WIND IS ON THE RISE

New coatings, foundation curing products and resins designed by BASF, help increase productivity and better performance with longer life.

By Torben Jensen

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WIND ENERGY IS BECOMING INCREASINGLY competitive compared to conventional sources of energy. Particularly emerging and developing countries decide to use this technology." This is the conclusion of a study by Sustainable Business Institute (SBI, Oestrich-Winkel, Germany) that the World Wind Energy Association (WWEA) presented at an international conference in Cairo, Egypt, in early November 2011. These findings are confirmed by the development of wind energy over the past decade: According to the WWEA Wind Energy Report 2010, the capacity of this sector rose from 24GW in 2001 to 197GW by the end of 2010. As a result of the financial crisis, however, the capacity of new plants installed declined in 2010 for the first time in the past 20 years. Despite this, all experts expect investments to rise again significantly in 2011. "We will end this year at the record 2009 level at least, and in 2012 the global wind industry will grow at a double-digit rate," predicts Thorsten Herdan, Managing Director of Power Systems at VDMA, the German Engineering Federation.

WWEA experts expect that capacity might increase to 600,000MW worldwide by 2015 (from just under 200,000MW today) and even rise as high as 1,500,000MW by 2020. Wind turbines now produce 430TWh of electricity each year — more than the entire electricity demand of the United Kingdom. All in all, wind energy cov-

ers 2.5 percent of the global demand for electric power. The global wind energy industry will continue to develop rapidly. According to "Internationales Wirtschaftsforum Regenerative Energien (IWR)," a German-based renewable energy industry institute, China has taken the lead on this road. In 2010, the industry as a whole failed to meet the new installations record set in the previous year.

About 35,800MW of wind energy capacity was newly installed in 2010, which represents a decline by seven percent with respect to the previous year's figure of about 38,000MW. As wind energy markets continued to become increasingly international, the focus kept shifting to non-European markets. With a capacity of nearly 16,500MW newly installed, China remains the biggest wind energy market in the world. New installations of wind power plants nearly halved in the U.S. as new capacity installed reached only about 5,100MW. India comes third (2,100MW), followed by Spain and Germany with 1,500MW each. By the end of 2010, the wind turbines installed around the globe had a total capacity of about 195,000MW (2009: 160,000MW). With a total of more than 42,000MW of capacity installed, China outpaced the U.S. (40,000MW) to become the new global wind energy champion. Germany remains in the third place (27,000MW). The fourth and fifth ranks are held by Spain, which has 20,000MW, and India with its 13,000MW.

In some countries, wind energy is now contributing significantly to power supplies. Denmark leads this ranking, at 21 percent, with Portugal and Spain following at 18 and 16 percent respectively, and Germany in the fourth rank, at nine percent.

Particularly ambitious targets are being pursued by Denmark, which plans to generate 50 percent of its electricity from wind by 2030.

The worldwide market for wind turbines again proved to be very robust in 2010: Around the globe another 37,600MW were added to the capacity installed. China took the lead yet again, adding 18,900MW — or more than half of all the additional capacity installed. Additions in Germany totaled 1,550MW. "The wind industry is becoming a major player in the world energy markets," states WWEA Secretary General Stefan Gsänger. "Despite the momentary dip, the trend that the installed wind capacity more than doubles every three years remains unbroken."

The share that wind energy contributes to the electricity mix is generally growing across the board. "The manufacturers of wind energy systems have a vital role to play in transforming electricity generation in Europe. According to expert forecasts by manufacturers of the different power generating technologies, by 2030 wind energy will account for nearly 25 percent of total power generation in the 27 EU countries," says Gerd Krieger, Deputy Managing Director of Power Systems at VDMA. By 2030, the experts expect wind energy capacities to increase threefold in Germany and even five-fold in the EU. "Plant retrofitting, which was largely irrelevant to date, plays a major role in this development," Krieger points out. The Global Wind Energy Council (GWEC) equally projects very positive developments for wind energy until the year 2014. "Outside of Europe, too, we are expecting strong growth in wind energy, especially in markets that are already growing fast, such as China and the U.S., and also in Latin America and Africa. We expect new construction to rise from 38.3GW to 62.5GW per annum in the next five years, giving a total installed energy capacity of more than 400GW by 2014. Our longer-term forecasts suggest that by 2030, between 25 and 30 percent of global electricity needs will be covered by wind power," says Angelika Pullen, GWEC Communications Director. Offshore installations will be one of the core issues on this road. This is demonstrated, for example, by the keen interest

Wind turbine at BASF's Verbund site in Antwerp, Belgium.

the maritime industry is showing in offshore wind energy activities, which range from special-purpose vessels for offshore wind farms to the production of steel towers and rotor blades.

A MARITIME FUTURE FOR WIND ENERGY

Experts expect that the potential of off-shore wind energy plants will be exploited more intensively in the future because the wind blows stronger and more consistently at sea. Offshore wind turbines have been Europe's domain to date. In terms of installed capacity, the United Kingdom (688MW by the end of 2009) and Denmark (663MW) are in the lead, followed by the Netherlands, Sweden and Germany. According to an overview by "Internationales Wirtschaftsforum Regenerative Energien (IWR)," a German-based renewable energy industry institute, the U.K. intends to add approximately 10,000MW more to this. And Germany is aiming high as well: The German Maritime and Hydrographic Agency BSH in Hamburg has granted permissions for 23 offshore wind farms in the North Sea and four in the Baltic Sea. Permissions for another 54 new wind farms in the North Sea and nine in the Baltic have been applied for. The total capacity of all German projects exceeds 27,000MW.

The U.S. energy ministry DOE also estimates that, by the end of 2030, 30,000MW of wind energy capacity may be installed in American territorial waters. Numerous projects are additionally being planned for the Great Lakes. According to the U.S. wind energy association AWEA, projects with a capacity of more than 5,000MW have already been applied for or are in different stages of planning or development. To speed up these projects, 10 U.S. states have formed an offshore wind energy consortium that is to coordinate initiatives for new projects and expedite their realization. The Cape Wind Project off the coast of Massachusetts is to play the pioneering role. This is a large-scale project comprising 130 wind turbines with a total capacity of 420MW. The cost of the investment amounts to $1 billion. According to a study by Stanford University and the University of Delaware, the wind energy potential off the U.S. Atlantic coast is about 330,000MW — which if fully harnessed would more than cover the energy demand of the East Coat states. One needs to remember here that the U.S. East Coast states consume about three-fourths of the total energy used by the nation. "The technology is proven, effective and available," stresses U.S. Secretary of the Interior Ken Salazar.

Wind energy is booming and will maintain its high growth rates. It is also becoming more demanding, though. There is a trend for plants to grow in size and performance, and offshore conditions are particularly demanding. This applies not only to turbines and rotor blades, but to towers and foundations as well. Against this background, the requirements on the systems and materials being used keep increasing. Accordingly, chemical solutions that are customized to suit specific uses are gaining importance. In the past years, BASF, the world's biggest chemical company headquartered in Ludwigshafen, Germany, had developed such solutions in various fields, thereby building a strong position in the wind energy industry that it intends to reinforce in the years ahead.

ROTOR BLADES AND WIND TURBINES

BASF developed new epoxy resin systems for fiber-reinforced composites, for example, that sell by the Baxxodur® brand and are highly suitable for the production of rotor blades for wind turbines: They allow for significantly shorter cycle times and so increase productivity. Rotor blades are growing ever bigger since a blade with twice the length covers an area that is four times the size and thus can capture four times as much energy from the wind flow. At the same time, however, a blade with twice the length is generally four times as heavy. While a 30-meter blade weighs 4 to 5 tons, a 60-meter one weighs in at nearly 20 tons. In spite of these increasing weights, the technical limits have nowhere near been reached, particularly thanks to the use of new materials such as carbon fiber composites. There are design concepts for 70-meter blades and test rigs for blades of up to 90 meters. At around 60 meters in length the possibilities for glass fiber reinforcement have been pretty much exhausted. Beyond this, carbon fibers tend to be used, but they cost around five times as much.

NEW EPOXY SYSTEMS BOOST PRODUCTIVITY

Limits at the top end are not set by the materials, however, but rather economic in nature since the profitability of a turbine increases only up to a point with rotor diameter. While larger turbines are of course more efficient, they are also more expensive in terms of transport and erection so that their profitability is influenced by many factors that matter significantly in rotor production. BASF sells a broad range of curing agents, accelerators and additives for professional epoxy resin processing. The company recently expanded its range by developing tailor-made epoxy resin systems for the manufacture of rotor blades.

Meanwhile, the epoxy resins for blades have been approved by Germanischer Lloyd. Engineers are increasing-

ly replacing conventional composites based on polyester resin by more resilient fiber-reinforced materials based on epoxy resins in order to reach the material properties required for rotor spans in excess of 100 meters. BASF has succeeded in developing innovative epoxy resin systems that, on the one hand, allow the long processing phase needed to produce ever larger rotor blades and, on the other hand, deliver short curing times in order to reduce cycle times. "In this way individual cycles can be reduced by around 30 percent," explains Dr. Gregor Daun, who is responsible for epoxy systems in BASF's Intermediate division.

The forces that act even on a 40-meter blade are enormous. On top of weight loads of around 70 kilonewton (the equivalent of five Volkswagen Golfs) and the rotational-speed-dependent outwards-acting centrifugal force, it is particularly the tangentially acting wind forces, which are dependent on wind speed, that can produce flexural moments of some 6,000 kilonewton-meters at the blade root, which corresponds to the leverage of 11 Volkswagen Golfs on the blade tip. To meet these requirements, epoxy resin systems are typically used with mainly glass fiber mats being inserted for reinforcement. Rather than being interwoven, these glass fiber layers are laid out next to one another or stacked in multiple layers and secured with a few threads in order to minimize fiber bending. Alongside this carbon fibers are also used, but in much smaller quantities as they are not only more expensive but also available in limited quantities only. Other materials such as aramid or basalt fibers have played no part as yet. In the manufacture of large blades the fibers or fiber mats are soaked with two fluid components, the resin and curing agent, that reacts with each other when heated in a shape-defining mold to form a very strong polymer. The entire system comprising the matrix and fibers makes a fiber composite material that delivers the necessary mechanical stability.

There are basically four different techniques for impregnating the fibers. In laminating the dry mats are impregnated manually one after the other using rollers dipped in the epoxy resin systems. Infusion technology uses a vacuum to suck the epoxy resin systems into the dry mats laid up in the mold. The third possibility is to soak the mats outside the mold and let them pre-cure to semi-rigid state before laying them up in the mold for final curing (prepreg technology). For round, long-ish components the fibers are impregnated and wound onto a mold before being cured using thermal energy (filament winding technology). Using these four technologies it is normally possible to manufacture all of the main components of a rotor. This includes in particular the thick multi-layer blade root that transfers the force to the hub as well as the internal load-bearing structure of shear webs, spar caps or hollow sections that take up the major part of the forces acting along the length of the blade. The third component is the outer shell of the blade, which is basically hollow. This shell performs the aerodynamic function and is either molded along with or bonded to the root and internal structure.

The modern infusion systems used in the wind energy sector consist of two components, the resin and a curing agent. Amine formulations are typically used for curing since they are well suited to the requirements of mechanical stability and processing. The new BASF systems also use this class of substances. Immediately before the infusion both components are mixed together at a predefined ratio. At this moment the potlife, or processing time, clock starts ticking because the reaction between the two components begins slowly and increases at higher temperatures. However, in order for infusion to work well the viscosity of the system has to be correct. For this reason so-called reactive diluents, which reduce the viscosity but at the same time form part of the cross-linking reaction, are included in the formulation. The actual cross-linking or curing of the resin is achieved by the amines reacting with the epoxy groups to form a three-dimensional network. This reaction is dependent on the reaction temperature, but can be influenced by the use of additives such as accelerators.

LATENT CURING AGENTS SQUARE THE CIRCLE

Turbine manufacturers, who are now concentrating on offshore plants, are for the most part targeting the use of large blades exceeding 50 meters in length in order to make most effective use of the more consistent wind flow out at sea. In the case of large structures such as the outer skin of such huge blades, processors using infusion technology face a dilemma. On the one hand, the epoxy resin system should react slowly in order to completely fill the mold before it begins to gel. On the other hand, however, the epoxy resin system should react rapidly once heated so that the mold can be released for the next blade as quickly as possible. BASF developed a chemical route — first slow and then fast — that uses so-called latent systems to square this circle. Here, some of the curing agents are activated thermally on passing a threshold temperature, having previously been "dormant."

These latent curing agents from BASF can be easily adjusted to simplify handling during the entire process. The bottom line is higher quality, better process stability and a lower scrap rate. Up until now, depending on external factors such as temperature several curing agents had to be mixed. In this respect as well, the Baxxodur system offers significant advantages because it can be used over a considerably greater range of temperatures. This means that the curing agent mixes do not have to be adjusted every day. Not the least of the advantages is that stocks are much easier to manage because only a single curing agent needs to be stocked. In addition, BASF is working on further improvements in the core mechanical properties and in fiber matrix adhesion.

Other engineering plastics also have a major role to play in future blade construction. Because the dimensions of rotor blades keep increasing, these are getting heavier, too, with the glass fibers used currently adding signifi-

cantly to their weight. Engineers are accordingly thinking intensively about replacing these fibers with much lighter carbon fibers. This has been tried out in China for the spar caps that ensure load transmission. These tests show that much thinner layers are possible, greatly reducing the weight of blades. In this arena, BASF offers its Ultrason E branded polyethersulfone (PESU), a high-performing plastic material. This thermoplastic material features exceptional impact resistance, is resistant to chemicals and suitable for components that are exposed to high thermal strain. Yet, while they are high-strength materials, carbon fiber composites are also brittle. Adding Ultrason® E 2020 P SR will make the system tougher. Two options are available: The plastic material either comes as a powder which is distributed homogeneously in the epoxy mix, or it is spun into a fine mat that is inserted between the laminate layers.

From the foundation to the very tips of the blades: In addition to making modern wind energy plants durable and effective, innovative solutions from BASF also help to manufacture and to install wind turbines more efficiently.

COATING SYSTEMS FOR MORE THAN 30,000 ROTORS

Whereas internal rotor blade stability is one part of the story, their outward protection is the other part. The general rule here is that the coating systems must be matched precisely to the blade production process for the blades to perform perfectly for a long time. Since the mid-nineteen-nineties, Relius Coatings GmbH & Co. KG in Oldenburg, Germany, which is part of BASF's Coatings division, has been developing coatings for rotor blades that are effectively protecting more than 30,000 blades. Product development focuses clearly on a long service life. The entire portfolio is highly suitable for application on glass-fiber reinforced plastics, GRP, used for rotor blades. It comprises gel coats, putties and topcoats. The two-component coatings based on polyurethanes (PUR) are either low-solvent or solvent-free products and therefore meet current VOC limits.

The coating systems being marketed under the new RELEST® brand excel by their well-balanced set of properties, which includes:

- Very high abrasion resistance for durable surface protection,
- Very high elasticity, which minimizes the risk of stress cracking,
- Excellent UV stability, ensuring colors stay the same for years,
- Eco-friendliness (compliance with VOC limits).

All coatings are obviously matched perfectly to the different production processes being used. And another point applies to all systems: The products of the RELEST® Wind brand, from gel coats, to putties, to topcoats, sustainably support the production of environmentally benign energy.

Since the rotor blades are exposed to exceptionally severe weathering, they need to be protected against humidity and light, for example, by application of a gelcoat. Putties are used to smooth minor surface unevenness. Then, to protect edges against wear and tear an edge protection coating is applied, and topcoat application is the final step in the coating process.

BASF provides customers with tailor-made solutions for each of these process steps: The solvent-free two-component polyurethane gel coats it offers as RELEST Wind ProcessCoat and RELEST Wind Gelcoat are VOC-compliant and feature convincing properties like long potlife, fast curing and re-coatability, and excellent abrasion resistance. They are available for different blade production processes.

RELEST Wind Putty Porefiller serves as a pore stopper. To complete its portfolio BASF also sells a viscoelastic putty known as RELEST Wind Putty Contour. It can be sanded after just one hour and is suitable for manual or machine processing. For a high-quality surface finish, exceptionally fast-drying topcoats are available by the name of RELEST Wind Topcoat, alternatively as water-based or high-solids formulations.

Ongoing product development is crucial because plant operators specify demanding performance standards. BASF works continually to improve its products. The company presented two novelties at JEC 2011 in Paris, Europe's major composites trade fair: The new RELEST Wind ProcessCoat is an exceptionally efficient solution for coating rotor blades. Effective protection against erosion and UV radiation is essential in this application. It is the kind of protection that you get from RELEST Wind ProcessCoat, which was developed to meet these precise requirements and incidentally, by its low product use, helps to reduce rotor blade weight and optimize the process. In addition, the RELEST Wind RepKit will be showcased, a system for repairing rotor blades. Along with all the materials and tools necessary for repairs, this kit also comprises an extensive application training seminar. The new RELEST Wind RepKit has been designed for stationary use on the ground or on wind turbines.

"BASF has decades of experience, through its RELIUS COATINGS subsidiary, in supporting the industry as a coating systems partner. Mature solutions are therefore

available to the wind energy industry for turbine towers as well, whether those 'legs' are made from concrete or steel," says Dr. Achim Gast, who is responsible for BASF's Industrial Coatings Solutions Business Management. Topcoats based on two-component polyurethane systems (as high-solids or water-based formulations) guarantee weather-resistant, non-reflecting surfaces. The coating material features active anti-corrosive properties, thereby enabling a long service life. BASF's extensive experience in marine coatings adds to its expertise in supporting complex offshore projects, an area that is becoming increasingly important. Moreover, equipment installed at the entrance and inside wind power plants requires equally efficient protection against exposure to weathering, which may be extreme in some cases. Environmentally friendly polyester powder coatings ensure optimum resistance against corrosion and chemicals for machines, stairs, doors and lightning protection systems.

DURABLE FOUNDATIONS? NOT WITHOUT CONSTRUCTION CHEMICALS

Safe and durable foundations are vital to the erection of wind turbines, and this applies equally to onshore and offshore installations. Offshore power plants are nowadays typically built on either monopile foundations, where a single pile is driven into the rocky or sandy seabed; as so-called tripod foundations featuring three piles; or by using concrete caissons for foundations that rest on the seabed due to gravity. Eighty percent of the installations erected to date are monopile structures. The choice of design depends on the conditions in which the specific wind farm is built such as the nature of the seabed, the water depth or its distance from the shore. For deep-water installations, which are increasingly moving to the focus of attention in the North Sea area, engineers tend to prefer new systems with four or six legs (known as jackets) or floating designs for even deeper waters. The booming wind energy industry, with its increasingly larger installations, need products of the highest quality in this particular field that help reduce construction times. BASF's Functional Solutions business offers a broad portfolio of construction chemicals. BASF Construction Chemicals is a global leader in the development of concrete admixtures like plasticizers, retarders or accelerators. Admixtures enhance the ease and efficiency of placing concrete. They also increase the stability and service life of concrete structures. The portfolio includes specialty grouts, which play a crucial role in the construction of wind turbines.

BASF has developed a special product, known by the brand name MASTERFLOW 9500, that is designed specifically for the construction of offshore wind turbines. This grout formulation guarantees excellent results in terms of strength and fatigue resistance. Its compression strength can be as high as 140 megapascals, and the modulus of elasticity, up to 50 gigapascals. The product was tested extensively by the independent universities of Aalborg, Denmark, and TU München, Germany. The grouting mortar was found to meet the strict fatigue resistance standards of the Det Norske Veritas (DNV) classification body and is the first grout to have been certified for use in offshore wind turbine construction. It even allows processing in the most adverse conditions, which include temperatures as low as 2 °C and underwater processing without any segregation issues. Another positive effect is reduced dust formation during processing. This grout is free of autogenous shrinkage and features good volume stability. MASTERFLOW® 9500 allows pumping over long distances of more than 200 meters or for rather long times — yet another processing advantage.

By its characteristic properties MASTERFLOW 9500 ensures high cost efficiency: It reduces installation times because the required strength builds up fast even at a low temperature.

Intermediates from BASF improve the production process of rotor blades for modern wind turbines. Producing rotor blades for modern wind turbines is now a much faster affair than it used to be — if you use BASF's Baxxodur® epoxy resin and hardener systems. They can help you to cut the time needed to produce these long blades by as much as 30 percent.

"In the past, offshore wind farms used to be built in two construction phases, with the foundations being erected in the first phase and the rest of the power plant following in the second phase. Investors and project designers would rather shorten the time of installation to a single phase, with foundations being erected in the winter and the turbines being installed earlier the next summer. However, this is feasible only if the grouting mortar cures fast and builds strength at low temperatures of less than 5 °C. It is precisely what you achieve by using MASTERFLOW 9500," says Luc Westhof, a graduate engineer who is responsible for spe-

cial-purpose construction materials for wind turbine towers and foundations within BASF's Construction Chemicals Europe division.

The product takes only five hours to set in standard conditions and nine hours at low temperatures. The long processing time (up to four hours) reduces the risk of interruptions and product being wasted. Short construction times eventually enable wind farms to be brought on stream faster, and the construction equipment required can be released faster for other projects. As a result, the use of MASTERFLOW 9500 produces foundations featuring excellent durability and a high capability to absorb dynamic loads.

The new mortar was used for the first time in October 2009 in the Danish Storebælt wind farm, which comprises seven Vestas wind turbines and was connected to the grid just in time for the opening of the Copenhagen Climate Conference in late 2009 thanks to the use and fast curing of MASTERFLOW 9500. The first large-scale commercial project using MASTERFLOW 9500 is the Rødsand II wind farm in Denmark. This farm was erected in the Baltic Sea, off the south coast of the island of Lolland, on behalf of E.ON. It comprises 90 wind turbines made by Siemens, each of which has a capacity of 2.3MW. About 50 tons of MASTERFLOW 9500 were used to build the turbines, with up to three turbines being grouted per day. The Siemens equipment has already stood the test of time in the Rødsand I wind farm that was started up in 2003 and consists of 72 of these turbines. The

Innovative epoxy resin systems for high-performance rotor blades

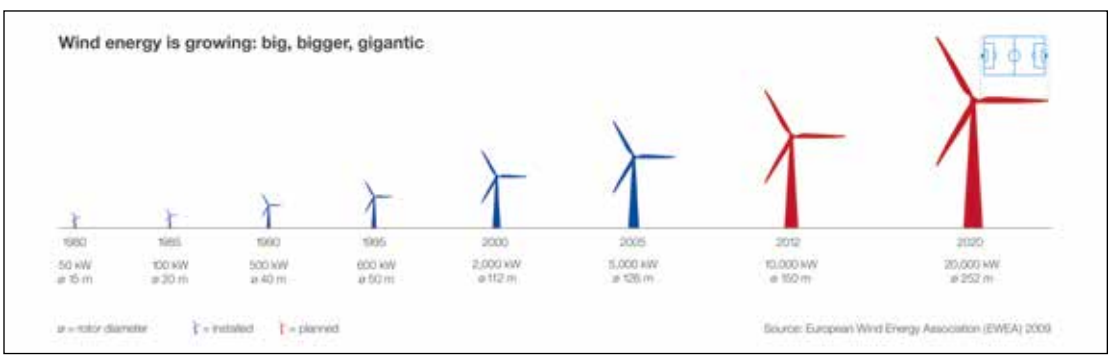
combined Rødsand I+II farm is today the largest Danish offshore wind farm. MASTERFLOW 885 was used to build it at the time, another BASF grouting mortar designed specifically for installing machinery, equipment and assemblies that need to take up dynamic loads on concrete floors. As MASTERFLOW 9500 is even more suitable for offshore use, however, it was selected for the new project.

MASTERFLOW 9500 also provided the basis for a new product development that BASF is launching this year under the name MASTERFLOW 9300. This is a special grouting mortar for onshore wind turbines that includes metallic admixtures and nanotechnology features.

SPECIALLY DESIGNED GROUTING MORTARS FOR ONSHORE TURBINES

The new grouting mortar also offers a response to the growing number of cracks in wind turbine foundations that have appeared with increasing frequency in the past three years. About 30 percent of all plants installed in Germany, for example, develop this type of problem in the first three to five years. These issues can be traced to a range of different reasons: They may be due to dynamic loads and variations in loads on the one hand, and on the other hand design errors and, above all, the ever larger dimensions of wind turbines have a role to play. These insights are among the factors that have resulted in special requirements being made on grouting mortars. These include, for example, optimum filling of all cavities in order to achieve perfect load transmission, guarantee a long service life and facilitate uninterrupted generation of energy. Other requirements are fast installation, which reduces costs, and a safe, durable structure that features top strength, guarantees volume stability throughout its service life and shows excellent fatigue resistance despite all the load changes it has to absorb.

MASTERFLOW 9300 meets these standards exceptionally well, thanks to its characteristic profile. The product expands while it is being



Wind Energy is growing

placed, filling all cavities. It is free of autogenous shrinkage in the curing phase and even continues to expand, ensuring perfect load transmission while the turbine is operational. At a temperature of 20 °C, its can be processed for at least three hours, and drying shrinkage is less than 0.5 millimeters per meter. Efflorescence, exudation or sinkage have not been observed. The flow properties have been improved again, compared to MASTERFLOW 885. Air void content and porosity are remarkably low compression strength after 28 days is at least 120 megapascals — which means that MASTERFLOW 9300 outperforms MASTERFLOW 885 by more than 50 percent in this respect. To allow fast installation of wind turbines, it is essential that the grouting mortar build strength quickly.

MASTERFLOW 9300 achieves a compressive strength of 50 megapascals — this criterion determines the moment when the turbine anchor bolts are tightened — within 24 hours at a temperature of 20 °C. At a temperature of just 2 °C, the product takes two days to reach this minimum level of 50 MPa. This translates into time-savings in wind farm construction, as turbines can be erected in poor weather conditions as well. In formulating MASTERFLOW 9300, BASF resorted to the best available plasticizer technology and even included nanotechnology for cement-type mortars. This product, too, was tested by Aalborg University and TU München University and has been certification tested by DNV.

HIGH-PERFORMANCE LUBRICANTS FOR WIND TURBINES

In the course of the Cognis acquisition BASF again expanded its wind energy portfolio, entering the arena of lubricants for wind turbines. The industry essentially needs three types of lubricant, gear lubricants, hydraulic fluids, and greases. BASF supplies its customers with both high-performance, synthetic gear lubricants (based on POA technology) and high-performance, synthetic hydraulic fluids.

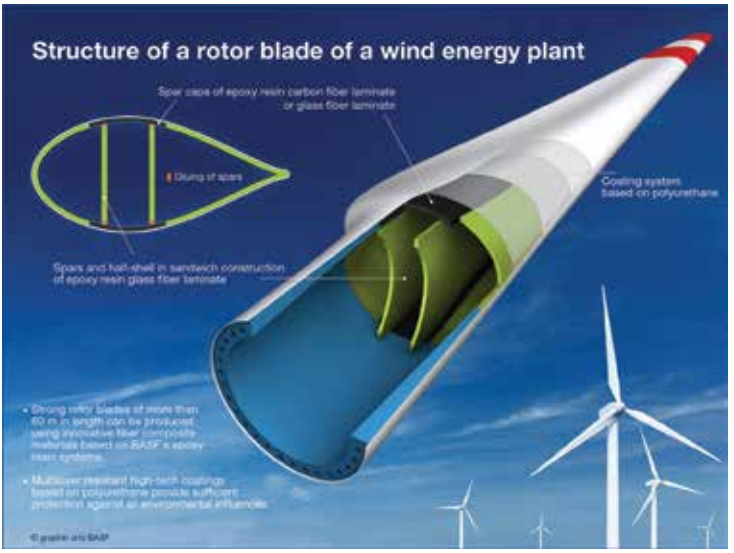
The performance requirements in the global wind industry are severe and the demands on performance increase every year. "Developing and proving a new formulation represents a significant commitment to innovation and to the development of the wind industry in general," explained Mark Hesseling, Global Strategic Marketing Manager at BASF. Once a particular formulation has passed a long list of fundamental specifications it is field-tested in conjunction with the wind turbine and gearbox OEMs. High-performance synthetic base oils are increasingly preferred over conventional mineral oils. One of the reasons is that customers place particular emphasis on long drain intervals since oil changes on wind turbines tend to be complicated and expensive affairs. In fact, their cost typically exceeds the cost of the actual oil many times over. While solutions based on mineral oil last no longer than one or two years in operation, high-performance oils from BASF have a much longer useful life.

Low temperature viscosity is another major criterion. While high-performance lubricants from BASF stay liquid and stable at extremely low temperatures down to minus 50 °C, mineral-oil-based formulations as a rule do not withstand temperatures below minus 20 °C. "We worked to improve low-temperature viscosity to reach excellent results in turbines located in the harshest environments, anywhere in the world," Hesseling said.

To meet the ever-increasing demands in wind turbine applications these high-performing synthetic basestocks are complemented with special additives. In developing BASF's high-performance gear lubricants, for instance, our scientists focused especially on minimizing wear and micropitting in the gearbox, the most expensive component of a typical wind turbine.

By combining its know-how in oil basestocks, performance additives, and finished lubricant formulations, BASF continues to invest in the innovation necessary to participate in this exciting and challenging industry.

The wind energy industry remains on the road to success, and materials from BASF play a major role in this development by enabling ever-higher performance, raising productivity and improving durability. Tailor-made materials will be crucial in the future, too, as we continue to see wind energy plants increasing in size and offshore installations becoming more popular. We will continue to expand our product range in this field because we are convinced that wind energy has the capabilities we need and must be developed further.



How rotor blades defy the forces of nature.