chain working in a partnership manner to achieve the common aim. DIAB has transformed itself into a fully market-driven global organisation, structured and led by the strategic market segments it supplies and will invest in supporting it. The largest of these today is wind energy, which has been the benchmark for this initiative, driving it as it does so many key aspects such as cost, quality, and consistency throughout all regions.

To that end DIAB's wind vision is to provide high-performance, cost-efficient core materials and innovative sandwich composite solutions which enable wind energy to reach a Levelised Cost of Energy (LCoE) with non-renewable energy

resources. In this way it is fully aligned with its customers and their customers, etc.

To deliver this vision, DIAB's mission is to be the chosen supply and technology partner by manufacturers and design materials selection teams alike, in order to enable them to deliver market-competitive blades, nacelles and spinners. DIAB, as experienced process, application and service specialists, offers optimised 'DIAB Core Infusion Technology' solutions, from a unique toolbox of high-performance core materials, finishing's, kits, technical services and its Composite Consulting Group (CCG).

Core as an engineering material

As mentioned previously blades are a key engineering component of the WTG and core materials are an essential element of their construction. In the final engineering structure, core materials (typically varying from 60 – 150 kg/m3) form part of a sandwich structure comprising of resin (epoxy or polyester) and reinforcement (glass and/or carbon) on either side. The core primarily is a means to reduce the weight of the laminate while sustaining the out-of-plane strength and rigidity.

Simplistically, the load carrying members of a typical blade today consists of structural webs connected to monolithic girders to form an approximation of a crude 'boxed beam' which in turn is joined to the root end. The surrounding two-part shell is transferring wind loads to the load carrying members while providing the optimum aerodynamic shape. Core material is normally used in both the spars and the shells, differently tailored in each component to provide ultimately the optimum level of design performance.

The blade root and its immediate adjoining spar/girder area is often referred to as the primary structural element of the blade, as it is here that the considerable forces and loading come to bear in service life. Therefore it is most common to find core materials in the 130-150 kg/m3 range used, be they predominantly balsa or PVC, such as ProBalsa and H/HP130 respectively. The remaining webs will, like the shell then typically use a much lighter core in the 60-80 kg/m3 density range, such as H60, H80 and second-generation materials like Matrix 7-7 and 10-8, which transitions to the tip of the blade.

Balsa and PVC have been (and still) is the engineering material of choice today, providing as it does an unrivalled balance of properties, weight and cost. The market has seen the use of SAN and PET material enter as alternatives during the high-growth years, when supply chain focus was on securing materials, however they have not penetrated the market as widely as PVC has done.

Looking forward, with such a wide range of material options available, structural design engineers could tailor the use of core in a more optimum way if design allowables could be opened up. Whilst the use of thickness (against global buckling) and density (for local buckling) have optimised designs, other opportunities exist. One could for example foresee the use of 45 kg/m3 material towards the tip end, transitioning to 60, then 80, 100 and 130/150 kg/m3 at the root end, with a corresponding reduction in materials cost.

Whilst adding such complexity brings issues with optimising waste during the process of cutting a preformed kit, this is manageable by a combination of effective material utilisation, reuse and nesting by the material supplier e.g. DIAB and its own direct kitting team, or a selective third party kitting partner.

Composite production processes

Today, blades are built by the infusion or prepreg process. Simplistically, the infusion process places dry reinforcement and core into a mould and resin is infused under a vacuum bag. Prepreg, on the other hand, as the name suggests uses reinforcement pre-impregnated with resin, laid up either side of core and cured under a vacuum bag at a higher temperature.

The attributes and benefits of these processes has been the subject of much debate and their basis originates from different sectors themselves. Prepreg is commonly used today in Aerospace and Formula 1 composite parts, with infusion widely used in more industrial applications.

The resultant laminate and material cost per m2 could be seen as being identical, although it is fair to say that one would expect to see a higher quality laminate from the prepreg process. During the 'build to stock' years, production lent itself to prepreg, but as the market expanded, particularly in America, India and China, many blade producers set-up quickly, which lends itself to the infusion process. This trend has continued and in today's 'made to order' and 'build to print' mode, flexibility is key, especially, in a market where financing and investments need careful management.

With blades becoming larger, perhaps with shorter product life cycles and increasing modular approaches around designs, with tactical market offerings for differing terrain conditions, the flexibility required is even higher.

Core in the Infusion Process

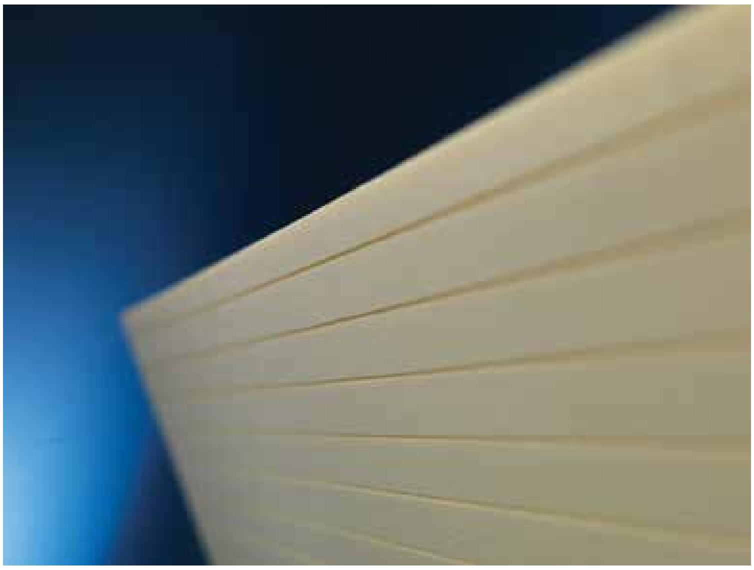
Unlike the prepreg process, in the infusion process core also performs a key function in acting as a processing aid to distribute resin during the manufacturing process. As such it can significantly impact on the blade weight, quality, production time/cost, resin consumption/cost and cost of consumables used within the process, which from DIAB's experience, can be considerable.

This is achieved by using an efficient combination of contoured cuts to enable the core to conform to the shape of the mould, infusion grooves and perforations to facilitate through thickness saturation of the fibre reinforcement.

By focusing on this aspect, massive savings can be achieved; however it requires a 'total blade cost' approach to achieve it. KPI's for typical procurement manager's focus on the cost per m2 of material, which has brought obvious benefits as described above. However, if we are really to impact on reducing the cost of energy, this thinking needs to broaden itself to focus on the 'total blade cost'.

Core in the Prepreg Process

As mentioned, the key requirement of the process is that the core needs to withstand a typical 125'c curing cycle, which could see higher temperatures in thick-section areas due to exotherm during cure. Heat-stabilised PVC e.g. HP80 has been the traditional material of choice, combining as it does a good combination of quality, machine ability for kits, weight and cost. PET has entered the market in some such blades, delivering similar mechanical performance, albeit by using higher density material in the 110-115 kg/m3 range, resulting in increased blade weights.



Focusing on the 'total blade cost'

DIAB has worked closely with several blade manufacturers who have applied this approach successfully. In the case of a dedicated blade production facility, the typical plant manager's KPI focuses on producing the maximum number of blades, to the highest quality at the lowest total cost, on time, in full. Consequently, by using DIAB's experience of optimising core infusion materials, finishing and kits, together with its considerable composites processing experience, real-time savings can be achieved, by reduced resin, reducing consumables such as mesh, speeding the infusion time, and enhancing laminate quality to reduce rework.

Such an approach is only possible in a collaborative, partnership way and utilising a cross-functional team from the blade manufacturer and supplier alike. By utilising everyone's respective expertise in a creative 'open' environment, massive benefits can result.

Within wind, every small cost saving can add up significantly because of the volumes involved. The authors have sought to demonstrate that, with an open mind and creative thinking in a collaborative way, within the area of core materials, there is considerable opportunity to deliver benefits. DIAB has an unrivalled reputation of using technical application knowledge in collaboration with customers globally, both through its 'hands-on' technical service team, and independent Composites Consultancy Group (CCG), which can take on confidential, specific tailored programs.

The opportunity for the industry is high. The basic demand for global electricity is rising and wind can provide this competitively in the years ahead, if all stakeholders can align to meet the aforementioned challenges. ■

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